WBNK | Wissenschaftlicher Beirat für Natürlichen Klimaschutz

Options for further development of the Federal Action Plan on Nature-based Solutions for Climate and Biodiversity

Executive Summary of the Report of the Scientific Advisory Board for Nature-based Climate Action for the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety

Imprint

Published by

Scientific Advisory Board for Nature-based Climate Action

Secretariat at the Federal Agency for Nature Conservation

DLR Projektträger
Heinrich-Konen-Str. 15, 53227 Bonn, Germany

Telephone: +49 228 3821 2900
E-mail: WBNK-GS@dlr.de

Complete report

www.wissenschaftlicher-beirat-fuer-natuerlichen-klimaschutz.de

Authors

Anke Herold, Matthias Drösler, Antje Boetius, Andreas Bolte, Mariele Evers, Andreas Gattinger, Harald Grethe, Rieke Hansen, Pierre L. Ibisch, Wolfgang Köck, Julia Pongratz, Katrin Rehdanz, Josef Settele, Franziska Tanneberger, Vicky M. Temperton, Michael Zschiesche

Editor

Secretariat of the WBNK

Translator

Environmental English Ltd

Photo credits

Cover photo: Philipp Deus/unsplash, p. 9: maksim_shutov/unsplash

Recommended citation

Anke Herold, Matthias Drösler, Antje Boetius, Andreas Bolte, Mariele Evers, Andreas Gattinger, Harald Grethe, Rieke Hansen, Pierre L. Ibisch, Wolfgang Köck, Julia Pongratz, Katrin Rehdanz, Josef Settele, Franziska Tanneberger, Vicky M. Temperton, Michael Zschiesche (2025): Options for further development of the Federal Action Plan on Nature-based Solutions for Climate and Biodiversity. Report of the Scientific Advisory Board for Nature-based Climate Action for the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety. ISBN 978-3-949245-39-8.

Originally published in July 2025

This document from November 2025 is a translation of the German publication “Optionen zur Weiterentwicklung des Aktionsprogramms Natürlicher Klimaschutz“ (https://www.wissenschaftlicher-beirat-fuer-natuerlichen-klimaschutz.de/wp-content/uploads/WBNK_Stellungnahme_Weiterentwicklung_ANK.pdf).

Acknowledgements

The WBNK obtained additional external expertise for the preparation of this Report. Specialist consultations were held and expert reports commissioned. As part of quality assurance, the WBNK submitted draft versions of individual chapters of this Report to a review by a diverse panel of experts, who provided chapter-specific comments.

The WBNK would like to thank the following experts for their professional comments: Prof. Dr Werner Härdtle (Leuphana University Lüneburg), Sophie Hirschelmann (Succow Foundation), Dr Robert Jandl (Austrian Research Centre for Forests), Dr Martin Komainda (University of Göttingen), Dr Katrin Kuka (Julius Kühn Institute, Braunschweig), Prof. Dr Harald Laser (South Westphalia University of Applied Sciences, Soest), Prof. Dr Christoph Leuschner (University of Göttingen), Anke Nordt (University of Greifswald), Prof. Dr Andreas Oschlies (GEOMAR), Prof. Dr Stephan Pauleit (Technical University of Munich), n.n. (Department of Coastal, Marine and Polar Research, MGS 1 of Project Management Jülich), Dr Mathias Scholz (Helmholtz Centre for Environmental Research), Prof. Dr Friedhelm Taube (Kiel University, CAU), Prof. Dr Dominik Thom (Dresden University of Technology) and Prof. Dr Nicole Wrage-Mönnig (University of Rostock).

Sincere thanks are also extended to the following experts: Prof. Dr Marc Oliver Bettzüge (Council of Experts on Climate Change), Prof. Dr Thomas Heimer (Council of Experts on Climate Change), Prof. Dr Axel Don (Thünen Institute, Braunschweig), Dr Roland Fuß (Thünen Institute, Braunschweig), Dr Klaus Hennenberg (Öko-Institut e. V.), Dr Udo Hemmerling (Bundesverband der gemeinnützigen Landgesellschaften), Dr Heinrich Höper (LBEG Niedersachsen), Prof. Dr Sabine Kasten (AWI), Tom Kirschey (Centre of Competence for Nature-based Climate Action, KNK), Dr Susanne Lehmann (DLR Projektträger), Dorothea Nagel (Institute for Federal Real Estate), Jutta Paulus (Member of the European Parliament), Katja Purr (German Environment Agency), Dr Joachim Rock (Thünen Institute), Aaron Scheid (Ecologic Institute), Dr Geerd Smidt (Niedersächsische Landgesellschaft, Aurich), Dr Nico Stelljes (Ecologic Institute), Dr Bärbel Tiemeyer (Thünen Institute), Andreas Tietz (Thünen Institute), Jenny Tröltzsch (Ecologic Institute), Dr Philipp Weckenbrock (Justus Liebig University Giessen), Prof. Dr Jutta Zeitz (Humboldt-Universität zu Berlin).

Representatives of the Federal Ministry for the Environment, Climate Action, Nature Conservation, and Nuclear Safety and the Federal Agency for Nature Conservation provided a great deal of valuable information and were reliable partners whose professional input was important for the preparation of this Report. We would also like to express our gratitude to them.

We would also like to thank all those involved in preparing the expert reports, as well as the participants in the workshops and standardised surveys for their important input.

The Scientific Advisory Board for Nature-based Climate Action (WBNK)

The Scientific Advisory Board for Nature-based Climate Action (WBNK) is an interdisciplinary body of 16 scientists. It advises the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety on issues of nature-based climate action and provides scientific support in the implementation of the Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK). The advisory work includes expert reports, recommendations, and statements aimed at the preservation, enhancement and restoration of natural and near-natural ecosystems in order to achieve the climate targets under § 3a of the Federal Climate Action Act and to contribute to the conservation of biodiversity. Experts from various fields use their experience to make a significant contribution to the protection, enhancement, and restoration of forests, floodplains, soils, peatlands, seas, water bodies, and urban green spaces.

The aim of the WBNK is to ensure that publicly funded measures for nature-based climate action have the greatest possible impact, particularly with regard to reducing greenhouse gas emissions and protecting biodiversity. To this end, the Advisory Board also considers and evaluates links and interactions between the various measures in the Action Plan and provides impetus for further development in the future.

The legal basis is the establishment decree of a Scientific Advisory Board for Nature-based Climate Action issued by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, dated 5th February 2024. Federal Environment Minister Steffi Lemke appointed the Advisory Board on 19th March 2024. The members of the WBNK are independent and serve in an honorary capacity. They receive scientific and organisational support from a secretariat.

The members of the WBNK were appointed by the Federal Environment Minister Steffi Lemke on 19th March 2024 for a period of three years. The chairs are Anke Herold and Matthias Drösler, their term of office is three years.

