CLIMATE CHANGE
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Interim report

Funding climate-friendly soil management: Risks and key issues

Key issues to be considered in the design of funding instruments

by:

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Abstract: Funding climate-friendly soil management: Key issues to be considered in the design of instruments

This report summarises key aspects that should be accounted for in the design of policy instruments to support the implementation of climate-friendly soil management measures. It outlines overarching aspects that need to be considered for any type of policy instruments, including land use competition, impacts on soil health, biodiversity impacts, ownership and rights to use of soils and social impacts. Furthermore, aspects that are relevant for all types of results-based funding schemes are elaborated upon, including additionality, determining the SOC content of soils, determining baselines avoiding carbon leakage, addressing non-permanence, jurisdictional vs. project-based approaches and ex-ante vs. ex-post crediting. Particular risks exist for transfer-based mechanisms which are a subset of result-based payment approaches. These challenges must be considered and addressed for policy instruments to deliver robust mitigation through soil carbon.

Kurzbeschreibung: Finanzierung für klimafreundliche Bodennutzung: Zentrale Aspekte bei der Ausgestaltung von Finanzierungsmechanismen

Dieser Bericht fasst die wichtigsten Aspekte zusammen, die bei der Gestaltung von politischen Instrumenten zur Unterstützung der Umsetzung klimafreundlicher Bodenbewirtschaftungsmaßnahmen berücksichtigt werden sollten. Er skizziert übergreifende Aspekte, die bei jeder Art von politischen Instrumenten berücksichtigt werden müssen, darunter die Konkurrenz um Landnutzung, Auswirkungen von Maßnahmen auf die Bodengesundheit, Auswirkungen auf die biologische Vielfalt, Eigentum und Nutzungsrechte an Böden sowie soziale Auswirkungen. Darüber hinaus werden Aspekte behandelt, die für alle Arten von ergebnisbasierten Finanzierungssystemen relevant sind, darunter die Sicherstellung von Zusätzlichkeit der Minderungsaktivitäten, die Bestimmung des SOC-Gehalts von Böden, die Festlegung von Baselines zur Vermeidung von Kohlenstoffverlagerungen, die Behandlung von Nicht-Dauerhaftigkeit, Vor- und Nachteile von juristischen vs. projektbasierten Ansätzen und von Ex-ante- vs. Ex-post-Zertifizierung. Besondere Risiken bestehen bei transferbasierten Mechanismen, die eine Untergruppe der ergebnisbasierten Zahlungsansätze sind. Diese Herausforderungen müssen berücksichtigt und adressiert werden, damit die politischen Instrumente robusten Klimaschutz durch die Umsetzung von Maßnahmen zur klimafreundlichen Bodennutzung bewirken können.

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C	Carbon
CAP	Common Agricultural Policy
CCBS	Climate, Community and Biodiversity Standards
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
ERU	Emission Reduction Unit
ETS	Emissions Trading System
EU	European Union
FAO	Food and Agriculture Organisation
FCPF	Forest Carbon Partnership Facility
GAEC	Standards on good agricultural and environmental conditions of land
GHG	Greenhouse gas
Gt	Gigatonne
ha	Hectar
HWPs	Harvested Wood Products
ILUC	Indirect land use change

IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MRV	Monitoring, Reporting and Verification
Mt	Megatonne
$MtCO_2e$	Megatonne Carbon Dioxide Equivalents
N	Nitrogen
NDC	Nationally Determined Contributions
N_2O	Nitrous oxide (laughing gas)
RED II	Revised Renewable Energy Directive
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDGs	Sustainable Development Goals
SOC	Soil organic carbon
t	Tonne
UNFCCC	United Framework Convention on Climate Change
VCS JNR	Verified Carbon Standard Jurisdictional and Nested REDD+

Summary

The land use sector and soils more specifically have a double role as a carbon sink and a source and sink of greenhouse gas (GHG) emissions. On the one hand, soils store significant amounts of carbon and have the potential to increase their sink capacity through enhanced soil organic carbon (SOC) sequestration. On the other hand, soils under agricultural land are also sources of CO_2, CH_4 and N_2O emissions from mineralisation in mineral and organic soils.

Different policy approaches can promote the implementation of climate-friendly soil management measures. These include political initiatives or regulations as well as incentive-based approaches. Incentive-based approaches create economic incentives to implement climate-friendly soil measures. These can be further differentiated into **results-based payment approaches**, which make a payment dependent on the achievement and verification of a mitigation (or other environmental) result, and **action-based approaches/direct payments** where the payment depends on certain actions being taken or practices being avoided and can be made ex ante. **Results-based payment approaches include results-based finance ("contribution claims") as well as offsetting approaches.** Results-based finance implies that a payment is made in accordance with the achievement of a mitigation result. This can be used for offsetting, where the buyer uses the credits for mitigation outcomes as a substitute for within value chain abatement or mitigation activities in their own sphere and counts it towards their own (voluntary) climate target. Alternatively, the result-based finance can take the form of a so-called contribution claim, whereby climate action by others is supported financially without accounting the mitigation outcome towards an own mitigation target. To ensure environmental integrity, payments should not be made ex ante under results-based payment approaches. Both results-based finance as well as action-based payments can be made e.g. in the form of subsidies or tax reliefs.

This report summarises key aspects that should be accounted for in the design of policy instruments to support the implementation of climate-friendly soil management measures. First, overarching aspects are outlined that need to be considered for any type of policy instruments as they can imply negative social or environmental impacts. Secondly, aspects that are relevant for all types of results-based funding schemes are elaborated upon. Particular risks exist for offsetting approaches which are a subset of result-based payment approaches. The factsheets (section 2) did identify some potential approaches for addressing challenges. However, for many issues identified, the approaches are unlikely to totally overcome the challenges, instead aiming to manage the issue.

All of these challenges were identified as **relevant within the EU**. For some topics, existing voluntary carbon market mechanisms active within the EU as well as some existing EU policies such as the Common Agriculture Policy (CAP) and LULUCF Regulation (2018/841) offer examples of how the issues arise within the EU-context or are handled by EU policy. For the design of funding for carbon farming activities within the EU and the planned Carbon Removal Certification Framework, it will be crucial to take the risks discussed in this report into account. Particularly, mitigation results from carbon farming projects should not be used for offsetting purposes in order to preserve environmental integrity.

Characteristics particular to the land-use sector pose **cross-cutting challenges** in the design of funding approaches for carbon friendly soil management. As the site of crop and biomass production and livestock rearing, land (and the soils upon it) is the central node in global food supply, as well as a key site of material and energy production, and the site of human settlements. Land is also finite, meaning that the demand for these multiple outputs results in **competition for land**; any policies aiming to influence land management must consider

competing policy objectives and aim to affect a policy space buffeted by multiple economic drivers. These decisions are further complicated by **complex and variable ownership, tenure, and rights that exist in the land sector**, which can limit the adoption of sustainable soil management and effectiveness of related policies. Besides its direct effects on soil health including soil quality, soil fertility and soil biodiversity, land management also generates significant **externalities, affecting local and distant water quality and availability as well as biodiversity**, among others. Collectively, this means that soil management has significant direct and indirect effects on society and land (and soil) management policies and instruments must be designed and implemented with these broader **environmental and social impacts** in mind. Also, due to land's centrality to numerous policy areas, the effectiveness of soil management policies and instruments to fund these will also be determined in part by other policies and economic drivers relevant for land use.

The use of **results-based payment approaches** to promote climate-friendly soil management faces a number of additional challenges that threaten the effectiveness of the finance to entail mitigation results. A fundamental challenge is posed by the **difficulty and cost of accurately quantifying changes in soil carbon**. This measurement of the mitigation result achieved is crucial for results-based payment approaches, as any uncertainty undermines confidence in the actual mitigation achieved. High costs of modelling, measuring or hybrid approaches to calculate changes in soil carbon further act as a barrier for farmers to voluntarily participate in climate-friendly soil management schemes.

The issue of **additionality** also poses challenges for result-based payment approaches. Mitigation is considered additional if it occurs as a result of the result-based payment incentives. Additionality implies causality; without the results-based incentives, the mitigation would not have occurred. A lack of additionality is a problem for environmental integrity and cost-efficiency reasons.

The related issue of **baselines** poses similar challenges. It is politically difficult to set acceptable benchmarks against which mitigation can be compared. These difficulties are compounded by uncertainties implicit in quantifying soil-carbon stocks and the high variability of participant contexts in the land sector (e.g. in terms of climate, rain, soil type, land management). The impacts of climate change exacerbate the uncertainty related to carbon stored in soils.

Design issues such as **double-counting**, **payment timing, and the geographic scale of results-based approaches (project vs. jurisdictional scale)** also must be carefully considered, as they can have significant impacts on the environmental integrity and costs of result-based mechanisms. For example, the selection of project-scale results-based approaches instead of a jurisdictional scale can increase the risk of leakage. If these changes result in increased emissions or reduced carbon sequestration that is not controlled for, this will offset the mitigation occurring within the result-based mechanism, undermining the mitigation it aims to deliver. These issues of double-counting, payment timing, and leakage are not specific to the land sector but exist for results-based payment instruments in all sectors.

A final key challenge is the risk of **non-permanence of sequestered soil carbon**, as well as carbon stored in biomass e.g. through agroforestry. To meet long-term climate objectives, mitigation must be permanent. However, the permanence of carbon removals can never be guaranteed in perpetuity and carbon stored in soils can be quickly reversed by natural disturbances such as fire or drought or through changes in soil management. Climate change itself will disrupt the land sector's ability to sequester carbon as well.

All of the challenges outlined above need to be considered in the design of funding instruments to promote climate-friendly soil management in order to preserve environmental integrity, i.e.

certainty about the actual, additional, long-term mitigation impact. Some of the challenges are common to all types of funding approaches (section 2.1), as they imply negative social and/or environmental impacts. Other challenges are faced only under result-based payment approaches which generate monetary incentives for climate-friendly soil management by paying implementers for the mitigation result that is achieved (section 2.2). **Particular risks exist for offsetting mechanisms** which are a subset of result-based payment approaches. Under such approaches the buyer intends to offset their own emissions thereby using the credits for mitigation outcomes as a substitute for within value chain emissions abatement or mitigation in their own sphere towards achieving their own (voluntary) mitigation target. Such approaches pose more risks for environmental integrity - that is, uncertainty about the actual, additional, long-term mitigation impact of funding approaches to promote climate-friendly soil management - than other funding approaches. If the actual mitigation outcomes resulting from the use of offsetting mechanisms ends up being less than what is sold to buyers (e.g. due to non-additionality, wrong estimation of SOC levels, inflated baselines, carbon leakage, non-permanence or double counting), then the total amount of greenhouse gases in the atmosphere will be higher than without the trade. Furthermore, the use of these certificates might displace other mitigation efforts. Additionally, using credits for offsetting purposes might substitute rapid and ambitious emissions reductions in other sectors (Seddon et al. 2021; Dooley et al. 2022). The risks for environmental integrity are mitigated to some extent if results-based payments are made in the form of contribution claims where the buyer intents to demonstrate their financial contribution to climate action elsewhere without counting it within their own GHG-balance towards their own mitigation target (see e.g. Warnecke et al. 2015; Fearnehough et al. 2020; Gold Standard 2017).

This means that for offsetting mechanisms, high and conservative standards must be set for all design elements. In particular, strict management of non-permanence, additionality, leakage, and measurement of soil carbon change are essential. Where these high standards cannot be met – which the analysis of existing approaches for dealing with the challenges suggests – then offsetting approaches are inappropriate instruments to pursue climate mitigation through carbon-friendly soil management. In addition to the challenges outlined in this report, crediting soil carbon mitigation activities provide further implementation challenges from a farmer's perspective. Offsetting approaches may therefore not provide the right incentives to farmers to stimulate environmentally necessary changes to agricultural practices.

Therefore, generally, soil management mitigation should not be used to offset other emissions, but instead, other policies and instruments, including action-based payments, should be used to incentivise action in the context of soils.