Members of the WBNK

Co-chairs

Prof. Dr Matthias Drösler, Peatland Science Centre, Weihenstephan-Triesdorf University of Applied Sciences, Germany

Anke Herold, Öko-Institut e. V., Germany

Other members

Prof. Dr Antje Boetius, Monterey Bay Aquarium Research Institute, USA

Prof. Dr Andreas Bolte, Thünen Institute of Forest Ecosystems, Germany

Prof. Dr Mariele Evers, University of Bonn (Rheinische Friedrich-Wilhelms-Universität Bonn), Germany

Prof. Dr Andreas Gattinger, Justus Liebig University Giessen, Germany

Prof. Dr Harald Grethe, Humboldt-Universität zu Berlin, Germany

Prof. Dr Rieke Hansen, Hochschule Geisenheim University, Germany

Prof. Dr Pierre L. Ibisch, Centre for Econics and Ecosystem Management, Eberswalde University for Sustainable Development, Germany

Prof. Dr Wolfgang Köck, Leipzig University, Germany

Prof. Dr Julia Pongratz, LMU Munich, Germany

Prof. Dr Katrin Rehdanz, Kiel University CAU, Germany

Prof. Dr Josef Settele, Helmholtz Centre for Environmental Research, Germany

PD Dr Franziska Tanneberger, University of Greifswald / Greifswald Mire Centre, Germany

Prof. Dr Vicky M. Temperton, Institute of Ecology, School of Sustainability, Leuphana University of Lüneburg, Germany

Dr Michael Zschiesche, Independent Institute for Environmental Issues e. V., Germany

Table of contents

1 Executive Summary 9

1.1 The Federal Action Plan on Nature-based Solutions for Climate and Biodiversity 11

1.2 WBNK recommendations for further ANK development 13

1.2.1 Protection of intact peatlands and rewetting 13

1.2.2 Forest ecosystems 14

1.2.3 Mineral soils under arable land and grassland 16

1.2.4 Settlement and transport areas 17

1.2.5 Seas and coasts 18

1.2.6 Natural water bodies and floodplains 19

1.2.7 Wilderness and protected areas 20

1.2.8 Overarching recommendations for improved framework conditions for implementation 21

1.2.9 Funding policy 22

1.3 Proposals for improving the monitoring and emissions calculation 22

1.4 Research requirements 23

1.4.1 Measurement and modelling 23

1.4.2 Monitoring the impact of measures 23

1.4.3 Synergies with other ecosystem functions 24

1.4.4 System boundaries, overall impact of measures and value chains 24

1.5 Promoting sustainable biomass use and reducing land-use competition 24

List of acronyms and abbreviations

§	section
ANK	Federal Action Plan on Nature-based Solutions for Climate and Biodiversity
BBodSchG	Federal Soil Protection Act
BfN	Federal Agency for Nature Conservation
BMUKN	Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety
bn	billion
C	carbon
CAP	Common Agricultural Policy of the EU
CARESupreme	scenario project of the German Environment Agency
cf.	*confer*; compare
CH_4	methane
ClimateWilderness	guideline for the promotion of smaller areas with self-dynamic development and of ClimateWilderness ambassadors as a contribution to nature-based climate action
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
e.g.	*exempli gratia*; for example
etc.	*et cetera*; and the rest, and so on
EU	European Union
EUR	Euro(s)
e. V.	registered association
g	gram(s)
GHG	greenhouse gas
ha	hectare(s)
IPCC	Intergovernmental Panel on Climate Change
KBU	Soil Protection Commission at the German Environment Agency
KfW	Reconstruction Loan Corporation
kg	kilogramme(s)
km	kilometre(s)
KSG	Federal Climate Action Act
kt	kilo tonne(s)
KWM / KWMPlus	Funding measures for Climate-Adapted Forest Management (Plus)
LULUCF	Land Use, Land Use Change and Forestry
m	metre(s)

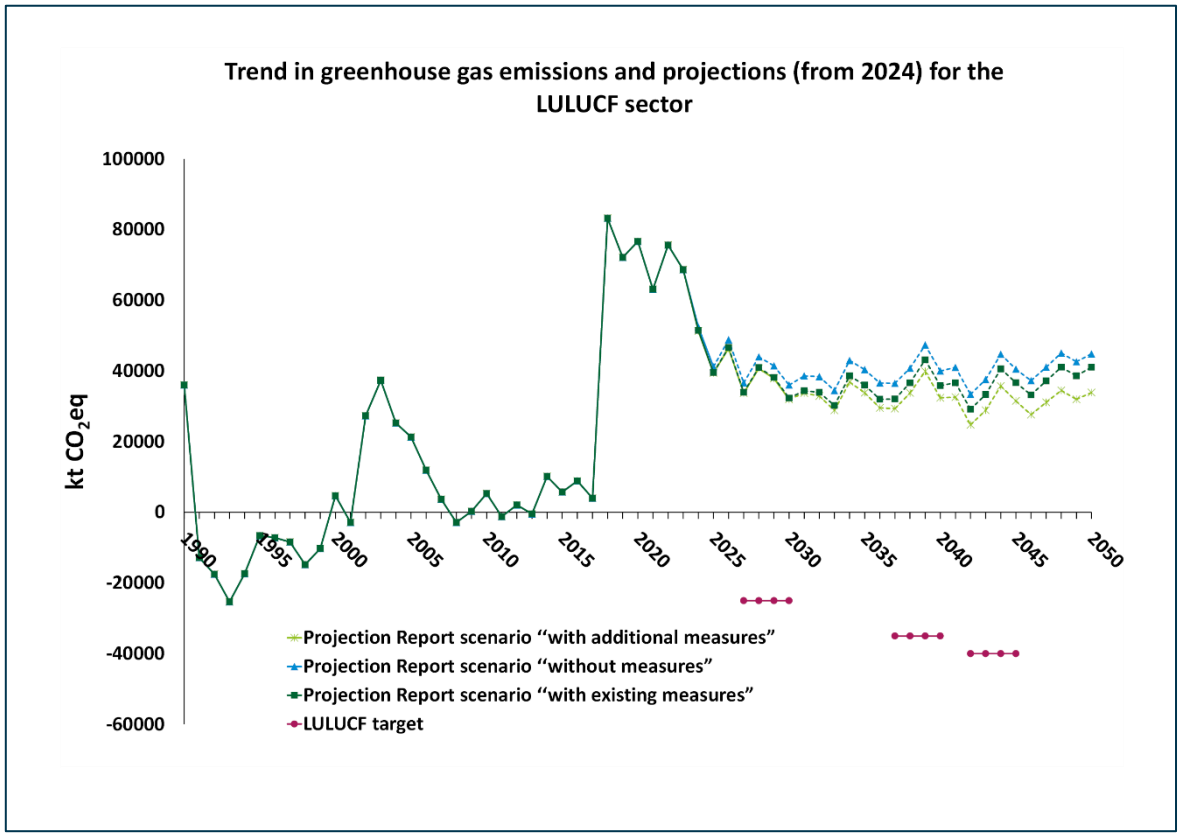
M	million
MoMoK	project "Development of a Germany-wide peatland monitoring system for climate protection"
Mt	million tonne(s)
N	nitrogen
N_2O	nitrous oxide (laughing gas)
NRR	Nature Restoration Regulation
P	phosphorus
Palu	Paludiculture funding guideline
PD	private lecturer
t	tonne(s)
UBA	German Environment Agency
WFD	Water Framework Directive
yr	year
ZUG	Zukunft – Umwelt – Gesellschaft gGmbH

1 Executive Summary

Executive Summary

Germany has set itself the target of achieving net greenhouse gas (GHG) neutrality by 2045 in its Federal Climate Action Act (KSG). The land use sector (referred to as LULUCF, from Land Use, Land-Use Change and Forestry) has a special position in this context. According to § 3a of the KSG, it is to contribute to the national reduction target with a net CO_2 sequestration of at least 25 Mt CO_2eq by 2030, 35 Mt CO_2eq by 2040 and 40 Mt CO_2eq by 2045. Emissions are generated in the LULUCF sector as in other sectors, but only the LULUCF sector can currently sequester CO_2 and thus form a net sink if CO_2 sequestration exceeds emissions. Since 2014, however, the LULUCF sector in Germany has become a net source of emissions. The drought period from 2018 to 2022 particularly intensified this; in 2023, net emissions from the LULUCF sector were 68.7 Mt CO_2eq. The German Environment Agency's 2025 Projection Report also identifies a significant gap between the sector's projected emissions and the targets under § 3a of the KSG. The results of the Projection Report therefore show that meeting the LULUCF targets of the KSG is a major challenge (Figure 1).

Figure 1: Trend in greenhouse gas emissions up to 2023 and in projections from 2024 as well as targets for the LULUCF sector



Source: Greenhouse Gas Inventory 2025 (UBA, 2025a) and Projection Report 2025 (UBA, 2025b)

This situation led to the first request for consultation from the BMUKN to the WBNK on 27th May 2024 for this document, in which the following questions are to be addressed:

- What options does the Advisory Board see for the further development of the Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK), including existing instruments, new instruments, and better support of implementation?
- What contribution can various instruments make to closing the target gap with regard to the target horizons up to 2045?
- Is there coherence between the proposed instruments and other policy instruments? What potential obstacles to implementation does the Advisory Board see?
- Does the Advisory Board have any suggestions for improvement in the area of emissions calculation or emissions projection?

In May 2024, the Higher Administrative Court (OVG) of Berlin-Brandenburg ordered the Federal Government to supplement the national climate action programme with measures to ensure that the LULUCF targets of § 3a of the KSG are met, which further emphasised the urgency of the issue. This document was based on the above-mentioned questions. A comprehensive measure-specific quantitative projection of the achievement of the LULUCF targets is not possible within the scope of this document and is the task of the annual Projection Report. Nevertheless, additional potential for emission reductions or additional CO_2 sequestration options for a national climate action programme could be identified. Deficits in the legal framework and obstacles to implementation were also identified that are currently preventing the potential of the LULUCF sector from being realised.

1.1 The Federal Action Plan on Nature-based Solutions for Climate and Biodiversity

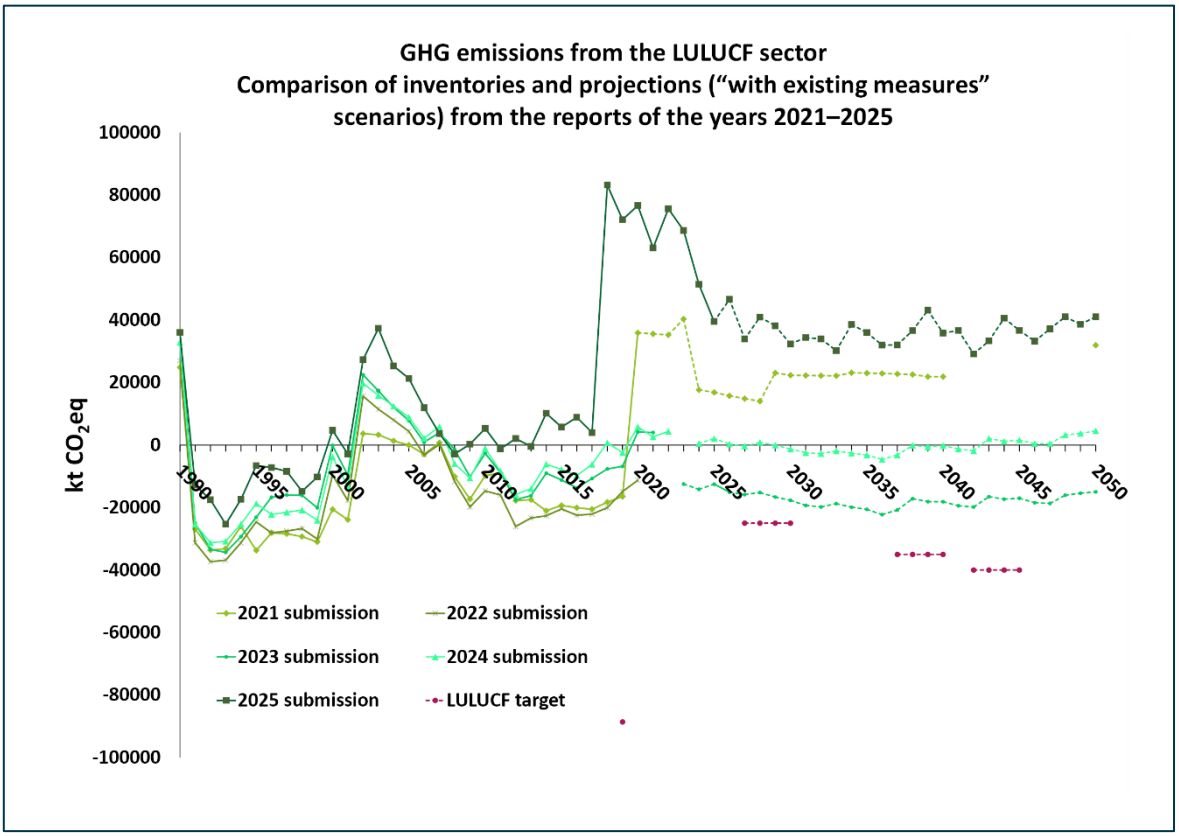
Nature-based Solutions aim to maintain and strengthen the climate mitigation potential of terrestrial and marine ecosystems in line with biodiversity conservation. Nature-based Solutions measures promote climate mitigation, the resilience of ecosystems in the face of climate change, and the conservation of biodiversity by exploiting the links and synergies between these areas.

The Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK) was launched in March 2023 under the leadership of the Ministry of the Environment (now BMUKN). It comprises around 120 individual measures in ten fields of action that address individual ecosystems, as well as structural and strategic cross-cutting measures. The programme has a budget of around EUR 3.5 bn for 2024 to 2028. More than half of the budget is earmarked for measures in forests (EUR 1.2 bn) and peatlands (EUR 680 M). Twelve funding guidelines have been launched to date, and seven more are currently in preparation.

In 2030, the Projection Report shows a net emission source of 36.3 Mt CO_2eq; for 2045, instead of a net sink of -40 Mt CO_2eq, net emissions of 34.9 Mt CO_2eq are projected. This means that the sector would not be able to contribute to offsetting residual emissions, but would instead significantly increase overall emissions.