Zusammenfassung

Der Landnutzungssektor und insbesondere die Böden spielen eine doppelte Rolle als Kohlenstoffsenke und als Quelle und Senke für Treibhausgasemissionen (THG). Einerseits speichern Böden beträchtliche Mengen an Kohlenstoff und haben das Potenzial, ihre Senkenkapazität durch eine Verbesserung der Sequestrierung von organischem Kohlenstoff (SOC) zu erhöhen. Andererseits sind landwirtschaftlich genutzte Böden auch Quellen von CO_2-, CH_4- und N_2O-Emissionen durch Mineralisierung in mineralischen und organischen Böden.

Verschiedene politische Ansätze können die Umsetzung klimafreundlicher Bodenbewirtschaftungsmaßnahmen fördern. Dazu gehören politische Initiativen oder Verordnungen ebenso wie anreizbasierte Ansätze. Anreizbasierte Ansätze schaffen wirtschaftliche Anreize zur Umsetzung klimafreundlicher Bodenmaßnahmen. Diese können weiter unterschieden werden in **ergebnisbasierte Zahlungsansätze („results-based payments")**, die eine Zahlung von der Erreichung und Überprüfung eines Klimaschutzerfolges (oder einer anderen positiven Umweltwirkung) abhängig machen, und **handlungsbasierte Ansätze/Direktzahlungen („action-based payments")**, bei denen die Zahlung von der Durchführung bestimmter Maßnahmen oder der Vermeidung von Praktiken abhängt und ex ante erfolgen kann. **Zu den ergebnisorientierten Zahlungsansätzen gehören die ergebnisorientierte Finanzierung ("contribution claim") sowie die Kompensations- bzw. Offsetting-Ansätze.** Ergebnisorientierte Finanzierung implizieren, dass eine Zahlung bei Erreichen eines Klimaschutzerfolges geleistet wird. Die Zahlung kann als so genannter „contribution claim" deklariert werden, wobei Klimaschutzanstrengungen anderer Akteure finanziell unterstützt werden, ohne dass der zertifizierte Klimaschutzerfolg auf ein eigenes Klimaschutzziel angerecht wird. Bei Offsetting-Ansätzen hingegen verwendet der Käufer die Zertifikate, die für Klimaschutzerfolge ausgegeben werden, als Ersatz für eigene Klimaschutzanstrengungen innerhalb der eigenen Wertschöpfungskette oder des eigenen Wirkungsbereichs und rechnet sie auf sein eigenes (freiwilliges) Klimaschutzziel an. Um die ökologische Integrität zu gewährleisten, sollten Zahlungen im Rahmen ergebnisorientierter Zahlungskonzepte nicht im Voraus geleistet werden. Sowohl ergebnisorientierte Finanzierungen als auch handlungsorientierte Zahlungen können z. B. in Form von Subventionen oder Steuererleichterungen geleistet werden.

Dieser Bericht fasst die wichtigsten Aspekte zusammen, die bei der Gestaltung von politischen Instrumenten zur Unterstützung der Umsetzung klimafreundlicher Bodenbewirtschaftungsmaßnahmen berücksichtigt werden sollten. Zunächst werden übergreifende Aspekte skizziert, die bei jeder Art von politischen Instrumenten berücksichtigt werden müssen, da sie negative soziale oder ökologische Auswirkungen haben können. Zweitens werden Aspekte herausgearbeitet, die für alle Arten von ergebnisorientierten Finanzierungssystemen relevant sind. Besondere Risiken bestehen für Offsetting-Ansätze, die eine Untergruppe der ergebnisbasierten Zahlungsansätze sind. In den Factsheets (Kapitel 2) wurden einige potenzielle Lösungsansätze zur Bewältigung der Herausforderungen aufgezeigt. Bei vielen der identifizierten Probleme ist es jedoch unwahrscheinlich, dass die Lösungsansätze die Herausforderungen vollständig überwinden, sondern sie zielen darauf ab, das Problem zu bewältigen.

Die besonderen Merkmale des Landnutzungssektors stellen **übergreifende Herausforderungen** für die Ausgestaltung von Finanzierungsmechanismen für klimafreundliche Bodennutzung dar. Land (und die darauf befindlichen Böden) ist das zentrale Element der globalen Nahrungsmittelversorgung, und bietet zugleich den Standort für Material- und Energieproduktion sowie für menschliche Siedlungen. Land ist außerdem endlich, was

bedeutet, dass die Nachfrage nach diesen vielfältigen Leistungen zu **Konkurrenz um Land** führt. Jede Politik, die Einfluss auf die Landbewirtschaftung nehmen will, muss konkurrierende politische Ziele sowie verschiedene wirtschaftliche Faktoren berücksichtigen. Diese Entscheidungen werden durch die **komplexen und variablen Eigentumsverhältnisse sowie Regelungen zur Nutzung von und Rechten an Boden** weiter erschwert. Dies kann die Umsetzung einer nachhaltigen Bodenbewirtschaftung und die Wirksamkeit der entsprechenden Maßnahmen einschränken. Neben den direkten Auswirkungen auf die Bodengesundheit inklusive der Bodenfruchtbarkeit, Bodenqualität und Bodenbiodiversität, erzeugt jede Art von Landnutzung auch **externe Effekte, unter anderem auf die lokale und entfernte Wasserqualität und -verfügbarkeit sowie auf die biologische Vielfalt**. Zusammengenommen bedeutet dies, dass die Art und Weise der Bodenbewirtschaftung signifikante direkte und indirekte Auswirkungen auf die Gesellschaft hat und dass die Politiken und Instrumente der Landnutzung und Bodenbewirtschaftung unter Berücksichtigung dieser **breiteren ökologischen und sozialen Auswirkungen** konzipiert und umgesetzt werden müssen. Da der Boden für zahlreiche Politikbereiche von zentraler Bedeutung ist, wird die Wirksamkeit der Bodenbewirtschaftungspolitik und der Instrumente zu ihrer Finanzierung zum Teil auch durch andere politische und wirtschaftliche Faktoren bestimmt.

Für die **Umsetzung ergebnisorientierter Zahlungsansätze** zur Förderung einer klimafreundlichen Bodennutzung ergeben sich eine Reihe zusätzlicher Herausforderungen, die die Wirksamkeit der Finanzierung in Bezug auf den Klimaschutz gefährden. Eine grundlegende Herausforderung besteht darin, dass es **schwierig und kostspielig ist, Veränderungen des Bodenkohlenstoffs genau zu quantifizieren**. Die Messung der erzielten Minderungsergebnisse ist für ergebnisorientierte Zahlungsansätze von entscheidender Bedeutung, da jede Ungewissheit das Vertrauen in die tatsächlich erzielte Minderungsleistung untergräbt. Hohe Kosten für die Modellierung, Messung oder hybride Ansätze zur Berechnung von Veränderungen des stellen ebenfalls eine für Landwirte dar, sich freiwillig an einem Mechanismus zur klimafreundlichen Bodennutzung zu beteiligen.

Die Frage der **Zusätzlichkeit** stellt eine weitere Herausforderung für ergebnisorientierte Zahlungsansätze dar. Eine erzielte Emissionsminderungsleistung wird als zusätzlich betrachtet, wenn sie aufgrund der ergebnisbasierten Zahlungsanreize erfolgt. Zusätzlichkeit impliziert Kausalität; ohne die ergebnisbasierten Anreize wäre die Milderung nicht erfolgt. Ein Mangel an Zusätzlichkeit beeinträchtigt die Umweltintegrität eines Finanzierungsmechanismus und schmälert die Kosteneffizienz.

Damit zusammen hängt die Frage, wie **Baselines** festgelegt werden. Dies stellt eine ähnliche Herausforderung dar. Es ist politisch schwierig, akzeptable Benchmarks festzulegen, mit denen Minderungsergebnisse verglichen werden können. Diese Schwierigkeiten werden durch die Unsicherheiten bei der Quantifizierung der Bodenkohlenstoffvorräte und die hohe Variabilität der Rahmenbedingungen im Landnutzungssektor (z. B. in Bezug auf Klima, Niederschlag, Bodenart, Landnutzung) noch verstärkt. Die Auswirkungen des Klimawandels verschärfen die Ungewissheit in Bezug die Kohlenstoffvorräte in Böden.

Weitere Fragen zur Gestaltung von ergebnisbasierten Finanzierungsmechanismen, wie **Doppelzählung**, der **Zeitpunkt der Zahlungen** und der **geografische Maßstab** der Ansätze (Umsetzung von Maßnahmen auf Projektebene oder auf Ebene eines Rechtssystems über ein größeres geografisches Gebiet) haben ebenfalls erhebliche Auswirkungen auf die Umweltintegrität und die Kosten der Mechanismen haben können. So kann beispielsweise die Wahl von ergebnisbasierten Ansätzen auf Projektebene anstelle von Ansätzen auf Ebene eines größeren Rechtssystems das Risiko von **Leckagen** erhöhen. Wenn diese Änderungen zu erhöhten Emissionen oder einer verringerten Kohlenstoffbindung führen, die nicht kontrolliert werden, wird dies die im Rahmen des ergebnisbasierten Mechanismus stattfindenden Minderungen aufheben. Diese Probleme der Doppelzählung, des Zahlungszeitpunkts und der Verlagerung sind nicht spezifisch für den Landsektor, sondern bestehen für ergebnisbasierte Zahlungsinstrumente in allen Sektoren.

Eine letzte große Herausforderung ist das Risiko, **dass nicht garantiert werden kann, dass der gebundene Bodenkohlenstoff sowie der in Biomasse, z. B. durch Agroforstwirtschaft, gebundene Kohlenstoff dauerhaft gespeichert bleibt**. Um die langfristigen Klimaziele zu erreichen, müssen Minderungsergebnisse dauerhaft sein. Der in den Böden gespeicherte Kohlenstoff kann jedoch durch natürliche Störungen wie Brände oder Dürren oder durch Änderungen in der Bodenbewirtschaftung schnell wieder abgebaut werden. Der Klimawandel selbst wird die Fähigkeit des Landnutzungssektors, Kohlenstoff langfristig zu binden, zusätzlich beeinträchtigen.

Alle oben genannten Herausforderungen müssen bei der Gestaltung von Finanzierungsinstrumenten zur Förderung eines klimafreundlichen Bodenmanagements berücksichtigt werden, um die ökologische Integrität, d. h. die Gewissheit über die tatsächlichen, zusätzlichen, langfristigen Minderungseffekte, zu wahren. Einige der Herausforderungen sind allen Arten von Finanzierungsansätzen gemeinsam (Abschnitt 2.1), da sie negative soziale und/oder ökologische Auswirkungen mit sich bringen. Andere Herausforderungen stellen sich nur bei ergebnisorientierten Zahlungsansätzen, die monetäre Anreize für eine klimafreundliche Bodenbewirtschaftung schaffen, indem sie die Durchführenden für das erzielte Minderungsergebnis bezahlen (Abschnitt 2.2). **Besondere Risiken bestehen für Offsetting-Mechanismen**, die eine Untergruppe ergebnisbasierter Zahlungsansätze sind. Bei solchen Ansätzen beabsichtigt der Käufer, seine eigenen Emissionen auszugleichen und die erworbenen Emissionsreduktionszertifikate als Ersatz für die Emissionsminderung innerhalb der eigenen Wertschöpfungskette zu verwenden, um sein eigenes (freiwilliges) Minderungsziel zu erreichen. Solche Ansätze bergen höhere Risiken für die Umweltintegrität als andere Finanzierungsansätze. Wenn die tatsächlichen Minderungsergebnisse, die sich aus der Nutzung von Offsetting-Mechanismen ergeben, am Ende geringer sind als das, was an die Käufer verkauft wird (z. B. aufgrund von mangelnder Zusätzlichkeit, falscher Schätzung der SOC-Werte, überhöhten Basiswerten, Verlagerung von Kohlenstoff, Nicht-Dauerhaftigkeit oder Doppelzählung), dann wird die Gesamtmenge der Treibhausgase in der Atmosphäre höher sein als ohne den Handel. Darüber hinaus könnte die Verwendung dieser Zertifikate andere Anstrengungen zur Emissionsminderung verdrängen. Darüber hinaus könnte die Verwendung von Emissionsgutschriften für Kompensationszwecke rasche und ehrgeizige Emissionssenkungen in anderen Sektoren ersetzen (Seddon et al. 2021; Dooley et al. 2022). Die Risiken für die Umweltintegrität werden teilweise gemildert, wenn ergebnisbezogene Zahlungen in Form von „contribution claims“ erfolgen, bei denen der Käufer beabsichtigt, einen finanziellen Beitrag zu Klimaschutzmaßnahmen an anderer Stelle zu leisten, ohne ihn auf seine eigene THG-Bilanz im Hinblick auf sein eigenes Minderungsziel anzurechnen (siehe z. B. Warnecke et al. 2015; Fearnehough et al. 2020; Gold Standard 2017).

Dies bedeutet, dass für Kompensationsmechanismen hohe und konservative Standards für alle Gestaltungselemente gesetzt werden müssen. Insbesondere sind ein striktes Management der Nicht-Dauerhaftigkeit, der Zusätzlichkeit, der Verlagerung und der Messung der Kohlenstoffveränderung im Boden unerlässlich. Wenn diese hohen Standards nicht erfüllt werden können – was die Analyse der bestehenden Ansätze zur Bewältigung der Herausforderungen nahelegt –, dann sind Offsetting-Ansätze ungeeignete Instrumente für den Klimaschutz durch klimafreundliches Bodenmanagement. Zusätzlich zu den in diesem Bericht beschriebenen Herausforderungen birgt die Zertifizierung von Maßnahmen zum Aufbau von

Bodenkohlenstoff aus Sicht der Landwirte weitere Herausforderungen bei der Umsetzung. Offsetting-Ansätze bieten daher möglicherweise nicht die richtigen Anreize für Landwirte, um ökologisch notwendige Änderungen der landwirtschaftlichen Praktiken anzuregen.

Daher sollten Bodenbewirtschaftungsmaßnahmen im Allgemeinen nicht zum Ausgleich anderer Emissionen verwendet werden, stattdessen sollten andere politische Maßnahmen und Instrumente, einschließlich handlungsorientierter Zahlungen, als Anreiz für Maßnahmen im Kontext von Böden eingesetzt werden.

1 Introduction

The land use sector and soils more specifically have a double role as a carbon sink and a source and sink greenhouse gas (GHG) emissions. On the one hand, soils store significant amounts of carbon and have the potential to increase their sink capacity through enhanced soil organic carbon (SOC) sequestration. On the other hand, soils under agricultural land are also sources of CO_2, CH_4 and N_2O emissions from mineralisation in mineral and organic soils.

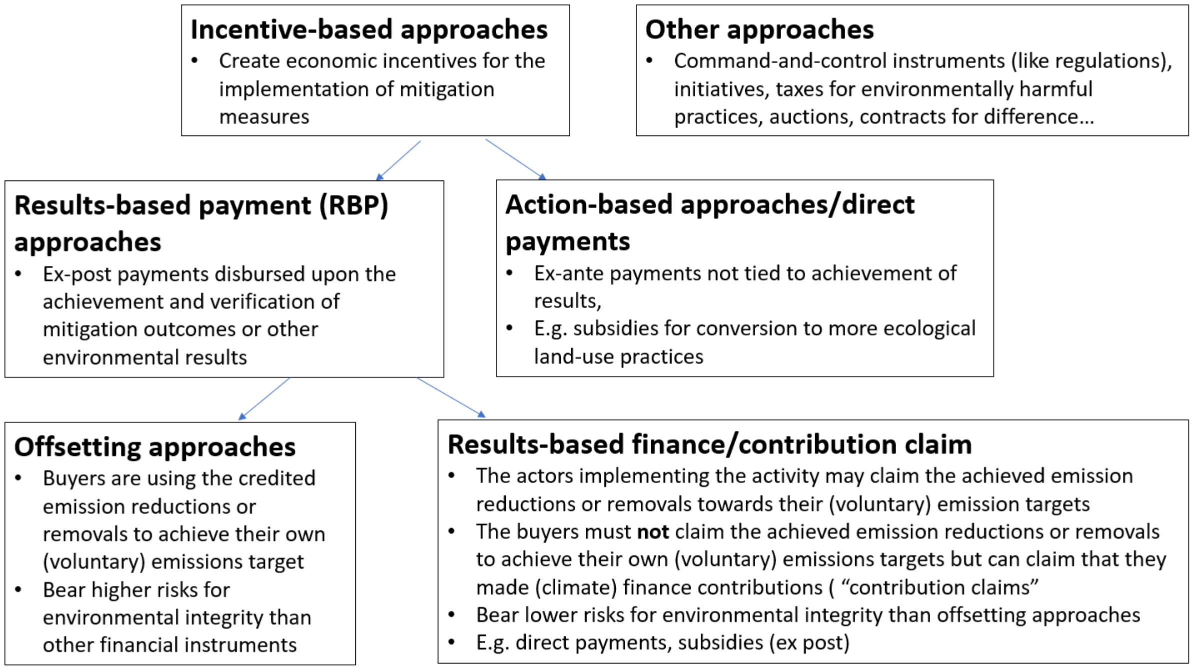
Due to the large amount of carbon stored in soils and their significant potential to store additional carbon, soils play a central role in climate change mitigation. Three different types of climate-friendly soil management measures can be distinguished: 1) land use change measures (e.g., conversion of arable to grassland, prevention of land take), 2) rewetting of peatlands and organic soils and 3) agricultural management measures (e.g., agroforestry, use of cover crops, improved crop rotation etc.). These measures bear significant co-benefits for biodiversity or soil health as well as adaptation but may also involve certain trade-offs regarding social or environmental impacts.[1]

Different policy approaches can promote the implementation of climate-friendly soil management measures. These include political initiatives or regulations as well as incentive-based approaches. Incentive-based approaches create economic incentives to implement climate-friendly soil measures. These can be further differentiated into **results-based payment approaches, which make a payment dependant on the achievement and verification of a mitigation (or other environmental) result**,[2] and **action-based approaches/direct payments** where the payment depends on certain actions being taken or practices being avoided and can be made ex ante. **Results-based payment approaches include results-based finance ("contribution claims") as well as offsetting approaches.** Results-based finance implies that a payment is made upon the achievement of a mitigation results. The payment can be declared as a so-called contribution claim whereby climate action by others is supported financially without accounting the mitigation outcome towards an own mitigation target. Under offsetting approaches by contrast, the buyer is using the certificates for mitigation outcomes as a substitute for within value chain abatement or mitigation activities in their own sphere and counts it towards their own (voluntary) climate target. To ensure environmental integrity, payments should not be made ex ante under results-based payment approaches. Both results-based finance as well as action-based payments can be made e.g. in the form of subsidies or tax reliefs.

[1] As part of this research project, ten selected climate-friendly soil management measures have been characterised and assessed with regard to their climate mitigation potential, co-benefits, trade-offs and implementation challenges. See Frelih-Larsen et al. (2022) for further details (www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation).

[2] The concept of results-based finance has been used in the context of development finance for many years. In the context of climate policy, the concept has gained prominence in the debates around climate finance effectiveness (Kachi and Day 2020). Additionally, it is extensively discussed in the context of funding for REDD+ activities (see e.g. Wong et al. 2016).

Figure 1: Differentiation of types of funding instruments



Source: Own compilation.

For the implementation of climate-friendly soil management measures through such policy instruments, a number of issues need to be considered in order to ensure measurable mitigation effects and realise co-benefits while avoiding negative environmental and social impacts.

This report summarises key aspects that should be accounted for in the design of policy instruments to support the implementation of climate-friendly soil management measures. The issues are divided into two categories and presented separately in the report. First, overarching aspects are outlined that need to be considered for any type of policy instruments are described (section 2.1). Secondly, aspects that are relevant for all types of results-based funding schemes are elaborated upon (section 2.2).

2 Funding climate-friendly soil management: Aspects to consider[3]

2.1 Overarching issues

2.1.1 Land use competition

2.1.1.1 Background

Definition: Land use competition refers to competing claims for using land - a finite resource - for different purposes by different actors.

Importance: Enhancing the carbon stored in soils can conflict with other forms of using the land, such as expanding settlements, infrastructure, the production of renewable energy or the use of land for biomass cultivation or food production. This competition arises as land is a limited resource and demand for land is increasing with a growing world population (Niewöhner et al. 2016; IPCC 2014). Land use competition might entail negative effects from the shift of competing land uses to other areas, as well as potentially causing leakage (see section 2.2.4).

Relevance: The problem of land use competition is relevant for all types of soil carbon mitigation including mitigation projects that aim to reduce or avoid emissions as well as activities that aim to sequester additional carbon. Conflicting land use claims need to be taken into account and addressed for all types of funding approaches for climate-friendly soil management as it might lead to leakage effects and thus reverse the positive climate impact of a specific soil carbon-related mitigation activity. For offsetting approaches, the risk is particularly high as unaddressed negative effects on the other land (i.e. leakage) would undermine the environmental integrity of such mechanisms.

2.1.1.2 Key issues

Land competition is unavoidable, as land is a finite resource. Land competition in itself is not a positive or negative issue, but the land use changes that can result from a new policy may have positive (e.g. more climate-friendly farming) or negative impacts (e.g. monoculture forests that reduce biodiversity), as well as equity implications, and therefore need to be taken into consideration. Mechanisms that increase the economic value of climate-friendly soil management do not create land competition, they simply shift the incentives for land management, with climate-friendly management becoming more attractive. This will benefit some (e.g. those who can implement climate-friendly practices) but disadvantage others (e.g. those who cannot).

Land use conflicting with climate-friendly soil management activities: Measures to enhance climate-friendly soil management and increase carbon stocks in soils can compete with several other claims to the land (see for example IPCC 2014; Smith et al. 2010):

- Using the land for forage or energy crops which are usually cultivated in monocultures;
- Reforestation or afforestation of land to enhance above-ground biomass, restore cleared forest land, increase biodiversity or to use the land for timber production;

[3] The sub-sections of this chapter also published as separate factsheets, see www.umweltbundesamt.de/publikationen/Funding-climate-friendly-soil-management.

- Using the land for more intensive forms of agriculture that store less carbon but might lead to higher yields in the short run, which play a particularly important role if food security is an issue;
- Continued use of drained organic soils for agricultural purposes instead of rewetting;
- Expansion of settlements or infrastructure to land that has not been sealed previously.

Factors impacting the prevalence of land use competition: An important factor impacting the extent of competition for land are diets and food supply chains. This is because more than half of the entire biomass used by humans globally is used as fodder for livestock (Haberl 2015). The demand for biomass more generally is a driver of land use competition; increased demand for bio-based products generally increases land demand (IPCC 2014).

Negative effects of land use competition: The competition for land can entail pressures on biodiversity, rising food prices and increasing GHG emissions. Competition between affluent countries with poorer people in the global South is likely to result in adverse social and development outcomes (Haberl 2015). Land competition can even cause violent conflicts or wars: population growth, overlapping land rights, ethnic fragmentation, economic inequality and corruption are factors than can contribute to the violent escalation of conflicting claims to land (de Jong et al. 2021).

Climate impact of land use competition: Firstly, competing claims to land can have negative climate impacts if the more unsustainable land use, which is often linked to vested and powerful economic interests, prevails. These land uses can entail soil erosion and soil degradation (Haberl 2015). Secondly, competing claims to land may not disappear even if conflicting claims have been reconciled at a certain point in time. This may lead to future reversals of achieved mitigation that cause damage to the climate and can undermine the effectiveness of funding mechanisms as well as the environmental integrity of offsetting mechanisms (see also section 2.2.5). This situation is aggravated in the context of weak governance systems or corruption, socio-economic inequality and existing social conflicts. Thirdly, land use competition can lead to leakage effects if environmentally harmful activities are displaced to other locations (see section 2.2.4). This also implies a risk to the effectiveness of funding mechanisms including the environmental integrity of offsetting mechanisms. Overall, land use competition can therefore limit the mitigation potential of sustainable land use activities including soil carbon sequestration. Land use competition also implies that mitigation potentials provided for specific mitigation measures are likely to be overestimated as they may compete for land (e.g. potentials for reduced deforestation and soil carbon sequestration in croplands or biochar application) (IPCC 2019; Reise et al. 2022).