In 2021, when the LULUCF target was set, the difference between the most recent inventory year (2019) and the target for 2030 was only 8.5 Mt CO_2eq (Figure 2).

Figure 2: Greenhouse gas emissions from the LULUCF sector – comparison of inventories and projections 2021–2025



Source: Greenhouse Gas Inventory 2025 (UBA, 2025a) and Projection Report 2025 (UBA, 2025b)

The following effects have drastically changed the situation since 2021:

Between 2018 and 2022, extensive forest damage due to drought, insect infestations, and storms led to significant emissions. These effects first became visible in the 2025 GHG Inventory, after the data from the fourth National Forest Inventory was integrated. The LULUCF sector has therefore become a net source of emissions of around 69 Mt CO_2eq, with emissions in 2023 being 58.6 Mt CO_2eq higher than in the previous year. Further climate-related disturbances in the future could increase emissions from the sector even more.

The inventories in the LULUCF sector are less comprehensive than in other sectors, as the methodology still needs to be improved to capture the impact of measures. The methods in the GHG Inventories have improved significantly since 2021. Methodological improvements since the 2021 inventory report have increased the calculated emissions by a total of 21.7 Mt CO_2eq, changing the values so that instead of an original net sink of -16.5 Mt CO_2eq, a slight net source was calculated. The EU LULUCF Regulation requires further inventory improvements by 2026. However, in the EU, if inventory methods have been improved and additional emissions are thus accounted for, this can be taken into account when monitoring targets. However, the KSG does not provide for target adjustments in the case of methodological changes, which leads to additional climate action efforts being required. The additional emissions resulting from climate-related disturbances or methodological improvements must be offset by ambitious measures that reduce emissions in the LULUCF sector and increase CO_2 sequestration, which is a major challenge.

1.2 WBNK recommendations for further ANK development

Fundamentally, the Advisory Board emphasises that the ANK makes a decisive contribution to achieving climate targets in the land use sector and that the financial support anchored in the programme is indispensable. In view of increasing extreme weather events and the judicial demand for additional measures in the land use sector, the need for action is greater than ever. The ANK offers innovative solutions that actively involve stakeholders such as landowners and land users. The ANK measures not only protect the climate, but also enhance the adaptability of our ecosystems and make them more resilient to the consequences of climate change. The programme contributes to the conservation of biodiversity and the creation of resilient landscapes that can meet the challenges of the future. To meet the challenges in the land use sector, the ANK programme must be continued, implemented more rapidly than before and, above all, expanded further. In the following fields of action, the Advisory Board has outlined where and how further development can achieve the greatest impact and which changes to the framework conditions are also necessary for successful implementation.

1.2.1 Protection of intact peatlands and rewetting

In quantitative terms, the Advisory Board sees the greatest potential for reducing emissions within the LULUCF sector via intensified rewetting of peatlands. The WBNK recommends a dedicated target for peatland rewetting of around 80 % of the peatland area currently used for agriculture by 2045, if possible with continued value creation through paludiculture or other peat-conserving uses. This would correspond to a rewetted area of around 1 M ha by 2045, or around 50,000 ha yr^{-1} above the current level.

This would allow the high emissions from drained peatlands to be almost entirely avoided and, on part of the area, enable the creation of a new carbon sink.

The 2025 Projection Report assumes significantly smaller areas of peatland rewetting, increasing to a maximum of 490,000 ha by 2050. The UBA's CARESupreme scenario forecasts peatland rewetting of 82.5 % of agricultural land by 2045, which could reduce emissions by 22.9 Mt CO_2eq. With further measures in the peatland area, a reduction of 28.5 Mt CO_2eq could be achieved by 2045, which is in the same order of magnitude as the 30 M calculated by other studies. If the emission reductions resulting from the rewetting of forest areas, peat extraction sites, and unused peatland areas are also included, this results in a total of around 40 Mt CO_2eq of emission reductions per year. The potentially high sink capacity of rewetted areas has not yet been taken into account. Recent research shows that this is especially true for paludiculture on fenland, which can store up to 10 CO_2eq ha^{-1} yr^{-1}, and conversion of arable land to paludiculture up to 52 t CO_2eq ha^{-1} yr^{-1}.

Peatland rewetting is a major social transformation challenge. For centuries, the objective was different: wetlands were drained on a large scale to create agricultural and forestry land, as well as settlement areas. Today, this requires a fundamental change in the assessment and utilisation of these areas, involving all stakeholders.

From an individual economic perspective, rewetting is usually still not worthwhile because neither the avoidance of GHG emissions, carbon sequestration, nor other ecosystem services are sufficiently remunerated. Support programmes are intended to address this, such as the planned ANK funding guideline "Palu", which aims to finance premiums to offset lost income from drained land use and investments in wetland management. The "Palu" funding guideline should be published and implemented promptly, in consultation with the potential beneficiaries, in particular the federal states and agricultural stakeholders,

and taking into account the recommendations made in this report. In addition, it is also necessary to promote the development of new value chains, particularly for the utilisation of biomass from paludiculture, in order to create market incentives for rewetting. This urgently requires the accelerated growth of rewetted areas so as to not slow down the interest in paludiculture biomass that already exists in the market.

At the same time, the German Government should advocate the gradual discontinuation of subsidies for drained agriculture on peat soils under the Common Agricultural Policy (CAP), where rewetting options exist for agricultural businesses.

Rewetting measures should be developed and implemented in dialogue with those affected and should initially rely heavily on voluntary participation and positive incentives as well as land consolidation procedures. In the long term, however, a purely voluntary approach will not always be feasible in practice. At present, however, it should be noted that effective incentives for rewetting do not yet exist on the ground.

Planning and approval regulations need to be readjusted to speed up rewetting initiatives. This includes legal recognition of peatland climate protection as an overriding public interest, the simplification of authorisation procedures, and the resolution of conflicting objectives. The institutions and authorities involved in the preparation and implementation of rewetting must be strengthened in terms of personnel and funding, and new formats for capacity building should be developed to efficiently utilise the existing experience in peatland rewetting in Germany.

Finally, peatland research must be supported and the preservation of long-term research infrastructures must be ensured in order to answer key questions on peat formation, carbon sinks, biodiversity, water availability, and land-use impacts. It is also strongly advisable and necessary to continue the Thünen Institute's peatland monitoring programme.

Taken together, these measures can help Germany to achieve the necessary pace in reducing peatland emissions after a period of largely stagnating progress – provided there is political courage, increased personnel capacity, strong cooperation, and consistent implementation. Otherwise, the scale of the solutions on offer and the size of the challenges will increasingly diverge.

1.2.2 Forest ecosystems

Forest ecosystems are also indispensable for nature-based climate action and for achieving the LULUCF target. Key measures for climate adaptation include promoting conversion to highly resistant and resilient deciduous and mixed forests, in particular the conversion of pure conifer stands into structurally diverse mixed stands. Natural forest development should take place where possible – active management where necessary. The ANK's current funding policy, such as the "Climate-Adapted Forest Management" (KWM) programme, aims to support forest owners in developing future-proof forests. These programmes are in high demand and an increase in funding and better planning security for forest owners is recommended. The conversion of spruce forests on high-risk sites should be prioritised.

CO_2 sequestration can be increased, in particular, through financial incentives for extensification of management in broadleaf forest stands. In future, extensification measures should focus more strongly on old beech stands on low-risk sites. These have a high growth rate and are therefore particularly suitable for carbon sequestration through extensification. By extending extensification in old beech stands on federal land to all areas in public forests through federal-state agreements and funding from local authorities, more than 110,000 ha of beech forests over 140 years old could be taken out of use. In the ANK, this is currently only planned for an area of 1,000 ha by 2040. This could lead to an additional annual sequestration capacity

of around 2 Mt CO_2eq. Additional ANK measures could further increase CO_2 sequestration. For example, the long-term suspension of management in deciduous and mixed forest stands where biomass has been greatly reduced, or reducing the harvested proportion of growth in broadleaved and mixed forests over a ten-year period.

According to the 2025 Projection Report, the funding guidelines "Climate-Adapted Forest Management" (KWM) and "Climate-Adapted Forest Management Plus" (KWMPlus) and the extensification measures they contained have so far only had a minor effect on additional CO_2 sequestration. In the UBA's CARESupreme scenario, however, it is projected that these funding programmes could lead to further extensification and correspondingly lower timber extraction, resulting in up to 33 Mt CO_2eq being sequestered in 2045. Both scenarios represent the range of possible outcomes depending on the level of ambition and implementation of the extensification activities.

Extensification reduces the amount of timber harvested. Existing laws, regulations, and support measures, in particular the Federal Funding for Efficient Buildings (BEG), incentivise the burning of fresh wood as an energy source, which runs counter to the objective of extensification and higher carbon sequestration in forests. Therefore, these incentives to burn fresh wood should be phased out and greater emphasis should be placed on material recycling of wood and its use in durable wood products.

Compensation for soil protection in forests would additionally sequester CO_2 in forest soils. Examples of such funding measures would be support for cable logging systems, horse logging, and innovative, soil-friendly extraction methods in sensitive areas, as well as maintaining ground cover after storm or pest damage.

Afforestation also clearly creates additional carbon sinks, but it must be carried out carefully with regard to site selection and should focus on making small forest stands more robust. Remuneration for soil protection measures in forests is also recommended. It is advised that a Forest Future Commission be set up, in which all relevant stakeholders at the various administrative and social levels engage in dialogue to agree on strategic goals for national forest development. Such a commission should, in particular, address potential conflicts between enhancing the forest's carbon sequestration, increasing timber use and promoting material applications of wood, protecting biodiversity, and the impending threats to forest health and productivity posed by climate change.

Based on the findings of the Forest Future Commission, the revision of the Federal Forest Act should be revisited. This would harmonise forest policy between the Federal and State Governments and define urgently needed guidelines for forestry practice at a uniform national level, regardless of the type of ownership.

An amendment to the Federal Soil Protection Act (BBodSchG) is also supported, as recommended by the Soil Protection Commission (KBU) 2025 at the UBA. In the forestry sector, key issues include maintaining the functions and carbon storage of forest soils, as well as the prevention of compaction, depletion, and nutrient loss.

Energy use (incineration) is envisaged as the final stage of the promoted cascade use (after material recycling). Emissions could be permanently avoided by landfilling waste wood under conditions that prevent biomass decomposition in the long term.

In addition to measures in the forest, support measures in the wood processing and wood industry are also necessary to develop innovative methods for new areas of application and wood products, enabling sustainable material utilisation of wood.

Applied forest, climate, and wood research, together with comprehensive monitoring provide a crucial knowledge base for assessing the effectiveness and success of the measures described above. It is therefore strongly recommended that funding opportunities be created for these research areas, or that funding mechanisms such as the Forest Climate Fund be re-established, or comparable options created.

The aforementioned measures can help ensure that forests are better adapted to climate change in the future and can once again make a greater contribution to CO_2 sequestration. However, this requires prompt and swift implementation of the measures. Otherwise, the window of opportunity to (re)develop forests and subsequent wood utilisation as a sustainable CO_2 sink will close in the near future.

1.2.3 Mineral soils under arable land and grassland

1.2.3.1 Arable land

Mineral soils used in agriculture can make a significant contribution to climate action by retaining and accumulating humus. However, only long-term carbon sequestration in soil humus or wood stocks has an impact on climate change. Significant increases in carbon input are required to enable humus build-up and compensate for carbon losses. Promising, humus-building cultivation practices that both fulfil the requirements for Nature-based solutions and have a low risk of carbon leakage are:

- Catch crop cultivation (1.17 t CO_2eq ha^{-1} yr^{-1} in the soil)
- Improved crop rotation with legumes (0.58 t CO_2eq ha^{-1} yr^{-1} in the soil)
- Introduction of organic farming (0.99 t CO_2eq ha^{-1} yr^{-1} in the soil)
- Conversion of arable land to grassland (2.67 t CO_2eq ha^{-1} yr^{-1} in the soil; low uncertainty regarding permanence)
- Agroforestry systems (0.38 t CO_2eq ha^{-1} yr^{-1} in the soil; 1.5 t CO_2eq ha^{-1} yr^{-1} in total including above-ground biomass over a period of around 20-30 years; low uncertainty regarding permanence)

Agroforestry systems make an important contribution to climate action as a carbon sink. The average GHG sink capacity is 1.5 t CO_2eq ha^{-1} of agroforestry system and 10 t CO_2eq ha^{-1} of woodland yr^{-1} over a period of 20-30 years. 2.5 Mt CO_2eq could therefore be stored on 10 % of Germany's agricultural land under agroforestry. At the end of 2024, the area under agroforestry systems was 1990 to 2200 ha, accounting for less than 0.015 % of available agricultural land.

In the Projection Report, measures to maintain and build up humus in arable land are generally not currently depicted on the basis of existing methods. This means that the effect of ANK measures aimed at increasing carbon storage in mineral soils is not included in the Projection Report. In the UBA's CARESupreme scenario, a maximum additional agroforestry area of around 1 M ha is assumed, which leads to an additional sequestration of 11 Mt CO_2eq in 2045.

As an instrument for the establishment of agroforestry systems, a new funding guideline in the ANK is recommended for additional funds, independent of the CAP, to promote the transition to more climate-resilient arable management in conjunction with "arable" agroforestry. According to current data, this harbours the greatest potential in nature-based climate action on mineral soils. A funding guideline for strip-cropping systems, undersowing and living mulch systems, and catch crops should also be drawn up as a low-threshold introduction to climate-resilient cultivation systems.

Agroforestry systems are also more resistant to extreme weather events (wind and water erosion are reduced), improve the connectivity of fragmented habitats, and increase the abundance of pollinating insects. Wider adoption of agroforestry is hindered by legal frameworks, inadequate financing and subsidy conditions, as well as a lack of knowledge and uncertainties regarding economic viability and practical implementation. Comprehensive measures for knowledge transfer, participation in real-world laboratories, and further training measures for authorities and stakeholders are required to increase acceptance. Knowledge of agroforestry should be integrated into agricultural education. Agroforestry systems on arable land and grassland should be recognised as production-integrated compensation areas.