2.1.1.3 Examples

Several patterns of land use competition can be identified at a global level. Firstly, **deforestation** in the Amazon region or in Indonesia for the purpose of expanding agricultural activities, particularly for **cultivating forage crops or palm oil plantations**, or extracting resources such as oil or timber have been clashing with indigenous living spaces and efforts to preserve the forest for mitigation, biodiversity and other environmental purposes. Secondly, **agricultural development on communal lands** has often led to land use conflicts, e.g. in rural parts of Africa. In such cases, communal areas used for pastoralism and/or informal extensive agriculture have been claimed by local actors for sedentary agriculture or by external actors for large-scale agricultural practices. Thirdly, **urban expansion** can conflict with other land uses, including the use of land in a way that enhances its sink function (de Jong 2021).

The production of **biochar** is an example of a specific measure to increase SOC stocks that can lead to competition for land. Biochar can potentially have positive effects on nutrient availability and thus increase crop yields as well as sequester carbon. However, the application of biochar may have negative effects on biodiversity and knowledge gaps exist regarding further effects on soils as well as applications at larger scale (Budai et al. 2016; Fuss et al. 2018; Smith 2016; Tammeorg et al. 2016; Vijay et al. 2021).[4] Additionally, to produce biochar, biomass such as wood, organic waste or natural feedstocks are needed. Their production can compete with other land uses. Also, if such biomass is removed from cropland areas for the production of biochar, biomass inputs to soils will decrease on these lands. This is an example of leakage: the availability of excess feedstock biomass is limited and therefore, mitigation potentials for biochar are often overestimated (Reise et al. 2022).[5]

2.1.1.4 Relevance for the EU

At the EU level, **land take**[6] is a major threat to enhancing the sink function of soils. According to the European Environment Agency (EEA) (2019), the main drivers of land take in Europe during the period 2000-2018 were the increasing demand for housing, services and recreation, industrial and commercial sites, transport networks and infrastructure, mines quarries and waste dumpsites and construction sites. In total in this period 14,049 km^2 land was lost to land take, with 78% of the land take affecting agricultural areas, i. e. arable lands and pastures, and mosaic farmlands (EEA 2019). According to the EEA, “conflicting demands on land impact significantly on the land's potential to supply key services” (EEA 2015). The 7th EU Environmental Action Programme as well as the EU Roadmap to a Resource Efficient Europe set the target to achieve ‘No Net Land Take’ in the EU in 2050 to mitigate the effect of urban sprawl. Land use competition in the EU can also have negative socio-economic impacts, such as rising land or tenure prices.

Voluntary certification mechanisms operating in Europe: To manage land competition risks, some voluntary certification mechanisms operating in the EU (e.g. Label Bas Carbone) require that participating farmland remains in productive use (i.e. cannot be retired or changed into another land use type).

2.1.1.5 Addressing challenges

Comprehensive policy frameworks are necessary in order to address the negative effects related to mitigation resulting from land use competition. To manage land sustainably, environmental considerations need to be integrated into territorial planning decisions on land use (EEA 2015; OECD 2019). Policies should regulate sectoral emissions for the whole land use sector in order to prevent the expansion or displacement of agricultural production (FAO 2013).

Competition for land can be mitigated by consuming less animal products and reducing food losses (Smith et al. 2013; Stehfest et al. 2013; IPCC 2019). Also, reducing the demand for AFOLU products more generally can help to decrease the demand for land, e.g. by increasing the use of residue and recycling of biogenic materials, although this might result in trade-offs such as soil erosion (IPCC 2014). Agricultural intensification has also been proposed as an approach to mitigate land use competition (IPCC 2019), but is likely to imply other ecological, social and economic costs as well as rebound effects, though these can be mitigated to some extent if intensification is done in a sustainable way (IPCC 2014).

[4] See factsheet on biochar, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[5] Additionally, the precise interactions of biochar with soils are uncertain and experiences with large-scale production and use of biochar is still missing so that long-term potentials are highly unsecure (Reise et al. 2022).

[6] See factsheet on land take, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

2.1.2 Impacts on soil health

2.1.2.1 Background

Definition: Soil quality and soil health are scientific terms and are mostly used interchangeably for describing the characteristics of an intact soil; we use soil health throughout this factsheet[7]. These terms encompass the prerequisites for the functioning of a soil as a part of an ecosystem or entire landscape to sustain environmental quality, biological productivity and healthy plants and animals (Doran and Parkin 1994). Any measure or management practice on the soil has multiple effects on the biological, biophysical and biochemical integrity of the soil as a complex structure of organic and inorganic compounds and thus on the carbon storage capacity and nutrient cycling.

Importance: A healthy soil is the basis for agriculture and essential for sustainable food production. Soil organic carbon (SOC) is one of the structural elements of healthy soil, since a high organic matter content of a soil enhances soil life, improves nutrient retention and water infiltration. A healthy soil is important to maintain the soil's integrity and agroecological function.

Relevance: The issue of soil health is relevant for all types of soil carbon mitigation (including removals and avoided emissions), as all measures of climate-friendly soil management affect soil health, and because soil health contributes to maintaining and sequestering soil carbon. Soil health also affect other GHG emissions.

2.1.2.2 Key issues

Complexity and interaction of management practices:

- **Soil health depends on both natural factors and management practices. Soil physical treatment** (e.g. tillage) and **organic input** either by plant vegetation or organic fertilisers affect the soil organic carbon content either directly (via organic matter input) or indirectly (by disturbance) and have therefore the greatest impact on soil health from a soil management perspective, along with natural soil and climatic factors..
- **Soil health is affected by soil management practices that interact across various scales,** from single plot to farm to even territorial level. For example, silvoarable agroforestry systems with diverse and improved crop rotations can enhance the overall effect of single management practices, while reduction of tillage in combination with intensive use of herbicides can diminish the success of carbon sequestration in the soil by environmental pollution and loss of above- and below-ground biodiversity.

Impact of soil health on carbon storage and sequestration:

- Healthy soils produce higher yields and therefore have the potential to increase the organic and inorganic carbon stock by plant root production and microbial transformation (the degree to which this holds depends in part on the use and initial carbon saturation of the soil). Additionally, the carbon stocks enhance resilience against natural disturbances (Lorenz and Lal 2015).

Management practices to enhance soil carbon stocks can have undesirable side effects on soil health, which should be avoided. For example:

[7] The term soil fertility seems to be mostly used by practitioners (Andreas Gattinger, personal communication).

- Cultivation of cover crops contributes to carbon sequestration but their removal prior to main crop cultivation is associated with the widespread use of herbicides, with possible adverse effects to the environment, e.g. to water quality and soil life.
- Organic inputs from external providers, e.g. organic municipality waste and biochar, can be contaminated with non-degradable or toxic compounds, e.g. plastic or heavy metals, that impair soil life and plant growth. On-farm production of organic inputs may meet higher quality standards.
- Biochar application can increase the pH of the soil and thus nutrient deficiencies that can negatively affect plant growth.
- Manure from livestock (mainly from conventional farming), but also grey water from municipalities can be contaminated with hormones or antibiotics or their degradation products. Their release to the field affects soil biodiversity and can increase resistance of pathogenic strains.

2.1.2.3 Examples

Land-use change, such as the conversion of arable cropland to grassland or the integration of tree lines as in **agroforestry,** impacts soil health (Golicz et al. 2021). The interaction of different permanent and annual species leads to self-regulating processes resulting in reduced pesticide use, which positively affects soil, biodiversity and groundwater (Tscharntke et al. 2021). Land-use change may even affect microclimatic conditions and the hydrological balance of the watershed. While many of these effects are desirable, some can also result in unwanted side effects and ecological imbalances (e.g. if not adapted to the local site). These measures also increase carbon sequestration due to the reduced soil disturbance and permanent tree or grass cover.

The use of **critical inputs,** such as municipality composts, may have negative effects on soil health with potential environmental toxicity. Municipalities produce large amounts of organic material that can be decomposed under controlled conditions to result in humus-like products, but organic residues from mixed waste can contain high levels of heavy metals and physical and biological contaminants (Farrell and Jones 2009). Due to the separation of food waste from other kinds of municipal waste as in Germany, the contamination of compost with toxic materials is negligible nowadays. However, the integration of other critical inputs such as biochar can possibly lead to an input of toxic compounds such as polyaromatic hydrocarbons.

2.1.2.4 Relevance for the EU

EU Soil Strategy for 2030: Establishes a framework for the management of soil health , sets EU soil health objectives, and will prepare concrete measures and actions. This builds on the **EU Biodiversity Strategy for 2030**, which also establishes objectives and procedures related to soil health. The EU Soil Strategy acknowledges that degraded soils lose their capacity to provide ecosystem services, including climate mitigation.

Common Agricultural Policy (CAP): The CAP features many cross-compliance conditions (good agricultural and environmental conditions) and measures related to improving and protecting soil health. The new CAP, due to start in 2023, will even include stronger support for healthy soils in line with the goals of the **European Green Deal**.

2.1.2.5 Addressing challenges

Climate-friendly soil funding policies and mechanisms have options for managing some of the risks of negative impacts on soil health. Potential approaches include:

- **Negative/positive lists:** Mechanisms allow only mitigation activities that have a low risk of decreasing or high chance of enhancing soil health, e.g. they avoid funding measures that pose risks to soil health, such as the input of contaminated municipal waste or the application of herbicides in the case of conservation agriculture.
- **Do-no-significant harm standards** can ensure that soil health is not negatively affected by mitigation activities.
- **Stakeholder consultation**: involving stakeholders throughout methodology and project development, as well as implementation and monitoring can help safeguard soil health.

In addition, it is crucial to monitor impacts of measures on soil health, and to respond to new research and evidence disclosing that measures are having adverse effects.

2.1.3 Biodiversity impacts

2.1.3.1 Background

Definition: Soil management practices can improve soil structure and soil fertility, increase water holding capacity, reduce compaction risk and soil erosion which can ultimately lead towards improving biodiversity above (mammals, bird, amphibians, vascular plants) and below ground (bacteria, fungi, macrofauna). Biodiversity means the variability among living organisms from all sources including terrestrial ecosystems. This includes diversity within species, between species and of ecosystems.[8]

Importance: Soils are a product of biodiversity, while biodiversity is a product of soil with direct and mutual impacts on climate regulation and carbon sequestration (Daba and Dejene 2018).

Relevance: The impact on biodiversity is relevant for all types of soil carbon mitigation including removals and emissions reductions. All types of financing can lead to climate mitigation activities that affect biodiversity (including results-based and action-based mechanisms). Safeguards need to be in place to ensure that biodiversity objectives are taken into consideration, in line with the cautionary principle.