1.2.3.2 Grassland

Permanent grassland has a high below-ground carbon storage capacity and, due to its multifunctionality, is of particular importance for food security, nature-based climate action, and biodiversity. Depending on site conditions and management, measures that promote deeper rooting are advantageous, as the carbon input is deeper and more persistent. Nitrogen-fixing legumes play an important role in this regard.

Despite the importance of grassland for carbon storage and biodiversity promotion, there are no specific measures for grassland in the ANK. Further research in a real-life laboratory settings is recommended to examine different management practices and intensities of use, as well as their relationship to carbon storage. Accompanying research activities provide an important basis for identifying management practices to be supported, including in connection with silvopastoral agroforestry. The resulting findings could then form the basis for improved support of managed grassland within the ANK.

1.2.4 Settlement and transport areas

Settlement and transport areas contribute significantly to emissions in the LULUCF sector. This is partly due to the persistently high rate of land take in Germany, which continues to occur largely at the expense of agricultural land. The German Government's goal is to reduce land take to less than 30 ha day^{-1} by 2030 and to achieve a circular land-use economy (net zero land take) by 2045. Although land take has been halved in the last 25 years (from 129 ha day^{-1} to 52 ha day^{-1}), it remains high, particularly in residential, industrial, and commercial construction. Land-saving should be positioned as an important political issue, misaligned incentives eliminated, and communication strengthened.

In addition to land take, the accounting of GHG emissions is a major challenge. Current GHG accounting methodology does not reflect the positive influence of urban green spaces (e.g., through greening or de-sealing) and ANK measures in urban areas on net emissions. This weakens the argument in favour of this ANK field of action. The methodology for recording settlement areas in the GHG balance must therefore be improved to differentiate between unsealed areas, green spaces, and tree stocks. De-sealing and the extent of unsealed/greened areas should be recorded in land monitoring by the Federal Statistical Office. Positive efforts by local authorities should be made visible in Germany’s GHG accounting, and incentives for integration of Nature-based Solutions into spatial development should be increased.

The high demand for the funding programmes that have been launched demonstrates the needs of local authorities. However, in view of the more than 10,000 municipalities and the considerable investment requirements, the current ANK funding volume is far from sufficient to achieve the climate action targets for settlement and transport areas. A considerable financial increase in existing programmes for urban greening

and de-sealing is necessary to meet the high demand. Their integration into municipal development strategies and other funding programmes should be considered (e.g., urban development funding).

Overall, nature-based climate action in settlement areas must be strengthened through a combination of financial support, adjustment of the legal framework, improved accounting, and active involvement of the population. The legal framework conditions include an amendment to the Federal Building Code, which could provide important incentives for nature-based climate action, in particular the development of green spaces. Urban land-use planning should also take into account the requirements of the EU Nature Restoration Regulation (NRR).

1.2.5 Seas and coasts

As with settlement areas, GHG emissions and sequestration by coastal and marine ecosystems have not yet been recorded in the National GHG Inventory, with the exception of inland coastal peatlands.

Marine and coastal ecosystems remove carbon from the atmosphere and store it in their biomass and in the seabed.

Comparative research indicates that the carbon storage capacity of marine ecosystems per unit area is higher than that of terrestrial ecosystems, especially in undisturbed locations.

Coastal ecosystems such as reefs, salt meadows, and mudflats offer protection from extreme events such as floods and storms and are rich in biodiversity.

Important ecosystems for carbon storage are:

- Salt and brackish marshes, which cover 400 km² on the German coasts. The organic carbon in their sediments varies greatly between 122 and 217 t C ha^{-1} in the North Sea and 18 to 886 t C ha^{-1} in the Baltic Sea. Annual sequestration in these areas on the North Sea is estimated at up to 5.5 t CO_2eq ha^{-1} yr^{-1}; no data is yet available for the Baltic Sea. Further expansion in line with the 30 % restoration target could unlock considerable additional storage potential.
- Eelgrass meadows act as sediment traps and stabilise the seabed. Their carbon sequestration capacity is highly dependent on location, density, and condition. They currently cover around 46,000 ha. Recent studies estimate the annual carbon storage capacity at 0.88 t CO_2eq ha^{-1} yr^{-1} in the North Sea and 1.43 t CO_2eq ha^{-1} yr^{-1} in the Baltic Sea. Expansion potential is estimated to be high, with a 50 % increase in area by 2045.
- Mudflats and subtidal sediments in the German Wadden Sea cover around 28,000 ha and, depending on their mineral composition, can store relatively large amounts of carbon (up to 100 t C ha^{-1}). For large-scale carbon sequestration, however, marine sediments in the North and Baltic Seas are most relevant. These could probably store between 0.81 and 1.75 CO_2eq ha^{-1} yr^{-1}. If disturbances were reduced (e.g., from bottom trawling), even a 10 % increase in protected area could allow the additional storage of several million t CO_2eq within a few years.
- Kelp forests and macroalgae have particularly high carbon stocks (up to 3.7 t C ha^{-1}) due to their high growth rate. However, they currently only cover around 1000 ha in the North Sea. Reintroduction would entail considerable prerequisites, such as the application of hard substrate. In addition, the existing biomass would have to be harvested and stabilized in the long term in order to utilise the storage potential of 13.57 t CO_2eq ha^{-1} yr^{-1}.

- Biogenic reefs (mussel beds and oyster reefs), which cover around 2300 ha in the North Sea, also have potentially high importance for nature-based climate action, as they can rapidly sequester large amounts of carbon. Achieving the 30 % restoration target could enable biogenic reefs to contribute significantly to carbon sequestration.

Marine sediments are therefore important stores of organic carbon, whereas reefs, kelp forests, and coastal vegetation have a lower potential. To make better use of the potential of these sinks, new measures need to be tested for sediment stabilisation, the reintroduction of eelgrass meadows, macroalgae and European oyster reefs, and the promotion of multifunctional aquaculture. Interdisciplinary model regions are needed to test complex measures such as controlled flooding and managed realignment to adapt to sea level rise. There is an urgent need to define specific targets for expansion areas by 2030 and 2045.

Standardisation of measurement methods (e.g., for carbon inventories and GHG balances) is a basic prerequisite for ensuring comparability and transferability of data. Systematic monitoring networks should be established along the German coasts and the responsibilities in departmental research for monitoring and reporting on carbon management and nature-based climate action should be clarified.

Fragmentation of responsibilities and a lack of coordination between different administrative levels make the success of comprehensive nature conservation measures on the coast more difficult. A strong focus on integrative governance structures could improve communication and coordination, for example through a marine conservation officer and the establishment of regular stakeholder workshops. International cooperation, particularly within the European research area, is essential for sharing experience and developing common standards.