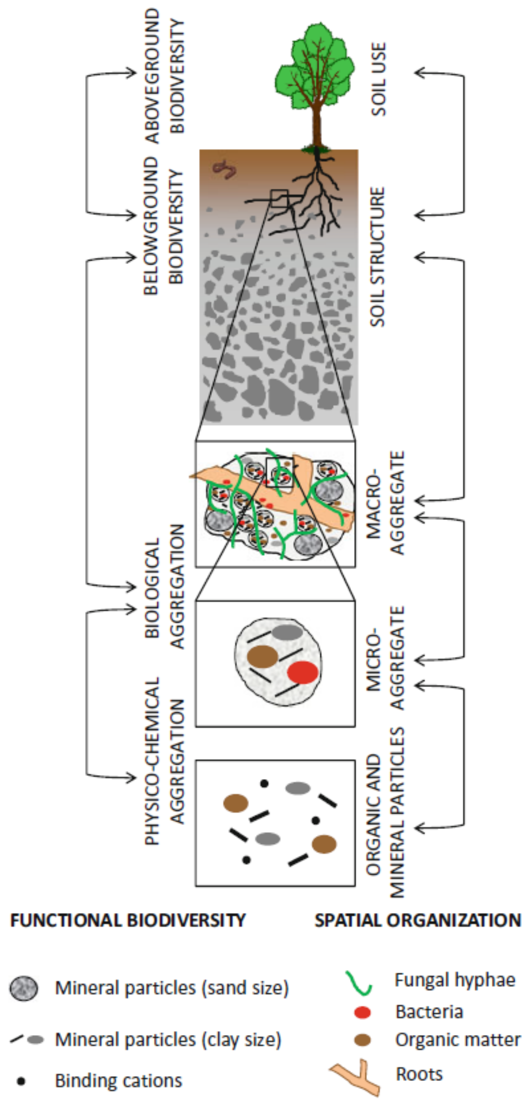
2.1.3.2 Key issues

Soils are a product of biodiversity with soils containing more species diversity than above ground ecosystems. Moreover, numerous species living below and above ground, for example termites, ants, spiders and larvae of insects, partake in the decomposition of organic matter ultimately leading to the soil organic matter cycling and soil carbon sequestration for climate change mitigation. According to Decaëns et al. (2006), at least one quarter of all living species belongs to strict soil or litter dwellers, with bacteria and fungi not covered by these estimations. Hence, soil is a decisive factor shaping all terrestrial ecosystems and a key factor regulating both above- and below-ground biodiversity. Soil management practices can influence the degree of biodiversity within ecosystems. Accordingly, it is important to consider how soil management practices can affect biodiversity, and vice versa, while measuring and monitoring these effects is crucial but challenging on all taxonomic levels (Anderson 2018). Ecosystem-specific biodiversity has to be part of the consideration, since there are ecosystems with specifically adapted biodiversity such as peatlands and marshes.

[8] Convention on Biological Diversity, available at https://www.cbd.int/doc/legal/cbd-en.pdf.

Soils are nonlinear and complex systems, characterised by a large number of interconnected components. This interaction of soil ecosystems takes place from the micro level to the macro level to the landscape level with two-directional feedback-loops (see Figure 2). This complexity means that assessing the impacts of soil management practices is difficult and not always well quantified (de Graaff 2019) with the need for further research regarding the direct linkage between soil management activities and biodiversity. To simplify this complexity, we can think of soil as a product of biodiversity and biodiversity as a product of soil, as below.

Figure 2 Interlinkage between macroscopic surface and microscopic soil surface



Source: Havlicek and Mitchell (2014).

Interpretation: The left shows relations between biodiversity at different strata, down to physical-chemical processes at the microbial scale; the right illustrates soil use and the organisation of organic and mineral soil components.

Impact of soil management on biodiversity

Soil management measures such as tillage, drainage, crop rotation, agroforestry, land use changes, use of pesticides and fertilisers can have a direct and immense impact on above- and below-ground biodiversity:

- **Positive impact:** A global meta-analysis shows that crop diversification including cover-crops, crop rotation, intercropping, agroforestry and variety mixtures can enhance biodiversity by 24%[9] (non-cultivated plants and animals) (Beillouin et al., 2021). Other soil management methods such as manure management can also increase soil biodiversity, though care must be taken to ensure good quality manure is used (Köninger et al. 2021).
- **Negative impact:** Agriculture and soil management practices have an immense impact on terrestrial ecosystems including above- and below-ground biodiversity (IPBES 2019; de Graff 2019). Especially agricultural intensification has led to a dramatic loss in biodiversity over the past decades (Thiele-Bruhn et al. 2012). According to a meta-analysis by de Graff et al. (2019), synthetic N fertilisation has negative impacts on arbuscular mycorrhizal fungal and faunal diversity, and tillage has negative impacts on soil faunal and bacterial diversity.

Impact of biodiversity on climate change mitigation

Biodiversity plays an important role in climate regulation and carbon sequestration (Daba and Dejene 2018). A literature review by Daba and Dejene (2018) found that biodiversity plays a great role in carbon sequestration and GHG mitigation. The sequestration and storage of carbon is one of the many ecosystem services supported by biodiversity. The ability to adapt to climate change highly depends on the diversity of species, while species diversity increases the effectiveness of above-ground sequestration (Daba and Dejene 2018). Vegetation and well managed soils can remove carbon from the atmosphere (Daba and Dejene 2018). Overall, natural ecosystems are usually rich in both biodiversity and carbon. Protecting one can ultimately lead to the protection of both (Campbell et al. 2008).

2.1.3.3 Examples

Silvoarable agroforestry[10] is a system where woody perennials such as trees or hedges and agricultural, usually annual crops are grown on the same cropland. Enhancing tree structures across croplands such as in agroforestry systems means to support biodiversity-friendly landscapes by achieving a large-scale mosaic of more natural habitats (Tscharntke et al. 2021). According to a study by Beillouin et al. (2021), agroforestry has the highest potential to enhance biodiversity with an increase of around 61% compared to other management practices considered[11].

Crop rotation[12] means cultivating different crops in a temporal sequence on the same land, compared to monocultures continuously growing the same crop (Summer 2001). Diversification in crop rotation also improves agrobiodiversity at farm and landscape level in space and time, increasing habitat niches for wildlife biodiversity. According to Beillouin et al. (2021), crop rotation has the second highest potential to enhance biodiversity with an increase of 37%[5].

[9] This study synthesises other meta-analyses; the 24% improvement is relative to non-intervention as it is defined in each study.

[10] See factsheets on silvoarable agroforestry and silvopastoral agroforestry, see www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[11] The study examined the crop diversification practices cover crops, crop rotation, intercropping, agroforestry and variety mixtures.

[12] See factsheet on crop rotation, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

Critical external inputs[13] involve the application of off-farm organic nutrients derived from plant biomass and organic waste materials (plant and animal wastes) for the purpose of soil amendment. This can have positive or negative consequences for biodiversity, depending on the level of application and specific context, with further research required.

2.1.3.4 Relevance for the EU

The EU has a number of policies directly addressing biodiversity that recognise its impact on climate mitigation including the **EU Biodiversity Strategy for 2030,** which has the objective of reducing the use and risk of pesticides by 50% and to increase high-biodiversity landscape features by 10% by 2030; the **Common Agricultural Policy (CAP)**, which features a number of measures targeting biodiversity and climate mitigation on farmland, including cross-compliance conditions (good agricultural and environmental conditions, GAEC). Additional CAP measures (such as eco-schemes or agri-environmental measures) are defined by member states and have the potential to concurrently improve biodiversity and deliver mitigation.

Some voluntary carbon markets operating within the EU also recognise the link between mitigation and biodiversity enhancement, such as MoorFutures[14], which has developed a methodology for rewetting peatlands in return for mitigation certificates that also monitors biodiversity improvement.

Funding of climate-friendly soil management practices can support or decrease biodiversity posing both a risk and opportunities for funding mechanisms. Existing mechanisms have different methods for quantifying and managing broader sustainability impacts (see next chapter).

2.1.3.5 Addressing challenges

Safeguards on biodiversity are crucial to ensure that funding of climate-friendly soil management practices do not have negative impacts on above- and below-ground biodiversity. Potential safeguards include:

- **Negative/positive lists:** Climate-friendly soil management funding mechanisms can allow only mitigation activities that have a low risk of decreasing or a high chance of enhancing biodiversity.
- **Quantitative or qualitative monitoring of biodiversity:** Monitoring biodiversity impacts and then disclosing this information, e.g. on offset credits, can create incentives for biodiversity enhancement alongside mitigation.
- **Do-no-significant harm standards** can ensure that biodiversity is not negatively affected by mitigation activities.
- **Stakeholder consultation:** Involving stakeholders throughout methodology and project development, as well as implementation and monitoring can help safeguard biodiversity.

[13] See factsheet on critical external inputs, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[14] See https://www.moorfutures.de/.

2.1.4 Ownership and rights to use of soils

2.1.4.1 Background

Definition: Ownership, tenure rules and other land use rights determine who can use which resources of the land for how long, and under what conditions.[15]

Importance: The design, absence or insufficient enforcement of such rights can disincentivise land users to use soils sustainably.[16] This is especially relevant in countries or instances where land ownership is not regulated or registered (Bodle et al. 2020). In addition, in several countries, local and indigenous rights are a serious and sensitive issue that might be a challenge for new governance mechanisms for climate-friendly soil use (Hannam 2018; Kamunde-Aquino 2018). Even where ownership rights are clear, complementary rights to use such as lease may lack sufficient incentives or permission to implement sustainable soil management measures, in particular over long time-periods.

Relevance: This issue is relevant for all types of mitigation actions, including emissions reductions and sequestration. It is particularly challenging for measures where permanence is a problem (i.e. all sequestration and carbon storage measures).

2.1.4.2 Key issues

The impact of land rights for climate change

The link between land rights, in particular tenure, and climate change is addressed widely in literature (Murken and Gornott 2022) and throughout in the 2019 IPCC Special Report on Climate Change and land (IPCC 2019a). It states that securing land tenure can enable the adoption of sustainable land management (IPCC 2019a). For instance, strengthening land tenure security is a major factor contributing to the adoption of soil conservation measures in croplands (IPCC 2019a). The World Bank, too, recognises that addressing climate change depends on secure land tenure, and that secure tenure is essential for safeguarding forests against external forces, in particular forests managed by indigenous peoples (Kukkonen & Pott 2019).

However, there is no direct or automatic link between a certain land ownership or land use right arrangement and the degree of climate-friendly land use (Hijbeek et al. 2018; Bartkowski et al. 2021). Land use rights are highly complex because they are defined by each individual country's specific legal system, and in every country there is a multitude of aspects such as types of land use rights (e.g. private, communal or public property, ownership, rent, lease), rules on how such rights can be acquired and passed on (e.g. through sale or inheritance), or the degree of protection and enforcement.

Customary tenure arrangements

An example of the complexity of land rights and tenure is given by customary tenure arrangements, which can mix aspects of common property and exclusive ownership, with complex systems of rights and duties among users (Hannam 2018). For instance, under Kenyan law, soil carbon can either be considered to be part of the soil, as a collectivity that forms the land (belonging to its rightful owners), or be considered as a special resource that belongs to the State and that is subject only to the control and ownership of the State (Kamunde-Aquino 2018).

[15] For a brief introduction to the implications of the legal concept of ownership and property with regard to soil see Stankovics et al. (2020).

[16] For an overview of the large amount of literature and country studies see e.g. Richardson (2018), Akram et al. (2019), Murken and Gornott (2022).

Yet where ownership rights are difficult to ascertain, investors may shy away, and it may even incentivise so-called land grabbing which displaces indigenous peoples. With the increasing pressure on land, land seizures - which displace a local (indigenous) population to the benefit of large investors - are a serious issue, in particular where the property status was unclear or based on customary right (Schmeichel 2018).

Main interactions between land tenure and climate change

A recent review of literature found three main interactions between land tenure and climate change in farming contexts (Murken and Gornott 2022):

- Land tenure characteristics affect the uptake intensity and type of adaptation or coping strategies undertaken by farmers;
- Land tenure systems also influence farmers' vulnerability to climate change, in particular the vulnerability of different demographic groups within farming communities, such as women, migrants and indigenous peoples;
- Land tenure systems themselves are impacted by climate change, in particular the perceived tenure security of farmers, mostly via indirect channels.

2.1.4.3 Examples

Silvopastoral and silvoarable agroforestry[17] involve the planting of shrubs and trees as part of arable or pastoral farmlands. The issue of land rights, ownership, and tenure can pose a challenge to implementation of this measure: the operators of a piece of land may not own it and may have limits on the measures that they can take. Land rights, ownership, and tenure also pose a challenge related to permanence: it may be challenging to transfer obligations to maintain shrubs and trees to future owners or operators of a piece of land.

Reduced soil compaction[18] by managing vehicle traffic over farmland soils can mitigate climate change. The issue of land rights, ownership, and tenure is unlikely to pose a challenge to implementing this measure. However, they do pose a challenge for permanence, as it may be difficult to transfer obligations to maintain the measure to later land owners/operators, and a reversal of this action can undo any emissions reductions/sequestration.

2.1.4.4 Relevance for the EU

EU: The EU basically does not have the legal competence to regulate actual ownership of land and does so in very limited areas such as conveyancing.[19] However, the EU has addressed aspects of property rights regarding land and soil use for instance in connection with free movement of capital, farmland concentration and so-called land take.[20] Indirectly, EU legislation and other measures such as agricultural subsidies affect and influence in particular how agricultural land is used in the EU.

[17] See factsheets on silvoarable and silvopastoral agroforestry, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[18] See factsheet on reduced soil compaction, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[19] Art. 345 TFEU provides that the "Treaties shall in no way prejudice the rules in Member States governing the system of property ownership". On areas of EU property law see chapter 13 of Sparkes et al. (2016) and van Erp (2020).

[20] For further information see Stankovics et al. (2020) and the Commission Interpretative Communication on the Acquisition of Farmland and European Union Law, C/2017/6168, OJ C 350, 18.10.2017, p. 5–20.

Member States: Land rights, tenure, and ownership are generally regulated at the Member State-level, meaning that there can be significant differences in approaches across EU countries.

2.1.4.5 Addressing challenges

While land rights, ownership, and tenure are challenges that go far beyond climate-friendly soil funding mechanisms, the latter can be significantly affected and should take these aspects into account. The challenge this poses is illustrated by the difficulty of defining theoretical frameworks for analysing and addressing not only the link between land use rights and agricultural practices generally, but also climate change (Bartkowski et al. 2021; Murken and Gornott 2022). With regard to security of tenure, while it is frequently mentioned as one important element (Amelung et al. 2020), there is no consensus on what constitutes secure tenure in which context, and land reform efforts have often proven ineffective, slow and at times even harmful (Murken and Gornott 2022). Only a fraction of investments by multilateral development banks are said to aim at increasing land tenure security (Kukkonen & Pott 2019). A number of international instruments address and provide guidance on land rights, although they differ significantly in how specifically they address the link to soil protection and climate change:

In the **climate regime**, neither the UNFCCC nor the Kyoto Protocol explicitly mention land rights or indigenous peoples. Land tenure issues were mentioned very rarely as an issue in the context of the Clean Development Mechanism and REDD+.[21] However, the Paris Agreement (PA) as well as several COP and CMA decisions recognise the role of indigenous peoples.[22] Article 7 PA acknowledges that adaptation action "should be based on and guided by [...], as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems [...]".[23] The decision that adopted the Paris Agreement also established the Local Communities and Indigenous Peoples Platform for the sharing of best practices on mitigation and adaptation.[24] Recent decisions more specifically acknowledge "the important role" of indigenous peoples in addressing and responding to climate change and urge parties to involve them.[25] While none of these instances establish clear obligations for parties, they nevertheless mark a shift towards political recognition of these actors. For instance, in 2018 the Green Climate Fund adopted a decision setting out its approach to incorporating the circumstances of indigenous peoples, including land rights, into decision-making (Green Climate Fund 2019). In addition, the guidance for the mechanisms under article 6.2, 6.4 and 6.8 refers to indigenous peoples. In particular, activities under article 6.4 have to undergo some form of local and subnational consultation also in relation to local communities and indigenous peoples.[26]

The **IPCC** Special Report on Land lists tenure reform as one of the "proven measures that facilitate implementation of practices that reduce, or reverse land degradation" (IPCC 2019a). However, in a more nuanced section, the IPCC also recognises that "[l]and tenure systems have implications for both adaptation and mitigation, which need to be understood within specific socio-economic and legal contexts, and may themselves be impacted by climate change and

[21] For example, to be addressed as a socio-economic impact of a CDM activity, decision 5/CMP.1, Appendix C; Decision 1/CP.16, para 72.

[22] See for example the preamble to the Paris Agreement, that parties "should, when taking action to address climate change, respect, promote and consider their respective obligations on [...] the rights of indigenous peoples", repeated e.g. in 2021 in the preamble to decision 1/CMA.3. The same wording also appears in the preamble to the decision that adopts the Paris Agreement, decision 1/CP.21. The last preambular paragraph of this decision also lists indigenous peoples among the non-party stakeholders.

[23] See article 7.5 Paris Agreement, reiterated in decision 7/CMA.3, preamble.

[24] See decision 1/CP.21, para 135; 2/CP.23, 2/CP.24, 16/CP.26. On its history see Riedel and Bodle (2018). The platform's web portal is located at https://lcipp.unfccc.int/homepage. For the work plan 2022-204 see FCCC/SBSTA/2021/1, annex IV.

[25] See decision 1/CMA.3, preamble, para 88 and 93 and also paragraph 62 regarding loss and damage; 7/CMA.3 para 9

[26] See decision 1/CMA.3, annex para 31(e). See also the (softer) provisions in decision 3(CMA.3, preamble, para 5(h), annex para 24(ix); 4/CMA.3, preamble, annex para 3(e)

climate action" (IPCC 2019a). It states medium confidence that land titling and recognition programmes, particularly those that authorise and respect indigenous and communal tenure, can lead to improved management of forests, including for carbon storage (IPCC 2019a).

The **Sustainable Development Goals** of 2015 aim at equal rights for all men and women to ownership and control over land, with a particular focus on reforms aimed at women. The SDGs also specifically mention "secure and equal access to land" as one of the means to achieve SDG 2.3: "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers...".

With regard to public policies and planning, the non-binding **World Soil Charter**, as revised in 2015, recommends addressing land-tenure structures that constitute obstacles to sound soil management (FAO 2015; Bodle et al. 2020).

The 2003 **Maputo Convention**, a regional treaty by the African Union, formulates more detailed requirements for the implementation of agricultural practices (African Union 2003). Parties are required to develop and implement land tenure policies that can facilitate the measures to prevent land degradation and to conserve and improve the soil (Bodle et al. 2020).

In 2012 the **UN Food and Agricultural Organisation** (FAO) endorsed the "Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests" (VGGT) (FAO 2012).[27] The VGGT were subsequently promoted by the G8, G20, Rio+20, and other bodies, including large multinational corporations (Bodle et al. 2020). They do not mention "soils" explicitly, and only briefly address the governance of land tenure in the context of climate change, mainly emphasising that states should protect tenure rights and the importance of participation in negotiating and implementing mitigation and adaptation programmes (FAO 2012).

The **FAO's "Voluntary Guidelines for Sustainable Soil Management**" recognise the role of sustainable soil management in addressing climate change and refer to securing land tenure under the VGGT as one element of promoting sustainable soil management (FAO 2017).

2.1.5 Social impacts

2.1.5.1 Background

Definition: Implementing mitigation projects under results-based financing mechanisms can have impacts on human rights, workers' rights, gender issues, rights of indigenous peoples, employment, corruption and economic development or intergenerational justice.[28] These impacts can involve social benefits (e.g. enhancing adaptation, improving health through better air quality) but they can also be negative (e.g. restricting subsistence use of forest resources by local populations, harming the rights of local populations).

Importance: It is crucial to ensure that mitigation activities have positive social impacts because sustainable development and climate change mitigation and adaptation are inextricably linked and can support each other. Both are key objectives for society and should be considered in any policy-making. Mitigation measures therefore need to be carefully designed in order to ensure benefits for sustainable development (Wissner and Schneider 2022). At the same time, socio-economic aspects may also act as a barrier towards implementing soil carbon mitigation activities, e.g. insecurity of tenure or the lack of financial resources. Addressing social aspects can therefore help to promote the implementation of climate-friendly soil management.

[27] Endorsed by the FAO's Committee on World Food Security, see https://www.fao.org/tenure/voluntary-guidelines/en/.

[28] Projects can also have positive or negative environmental impacts on e.g. biodiversity or water availability or pollution. The scope of this factsheet is limited to social impacts though.

Relevance: Social impacts play an important role for all types of soil carbon mitigation activities including the enhancement of removals as well as the reduction or avoidance of emissions. They also need to be considered under all types of financing mechanisms, including offsetting mechanisms.

2.1.5.2 Key issues

Scope of social impacts: The sustainable development goals (SDGs), adopted as part of the UN Agenda 2030[29], provide a useful global framework for assessing the impact of mitigation projects on sustainable development (Wissner and Schneider 2022). Indirect social impacts should also be considered, e.g. enhancing biodiversity strengthens the ability of an ecosystem to provide people with services such as clean air and water and fertile soil, which in turn enhances health and well-being (Roe et al. 2021).

Approach towards assessing social impacts:

- The **specific geographical and governance context** as well as the time horizon matters for analysing impacts related to sustainable development (Nilsson et al. 2018). It is therefore pertinent to assess social impacts for each individual project. At the same time, some project types might have similar SDG impacts that are independent of the specific geographical context. For example, integrating trees on croplands to advance agroforestry will diversify income sources for farmers, improve wellbeing and offer economic benefits if implemented in an environmentally sound way.[30] It is therefore possible to assess typical SDG impacts for well-defined project types (Wissner and Schneider 2022).
- To evaluate sustainable development impacts of mitigation projects qualitative and quantitative approaches should complement each other. For **quantitative assessments**, a baseline scenario needs to be defined which the impacts are compared against. For **qualitative assessments**, certain online tools are available.[31] It is important that the criteria applied and the process of the assessment are transparent in order to avoid biases in the assessments. Additionally, specific indicators that are particularly relevant for the context of the project should be identified that guide the assessment (e.g. related to mortality and health as a result of cleaner household air through using efficient cookstoves) (Wissner and Schneider 2022).
- Additionally, it can be assessed to what extent mitigation projects directly or indirectly contribute to improving adaptation and resilience (Schneider et al. 2022). Adaptation benefits can be used as a proxy for social impacts because a lack of adaptation or resilience will cause social damage in the light of more frequent extreme weather events, droughts and fires caused by global heating.
- Under several funding mechanisms, complementary standards that provide more rigorous requirements can be used to ensure that sustainable development impacts of projects are assessed and that social safeguards are in place. For example, for projects under the Clean Development Mechanism (CDM), the Gold Standard's requirements have often been used

[29] See https://sdgs.un.org/goals. The goals cover the reduction of poverty, hunger, inequalities, as well as enhancing health and well-being, quality education, gender equality, access to clean water and sanitation, affordable and clean energy, decent work and economic growth, industry development, innovation and infrastructure, sustainable cities and communities, responsible consumption and production, climate action, conditions for life below water and life on land, peace, justice and strong institutions as well as partnerships for the goals.

[30] See factsheet on silvoarable agroforestry, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[31] E.g. SDG Climate Action Nexus Tool, SDG Synergies Tool, SDG Interaction Map or UNDP Climate Action Impact Tool.

complementarily. Also, the Verified Carbon Standard (VCS) can be combined with the Sustainable Development Verified Impact Standard (SD VISta) or the Climate, Community and Biodiversity Standards (CCBS).

Environmental integrity: Due to the strong interlinkages between climate change mitigation and adaptation and sustainable development, it is essential to promote synergies between these two goals. At the same time, negative social impacts might imply repercussions on the ability of society to take action against climate change (Roy et al. 2018).

Challenges: Safeguards are essential to minimise potential risks, particularly in the land use sector where these risks cannot be avoided completely but need to be minimised. However, the implementation of safeguards varies greatly, ranging from simple reporting to redress mechanisms. How effectively safeguards can be implemented also depends on the legislative context and governance structure of the host country. Additionally, challenges arise from the fact that social impacts are very context-specific and hard to standardise. Also, they may pose obstacles to starting new mitigation initiatives as assessing social impacts makes the design of a project more complex (Böttcher et al. 2022a).