1.2.6 Natural water bodies and floodplains

Natural floodplain landscapes offer a wide range of ecosystem services for climate action, biodiversity, and landscape water balance. Floodplains are centres of biodiversity because their flooding dynamics create a mosaic of aquatic, amphibian, and terrestrial habitats. Recent (hydrologically connected) floodplains generally store more carbon than old (disconnected) floodplains. The carbon stock in mineral soils of recent floodplains is 50 % to 100 % higher than that of old floodplains used for arable cultivation or other terrestrial ecosystems. Hardwood floodplain forests can accumulate carbon stocks of up to 200 t ha^{-1} in the soil and up to 300 t ha^{-1} in the above-ground woody biomass. Floodplains enhance flood retention, groundwater recharge, and the replenishment of watercourses during dry periods, thereby mitigating hydrological droughts.

In water bodies and their floodplains, anthropogenic use increases organic pollution, reduces self-purification processes, increases eutrophication, and promotes the accumulation of organic material in sediments, leading to oxygen depletion. This, in turn, drives the release of GHGs, especially methane. Rising water temperatures and increasing periods of drought due to climate change exacerbate the release of methane and the drying out of wet sites, which can release the stored carbon stocks.

Reconnection and revitalisation of floodplains: reactivating hydrological dynamics and reconnecting floodplains to watercourses are central to increasing GHG storage potential, maintaining biodiversity, and mitigating both droughts and floods.

Options for further development of the ANK include:

- Floodplain reconnection and revitalisation, including set-back dykes, opening of dykes, and reconnection of oxbow lakes. This potential is assessed as moderate to high for CO_2 and CH_4, and moderate for N_2O.
- Restoration of watercourses: a natural river course (meanders, islands, banks) promotes primary production (e.g., algae), which binds CO_2, and produces oxygen. Improved longitudinal connectivity (e.g., removal of transverse structures) can reduce methane emissions. The potential for GHG retention is assessed as moderate to high.
- Change in land use: conversion of arable land into floodplains, grassland, or forest (especially riparian forest) is essential. This increases carbon storage in soil and vegetation by 50 % to 100 % compared to old floodplains used for arable farming. It also reduces soil erosion as well as nutrient and pollutant inputs into water bodies and enhances the potential for floodplain-typical biodiversity.

Overall, there is a strong need for instruments for land acquisition and financial incentives. The NRR contains binding requirements for the restoration of habitat types and river kilometres and offers great synergy potential with the EU Water Framework Directive (WFD) and the objectives of the ANK.

Improved, systematic monitoring and accompanying scientific research on GHG balances in floodplains and inland waters is essential for the selection of effective measures, as the exact quantification of GHG reduction effects is complex.

1.2.7 Wilderness and protected areas

Protected areas are fundamental instruments for conserving biodiversity and ecosystem services, and they make a significant contribution to climate and flood protection. The existing network of protected areas in Germany has considerable deficits, particularly regarding connectivity, area size, management intensity, and monitoring, which often prevents the conservation objectives from being achieved. Although biodiversity is higher inside protected areas than outside them, there are also significant declines, particularly at the population level. Over 60 % of natural habitat types in Germany are in an unfavourable or poor condition, especially peatlands, floodplain landscapes, and wet meadows. The loss of biodiversity is mainly caused by fragmentation, intensification of agriculture, land sealing, and climate change.

Protected areas must not be designed in isolation but should be networked and integrated into the wider landscape, while being protected from further fragmentation. Quality standards and objectives must be defined and further developed for them to promote both nature conservation and climate action at regional, national, and international levels.

For a long time, climate change has only played a minor role in the management of protected areas, which may have significantly increased their vulnerability. A central deficit of previous protected area policy is the fragmentation of responsibilities. The ANK offers the opportunity to establish an overarching governance architecture.

A key finding is that conflicts of objectives between biodiversity and climate protection can be largely resolved by supporting synergies through careful planning of measures. For example, the near-natural development of a floodplain forest provides flood protection and the promotion of biodiversity, as well as carbon sequestration.

Important measures to be promoted in the protected areas sector are:

- Expansion, networking, and multifunctionality to achieve the target of 30 % global protected area coverage by 2030, both on land and in the sea; in addition to area size, their physical connectivity within functional habitat networks is also crucial.
- Establishment of management networks at the landscape level with a coherent strategy portfolio to improve climate change resilience and effectiveness in nature-based climate action
- Systematic integration of climate change and climate action into protected area management (including strengthening relevant capacities in protected area administrations and inclusion of smaller protected areas outside of large protected areas)
- Spatial planning requirements, in particular:
    a. Integration into municipal land use and landscape plans
    b. Prioritisation of areas with restoration potential
    c. Consideration of climatic effect corridors (e.g., cold air channels, water retention)
    d. Combination with ecological infrastructure measures (e.g., field margin strips, riparian buffers, meadow orchards)
- Success monitoring, applied learning and research, including the establishment of living labs for better integration of nature conservation and nature-based climate action as well as adaptive, climate change-resilient management (if appropriate, targeted promotion of existing biosphere reserves to take on this role).

1.2.8 Overarching recommendations for improved framework conditions for implementation

The interests of nature-based climate action should be taken into account within the framework of sectoral spatial plans, such as forestry framework planning or water law planning, as well as in overall spatial planning (urban land-use planning, regional planning, landscape planning). Due to the urgency of nature-based climate action, these interests should also be given greater weighting in the planning process (as an overriding public interest).

It should be ensured that an appropriate legal procedure is available (especially for rewetting projects) that meets all necessary requirements, has an integrated approval procedure, and is organised in such a way that the necessary official expertise is brought together and that a central contact person is identified.

The identification of the most suitable areas for Nature-based Solutions purposes could be prepared through landscape planning or another type of sectoral planning, in particular through water management planning under water law or the new restoration planning required under the EU NRR, which, by virtue of its legal mandate, already pursues climate action objectives in an integrated manner (Article 1(1)(b) NRR). Significant synergies with the ANK can be expected here with appropriate strategic implementation. If the "acceleration areas" approach is also to be applied to nature-based climate action, the use of spatial planning instruments is recommended for spatially significant rewetting and other large-scale restoration measures.

1.2.9 Funding policy

The ANK consciously sees itself as a learning programme that is constantly improving. This is an ambitious goal and highly commendable. The following recommendations are intended to further reinforce this approach:

- Greater willingness to experiment and less bureaucratic funding programmes. Examples to follow are funding programmes in Germany and the EU, which are already administered in a simplified manner (e.g., individual EU funding measures) or for which simplification is planned.
- Introduction of an incentive system as an encouragement for project partners to ensure fast and unbureaucratic processing of funding applications. This may require a corresponding adjustment of contractual clauses in contracts between the BMUKN and project organisers such as ZUG and KfW.
- Establishment of a committee of experienced experts from project partners and funding recipients with the aim of permanently simplifying ANK funding procedures and making ongoing minor adjustments.
- Proactive support for municipalities under financial administration that are unlikely to participate in the ANK calls for proposals. The aim is to familiarise these municipalities in Germany with the ANK funding framework and to support them through appropriate measures.
- Establishment of small but flexible institutional experience centres, for example, to be able to quickly disseminate the exchange and best possible dissemination of good project practice and, last but not least, to support project partners. This has already been partially established through the creation of the KlimaWildnisZentrale (ClimateWildernessCentre) as a pilot project within a specific funding focus. That said, this approach would be advisable for peatland protection, which is of particular importance within the ANK, as well as in other funding areas.