2.1.5.3 Examples

Agroforestry aims at incorporating trees into croplands and thereby promoting soil carbon sinks by sequestering carbon in soils as well as by trees in aboveground biomass. It can improve food security, production of commercial products and energy production (e.g. timber) (Smith et al. 2012), thereby diversifying income sources for farmers, improving well-being and offering economic benefits (Bene et al. 1977; Smith et al. 2014).[32]

Shifting from farms focused on crop or livestock production to **mixed crop-livestock systems** can lead to the accumulation of carbon in soils through applying livestock manure as fertiliser and including forage legumes and perennial grasses in crop rotations. Such practices can support economic resilience for farmers by providing more stable and diversified sources of income. As a result, farmers reduce their exposure to major changes in prices. Shifting to mixed crop-livestock systems can also have positive effects on employment by better utilising labour throughout the year and creating new jobs. At the same time, the need for more or more skilled labour might also be a negative socio-economic impact of shifting to mixed farms by causing higher costs for farmers (Ryschawy et al. 2012; Garrett et al. 2017; Schut et al. 2021).[33]

The use of **nitrification inhibitors** aims to increase the nitrogen available to plants which in turn leads to increased carbon stored in soils. Nitrification inhibitors reduce the nitrification process in soils resulting from the use of fertiliser or animal urine and thereby diminish the risk of human nitrate consumption. Nitrate consumption can lead to human health risks through drinking contaminated water or consuming vegetables with a high nitrate level ultimately leading to various kinds of human cancer, neural tube defects, diabetes and blue baby syndrome (Ahmed et al. 2017). However, the use of nitrification inhibitors can have a number of negative effects on soils and ecosystems and the effects on soil carbon sequestration are still uncertain.

Measures to enhance soil fertility and health such as the use of cover crops, enhanced crop rotations including legumes, mulching or applying manure or compost to soils enhance the productivity of soils. As a result, they will have positive effects on food supply and food security (Roe et al. 2021).

[32] See factsheet on agroforestry, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[33] See factsheet on mixed crop-livestock systems, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

2.1.5.4 Relevance for the EU

In 2002, the European Commission introduced an internal system of integrated impact assessments under which the environmental, economic and social consequences of its major policy proposals must be assessed (European Parliament 2015). This includes proposals on mitigating climate change. In line with this thinking, the EU Green Deal explicitly aims to meet environmental objectives alongside economic and social goals, for example.

Social impacts are also addressed by the EU Taxonomy released in 2020.[34] It translates the EU's climate and environmental objectives into criteria for specific economic activities for investment purposes. For an activity to be aligned with the Taxonomy, four conditions need to be met, including the requirement to comply with minimum social safeguards (Articles 3 and 18).

Various programmes are operating in the EU voluntary carbon market and implement soil-related mitigation projects that apply different approaches to avoiding negative social impacts.

2.1.5.5 Addressing challenges

To avoid and minimise potential negative impacts of mitigation projects realised under results-based financing mechanisms, funding mechanisms often have requirements in place to avoid or manage negative social (and environmental) impacts. This includes the application of safeguards in the development and implementation of projects as a 'do-no-harm approach', such as (see Wissner and Schneider 2022):

- Conducting stakeholder consultations to ensure that affected stakeholders are identified and can voice their concerns which can then be addressed in the implementation of projects;
- Establishing grievance mechanisms to enable stakeholders to raise concerns and demand fair treatment;
- Establishing specific safeguard requirements that must be adhered in the implementation of projects in order to avoid any potential negative impacts;
- Monitoring negative impacts on an ongoing basis;
- Ensuring due diligence of the ability of project implementers to implement and respect safeguards;
- Validating and verifying the assessment of social impacts by independent third parties.

In addition to safeguards, many carbon crediting programmes and standards have provisions in place for assessing the sustainable development impacts of projects. This can be done by comparing impacts to an established baseline to determine the net effect of the project, implementing qualitative and quantitative assessments according to transparent methodologies, requiring projects to monitor sustainable development impacts and ensuring third-party validation of such impacts (Wissner and Schneider 2022).

The Gold Standard provides an example of a carbon crediting programme with robust safeguards in place for avoiding negative social impacts as well as a detailed guidance on assessing positive sustainable development impacts (Wissner and Schneider 2022).[35]

[34] See https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en.

[35] See https://globalgoals.goldstandard.org/100-principles-and-requirements/; https://globalgoals.goldstandard.org/430-iq-sdg-impact-tool/.

2.2 Issues relevant for results-based payment approaches

2.2.1 Additionality

2.2.1.1 Background

Definition: Emission reductions, avoided emissions, and removals (hereafter referred to as mitigation) are considered additional if they occur as a result of the incentives created by the funding for climate action, in this context climate-friendly soil management (McDonald et al. 2021). That is, additionality implies causality: without the mechanism, the mitigation would not have occurred (Böttcher et al. 2022a).

Importance: Additionality is particularly important if the mitigation results are used to offset emissions in other sectors or locations (Schneider et al. 2014). It is also important for cost-effectiveness reasons, as it ensures that the recipients of funding are not rewarded for actions they would have otherwise taken (McDonald et al. 2021).

Relevance: Additionality is relevant for all kinds of projects, including soil carbon mitigation projects that lead to removals (e.g. increase in soil carbon stocks resulting from improved crop rotation), and emission reductions or avoided emissions (e.g. mitigation from avoiding soil degradation due to reduced compaction). Additionality is crucial for offsetting mechanisms. It is more optional for other results-based financing, as in these mechanisms non-additional mitigation would not present environmental integrity risks (although it would undermine the effectiveness of climate finance).

2.2.1.2 Key issues

Environmental integrity risks: If non-additional mitigation is used to offset emissions reductions in other sectors or areas, and mitigation in other sectors is lower as a result, then the total amount of GHGs in the atmosphere will be higher (Schneider and La Hoz Theuer 2019). This would occur if a farmer was going to act to decrease erosion (and soil carbon losses) even without the incentives created by a mechanism (i.e. non-additional mitigation), but then receives certificates for doing so, and a corporate actor purchases these certificates instead of reducing its own emissions.

Difficulties of assessing additionality: Proving additionality is inherently challenging, as it requires an understanding of what would have happened without the mechanism, a counterfactual that can never be observed but only be constructed with uncertainty (Böttcher et al. 2022a; Gillenwater 2012; Schneider 2009). Further, it is difficult for third parties to assess the plausibility of this counterfactual, as it often depends on information provided by those carrying out the mitigation, who have incentives to provide favourable information. Finally, the complexity of the land sector – with its multiple private, market, and government drivers - makes it particularly difficult to isolate causality to just one policy intervention, especially over longer time periods (Böttcher et al. 2022a).

Additionality evaluation approaches: Different land-based climate-friendly soil mechanisms evaluate additionality in different ways, with strengths and weaknesses, as set out in the table below.

Table 1: Additionality assessments

Individualised assessments	**Baselines:** Some mechanisms define any mitigation that goes beyond an activity-specific or standardised baseline as additional (McDonald et al. 2021). **Individualised additionality tests:** Some mechanisms apply tests that try to identify and exclude non-additional mitigation, including: ▶ **Financial additionality tests** aim to exclude projects or mitigation activities that would have been financially viable without the mechanism incentives, using narrative evidence, simple cost-benefit calculations, or a financial analysis that compares the mitigation action to other options or a financial hurdle rate (McDonald et al. 2021). For projects in the EU's land sector, these should consider incentives of complementary policies such as the Common Agricultural Policy. ▶ **Regulatory additionality tests** assess whether mitigation activities go beyond what regulation would have required the actor to do. ▶ **Barrier assessments** evaluate whether there are barriers that would have prevented an actor from implementing the mitigation activities (meaning they are additional) and how the mechanism helps overcoming such barriers. This may include institutional or technological barriers, or social or local knowledge barriers.	**Advantages:** Individualised **Disadvantages:** Costly for actors Rely on actor-provided information Subjective
Standardised assessments	Some mechanisms establish additionality in a standardised way for a type of mitigation activity, effectively working as eligibility criteria (Böttcher et al. 2022a). Examples include: ▶ **Financial additionality evaluations** that assess the typical financial feasibility across different activities (unlike individual projects or actors, as above). ▶ **Market penetration evaluations** that deem activities as additional if their market penetration is below a threshold value. ▶ **Performance benchmarks** that only consider mitigation as additional if it goes beyond a certain benchmark, e.g. mitigation rates achieved by the top 20% of farms.	**Advantages:** Low participant transaction costs Transparent **Disadvantages:** Costly to develop; must be updated regularly Risk of adverse selection

Source: Own compilation.

Additionality evaluation costs: It can be complex, time-demanding, and expensive to evaluate additionality. When these costs fall on participants, this reduces the net economic benefit of participating in voluntary mechanisms and could be a barrier to uptake. Mechanisms may choose to accept some risk of non-additionality to reduce costs and increase uptake (COWI, Ecologic Institute and IEEP 2021).

2.2.1.3 Examples

Critical external inputs[36] involve the application of off-farm organic nutrients (e.g. plant biomass or organic waste) as soil amendments that can boost soil carbon storage. Resulting mitigation would be considered additional if critical external inputs had not been applied without the mechanism. This could be tested by assessing whether farmers would have financial incentives to implement them without the mechanism incentives, whether regulation would require their application, and whether critical external inputs are common. However, additionality would also have to consider the source of the external inputs to ensure that leakage did not occur, e.g. if the sourcing of external inputs meant that soil carbon sequestration decreased in the source site, this would have to be balanced against gains achieved at the application site.

Precision farming[37]: Precision faming is a technology-intensive approach that applies appropriate management practice at the place and time where and when it is needed, adjusted to the heterogeneity of the agricultural field at a small scale. Mitigation that arises from precision farming would be considered additional if it had not occurred without the mechanism incentives. Because precision farming has different costs and benefits in different farming contexts, it would be very difficult to assess additionality using standardised assessments. Additionality would likely have to be assessed individually for each project/actor, based on financial additionality tests and barrier tests. However, because precision farming consists of many small actions, which collectively lead to mitigation, additionality is difficult to accurately assess and demonstrate even at the individual level.

2.2.1.4 Relevance for the EU

Common Agricultural Policy (CAP): The Common Agricultural Policy sets many complex incentives and drivers for landowners, which may change at least every seven years, when the CAP is revised. This can make it difficult to identify whether an individual policy measure causes mitigation actions (i.e. additional mitigation), or whether the mitigation action is caused by other CAP measures. In Europe, additionality assessments must consider existing (and potentially future) CAP regulations and incentives to be able to identify whether mitigation is additional.

Voluntary certification mechanisms operating in Europe: Additionality assessments are central to many mechanisms providing voluntary carbon market certificates in Europe, e.g. Label bas Carbone Carbon Farming, Verra Voluntary Carbon Standard, Gold Standard (McDonald et al. 2021).

2.2.1.5 Addressing challenges

It can be difficult to manage the risk of non-additional mitigation being correctly recognised and rewarded for some type of measures. The many different types of additionality assessments (as shown in the table on the previous page), with their varied strengths and weaknesses, provide numerous ways to assess additionality. Some mitigation activities (new, individual actions with few co-benefits) can be simple to identify as additional, while others (e.g. complex suites of actions such as precision farming) can be more difficult.

To avoid the environmental integrity risk of non-additional mitigation, only mitigation with a high probability of additionality should be acceptable for offsetting emissions reductions

[36] See factsheet on critical external inputs, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[37] See factsheet on precision farming, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

elsewhere. That is, such mitigation should not be incentivised through offsetting approaches, and instead limited to results-based finance approaches or action-based incentive mechanisms, if permitted at all.

2.2.2 Determining SOC content of soils

2.2.2.1 Background

Definition: Determining the content of soil organic carbon (SOC)[38] aims to quantify the present amount and the change over time of SOC in the soil of a set area.

Importance: Knowledge about SOC contents and their variation over a site and by time is crucial to determine the effectiveness of climate-friendly soil management practices.

Relevance: Determining total organic carbon in the soil and its variation over time shows the potential of a soil and management practice to be a sink for carbon, i.e. have carbon sequestration potential, or to be rather a source of CO_2 emissions. The ability to determine the carbon storage of soil (and any change) is a prerequisite for any results-based reward mechanism. It is especially crucial for offsetting mechanisms, as any inaccuracy can lead to poor quality offsets that when used by other sectors result in more GHGs in the atmosphere.