1.3 Proposals for improving the monitoring and emissions calculation

ANK fields of action that are not currently included in the National GHG Inventory should be incorporated, and both emissions and carbon sequestration should be calculated.

Peatlands / organic soils: Emissions calculation has been improved using dynamic water table maps, but the modelling is still generalised. The inclusion of rewetted areas poses a challenge, but is very important and necessary. Regional datasets and land-use specific algorithms should be developed (including paludiculture). The MoMoK peatland monitoring programme is the basis for reporting and should be financially secured on a permanent basis. Success monitoring should be conducted at the level of peatland regions, with region-specific modelling, in order to obtain precise assessments of measures and their impacts.

Natural water bodies and floodplains: Floodplains are only included in the GHG Inventory as part of forests and grassland. For better planning of measures, emissions should be quantified separately and floodplain forests should be reported separately. This requires detailed data on soil types, habitats, and hydrological dynamics. Comprehensive monitoring and open databases are important in order to assess the impact of measures.

Seas and coasts: There are no reliable data on GHG fluxes from salt meadows, eelgrass meadows, and fine sediments. The methods are not yet standardised and monitoring networks are lacking. The IPCC published calculation methods in 2013, the application of which is voluntary. Systematic monitoring is necessary to create reliable inventories.

Forest: National forest monitoring should be supplemented by a remote sensing-based system to better record changes in forest condition and performance. Annual monitoring of damage events and measures, such as with remote sensing data, is important. Improved modelling, including climate-sensitive growth models, helps to evaluate the impact of measures and better predict future developments.

Mineral soils: Emissions calculation for arable land and grassland was introduced in the 2025 report. Future improvements should include regional management data and dynamic modelling to better reflect the impact of measures. These should also be integrated into the Projection Report.

Settlement areas: GHG emissions and sequestration in urban areas are not yet considered, for example through recording green space, greening measures, and de-sealing in inventory reporting. Unsealed areas, green spaces, and trees should be better recorded. There is also a lack of data on de-sealing potential and its contribution to natural carbon sequestration. An organisation to handle tasks or targeted research projects could bring improvements. Above all, however, there is a lack of specific overviews of expansion areas and restoration targets.

Projection Report: The report does not currently cover all fields of action and measures of the ANK, which limits projection of the effectiveness of the measures. A review and adjustment of the assumed area potentials against the background of the recommendations of the Advisory Board in the fields of action is recommended, as well as a sensitivity analysis of measures implemented to varying degrees.

1.4 Research requirements

The research requirements are summarised here and divided into different categories for all chapters, with different priorities depending on the subject area. In addition, overarching research topics are outlined that cannot be addressed within the scope of the individual chapters.

1.4.1 Measurement and modelling

Certain land uses and ecosystems have so far been underrepresented in the datasets and need to be analysed more closely with regard to the GHG balance. These include forests on moorland, paludiculture, near-natural and restored peatland areas, floodplain ecosystems, and coastal ecosystems (such as kelp forests, eelgrass meadows, and salt meadows), as well as green spaces in urban areas. Another remaining important research task is the validation of allometric carbon balance models with survey data and permanent observation plots for mineral soils, as well as the integration of remote sensing indicators (e.g., for forests) with survey data for better temporal resolution and more up-to-date information. Equally important is the financial securing and expansion of existing long-term measurement programmes that provide important data for GHG accounting. Research into the effects of climate change on emissions and the carbon sequestration capacity of various ecosystems should also be expanded.

1.4.2 Monitoring the impact of measures

Another important research area is the improved measurement of the effects of measures in the field of nature-based climate action on emissions reduction or carbon sequestration, in terms of the speed, magnitude, and permanence of these effects. Many examples of specific research needs are given in the fields of action.

1.4.3 Synergies with other ecosystem functions

The WBNK also identifies research needs to clarify open questions regarding the synergistic effects between nature-based climate action, climate adaptation, and biodiversity. Relevant questions would be, for example: What contribution can rewetted peatlands make to stabilising the landscape water balance? How pronounced is the interaction between biodiversity and carbon storage in grassland? Can systematic demonstration of the synergy between biodiversity and CO_2 sequestration be achieved through targeted protected area management? In which systems do climate mitigation measures also serve climate adaptation, and how can these effects be determined and scaled?

1.4.4 System boundaries, overall impact of measures and value chains

ANK funding generally targets site-specific measures. However, there is insufficient knowledge about the overall impact of measures across connected areas, as well as about their impacts across system boundaries. Methodologies need to be researched and developed to better integrate Nature-based Solutions into spatial planning.

A number of research and implementation projects have significantly increased knowledge on the development of new value chains in paludiculture. Nevertheless, there is an urgent need to close the remaining knowledge gaps (establishment, cultivar development, harvesting, end products, harvesting technology, etc.) and to establish region-specific networks to secure both the supply and demand of biomass. In the case of climate-adapted forest conversion, existing value chains are also changing due to other types of wood that may be available in sufficient quantities in the future, which should be supported by research on the wood utilisation side.

Inter- and transdisciplinary approaches to analysing the effects of Nature-based Solutions in the landscape on (a-)biotic resources, food security, economic feasibility, and social acceptance should be further developed to identify conflicts and enable synergies. Optimising the landscape for climate change mitigation while balancing it with other demands is a multidimensional process that has not yet been systematically studied. One possible approach could be the development of region-specific scenarios that are developed with intensive stakeholder participation.

1.5 Promoting sustainable biomass use and reducing land-use competition

Sustainable and long-term success of the ANK measures also requires sustainable biomass use, contributing to a reduction in land use competition. In terms of human nutrition, this primarily involves a significant reduction in per capita consumption of land-intensive animal products. Proposals for a healthier and more sustainable diet with a significantly lower proportion of animal products have been made, for example, by the German Nutrition Society (DGE) and the EAT-Lancet Commission. The reduction of food waste and food losses along the entire value chain is also important. Extensive proposals for policy measures to promote more sustainable diets in Germany were, for example, put forward by the Scientific Advisory Board on Agricultural Policy and Food in 2020, but so far only a small part has been implemented.

In the bioeconomy, the material use of biomass should be prioritised, particularly in the form of cascade use, and the use of cultivated biomass for energy production should be reduced, partly because other sources of renewable energy generally offer more sustainable alternatives for energy generation.

A reduction in land use competition made possible by sustainable consumption will therefore create additional scope in future to use land for biodiversity conservation and nature-based climate action.

References

UBA. (2025a). Submission under the United Nations Framework Convention 2025. [National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2023]. https://www.umweltbundesamt.de/publikationen/submission-under-the-united-nations-framework-10

UBA. (2025b). Treibhausgas-Projektionen 2025 für Deutschland (Projektionsbericht 2025) (p. 334). German Environment Agency (UBA). https://doi.org/10.60810/OPENUMWELT-7906