2.2.2.2 Key issues

Determining soil carbon and soil carbon sequestration, i.e. the change of the carbon stock over time, faces the following challenges:

- **Slow soil carbon sequestration rates:** Sequestration is the difference of the carbon stock over time, usually shown as sequestration rate in tonnes per hectare per year. Sequestration can occur over long periods of e.g. more than 25 years for changes in tillage rotations and more than 30 years for grassland systems (West and Six 2007). Sequestration rates can differ greatly between sites and different management measures, for example, carbon sequestration of a degraded soil can be much higher than of soil close to saturation since degraded soils have a higher potential to capture and store even low carbon inputs, while soils close to saturation will need much additional input to store additional carbon. Carbon-rich soils close to saturation are also more exposed to mineralisation and loss of carbon due to higher microbial activity in fertile soils. Even when a saturation level is reached, potentially additional carbon can be sequestered by further changes in management, e.g. additional inputs or converting to reduced tillage, until the soil C storage capacity reaches its maximum saturation stage (West and Six 2007).

- **Low signal to noise ratio:** Relatively small changes in SOC over time (compared to baseline stocks) or high **soil heterogeneity** across areas may result in a high variance of the carbon stock measurements. If this variance is close to or greater than the expected SOC increases caused by the applied measures, measurement is very challenging.

- **Need for standardised procedures**, which are important to enable comparisons between different sites and management practices. This includes standardised sampling methods and laboratory analysis.

- **Other greenhouse gases:** The determination of soil carbon gives no direct information about emissions of other GHG, e.g. nitrous oxide, which can also be affected by climate-friendly soil measures.

[38] A tonne of carbon is equivalent to 3.7 tonnes of carbon dioxide, i.e. 0.27t C = 1 t CO_2-e.

Soil sampling and laboratory analysis

Soil carbon content is classically determined by soil sampling and analysis in a laboratory according to standard methodology. The most widespread approach is to determine the carbon content by dry combustion in an elemental analyser (Smith et al. 2019). The whole procedure including sampling, sample preparation and analysis requires a high number of samples due to soil heterogeneity; soil bulk density must also be calculated (Smith et al. 2019). To account for carbon changes in the soil, repeated measurements have to be applied over the same area, i.e. a sample must be taken before measures are implemented, which must then be repeated at regular intervals to measure how soil carbon has changed due to implementation of measures.

Key issues related to soil sampling and measurement:

- **Number of samples:** The total number of soil samples to describe an area depends on the site and heterogeneity of landscape, land use, management and land-use history. To calculate the change in the soil carbon stock due to a measure, sampling will have to be repeated after a certain time (e.g. five years).
- **Measurement depth:** Soil carbon determination is often restricted to the topsoil (30 cm), both by sampling and soil spectroscopy. This does not take into account shifts of carbon to deeper soil layers, e.g. by deep rooting plants, and long-term sequestration in depth. Sampling at multiple depths will increase the number of samples necessary. Carbon stocks in deep soil layers (> 60 cm) are more stable even after land use change (Guo and Gifford 2002). As long as microbial activity and carbon decomposition is not enhanced by fresh organic matter or soil turbation in depths, focusing the monitoring on shallower layers is justified (Fontaine et al. 2007).
- **Soil- and field-specific issues in sampling:** Sampling can be challenging when the soil is stony or has a high clay content and is dry. When field conditions (present management, topography) are suitable, a (semi-) mechanic device for sampling (e.g. a Nietfeld sampler attached to a tractor or a ramming core probe used with a jackhammer) may facilitate sampling in deep soil layers (> 50 cm). Manual sampling is still the method of choice because of machinery costs and field compaction reasons.
- **Labour and costs of soil sampling:** Determining SOC stocks is labour- and cost-intensive, due to the high number of samples over space (area and depth) and time (sequestration) as described above, in addition to laboratory analysis costs.

In-field measurements

As an alternative approach, in-field measurements were developed as a portable, rapid, precise and cost-efficient alternative to laboratory analysis (dry combustion). While some physical soil sampling is necessary for calibration, the number of laboratory soil sample analyses is drastically reduced. There is, however, a trade-off of lower accuracy than with laboratory methods, though due to lower costs the resolution across a field is much higher (Izaurralde et al. 2013). Soil scanning depth is usually restricted, e.g. to 30 or 50 cm.

Modelling

Soil carbon stocks and changes can also be modelled. Most common SOC models are compartment models which use different mathematical functions to simulate SOC decomposition (Parton et al. 2015). A cost-efficient alternative can be to model SOC in an area using some low-cost or already available data on that area, and interpolating based upon emissions factors and other data from related fields; however, this requires existing data and lacks precision and robustness compared to sampling approaches (Smith et al. 2019).

Technology development

Recent years have seen various companies developing tools for in-field measurements relying on sensor techniques, whose accuracy and cost are still under investigation. These include, for example, spade-like tools with a sensor at the end that is pushed only a few cm into the soil, with measured values transferred directly into soil parameters, including SOC and nutrients, as well as soil physical or structural parameters.[39] Other examples include sensor-based tools fixed to agricultural machinery that detect gamma rays emitted by the soil, which, if appropriately calibrated, may be able to provide information on the SOC content and stocks, though it is unclear whether this is currently being scientifically investigated.

While in the future satellite and remote sensing data could feasibly support monitoring of soil carbon, current EU Copernicus Sentinel satellite data is not yet sufficient. The resolution of current satellite images is too low (weekly data at 10m scale) to capture most climate-friendly soil management activities, with the potential exception of land-use changes (e.g. agroforestry) and soil coverage over the year. However, any satellite monitoring data would need to be ground-truthed.

2.2.2.3 Examples

Silvoarable agroforestry is a system where woody perennials such as trees or hedges and agricultural crops are grown on the same cropland. Such systems pose significant challenges for SOC determination due to their structural heterogeneity with permanent tree rows within cropland in addition to the natural soil heterogeneity and topography. Permanent tree rows have a higher SOC sequestration rate than cropland and the tree rows also can affect the adjacent crop strips (Golicz et al. 2021). The number of laboratory or in-field measurement samples must be higher to deliver accurate data compared to pure cropland or forest to account for the different components of the system and their interactions.

2.2.2.4 Relevance for the EU

LULUCF[40]: Under the LULUCF regulation and in accordance with UNFCCC methodologies, Member States calculate national level soil carbon (and changes) based upon country-wide measurement programmes, which are then upscaled to the national level using modelling.

The EU Commission sustainable carbon cycles communication[41] states that by 2028 every land manager should have access to verified emission and removal data. It is as yet unclear where this data will be sourced from or verified by; given the challenges identified in this factsheet, obtaining soil carbon data in particular will be challenging and/or costly and initial soil data to calculate the sequestration rate will be missing.

Voluntary certification mechanisms operating in Europe: Different approaches are used by different existing mechanisms providing voluntary carbon market certificates in Europe to determine soil carbon content, e.g. Label Bas Carbone applies a modelling approach, IndigoAg and Verra Voluntary Carbon Standard allow modelling or measurement approaches, MoorFutures uses a modelling approach (McDonald et al. 2021).

[39] See https://stenon.io/

[40] Regulation (EU) 2018/841: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0001.01.ENG

[41] EU COM (2021) 800 https://ec.europa.eu/clima/system/files/2021-12/com_2021_800_en_0.pdf

2.2.2.5 Addressing challenges

Determining the carbon content of soil is challenging due to the fundamental difficulties identified in Section 2. Potential measures for dealing with the uncertainties include (McDonald et al. 2021):

- **Quantify/estimate uncertainty:** By identifying uncertainty, it can be communicated or controlled for.
- **Discounting:** Where determination of soil carbon stocks is uncertain, discounts can be applied to any calculations of removals (and resulting offset certificates).
- **Use of conservative assumptions:** This can bias uncertainties in a way that reduces the risk of overestimating removals.

2.2.3 Baselines

2.2.3.1 Background

Definition: In the context of climate mitigation, the "baseline" is the level of emissions and removals against which the mitigation impact is determined – the benchmark. Mitigation is calculated as the difference between the baseline GHG fluxes or carbon stock changes and those following mitigation actions. In most cases, the baseline is set as a counterfactual scenario, i.e. the emissions and removals occurring without the policy intervention. Baselines can also be performance-based, setting a minimum standard.

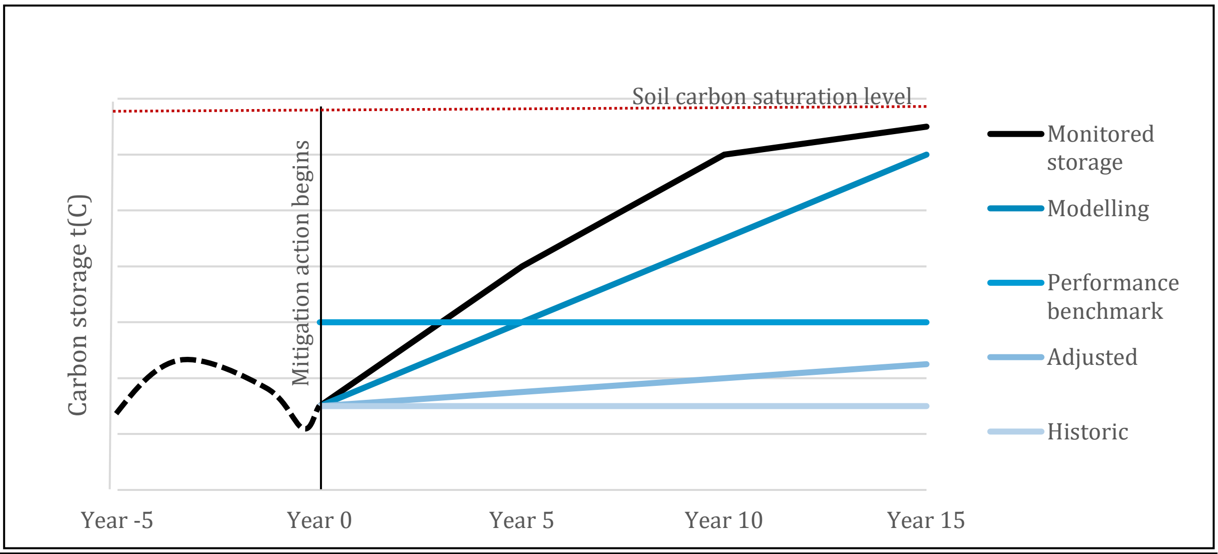
Importance: Baselines are important for the robust quantification of emission reductions or increased removals. If baselines are overestimated, this undermines environmental integrity (i.e. recognised removals/emissions reductions are larger than the real mitigation) and lowers cost-effectiveness (Böttcher et al. 2022a).

Relevance: Baselines are relevant for all types of soil carbon mitigation: removals (e.g. to calculate change in soil carbon stocks resulting from improved crop rotation) and emission reductions / avoided emissions (i.e. to quantify the mitigation impact of avoiding soil degradation from reduced compaction). Baselines are used for all results-based financing, including offsetting mechanisms.

2.2.3.2 Key issues

Different baseline approaches: Baselines represent an emissions or removal level against which mitigation activities are measured. This level can be defined in different ways, with different implications for what can be accounted for as beyond the baselines. The table on the following page describes different approaches to baselines (see figure below) and their strengths/weaknesses (McDonald et al. 2021).

Figure 3: Different benchmarking approaches



Source: Authors' own elaboration.

Table 2: Different baseline approaches, strengths and weaknesses, and examples

Baseline type	Strength/weakness	Example: Improved crop rotation	Example: Silvoarable agroforestry
Historic baselines are established using historic data, e.g. the previous year's soil carbon stock, or an average of multiple previous years of data. These can be **adjusted** (e.g. set 10% below historic levels) or incorporate trends (e.g. decline 5% per year).	- Depend on reliable historic data - Can involve high uncertainty + Simple approach	Baseline based upon previous cropping practices and soil carbon stocks, e.g. average of past three years.	Baseline based on previous level of woody biomass (e.g. hedgerows); potentially zero. Baseline should also cover existing carbon stocks (e.g. soils) and other GHG gases.
Monitoring: Baselines are set by monitoring current activity or taking measurements (e.g. of soil carbon stocks).	- Can be expensive, acting as a transaction cost that reduces incentives to participate + Can have high certainty	Baseline set by sampling current soil carbon stocks.	Baseline set by sampling current soil carbon stocks and site-based measurements of existing woody biomass.
Modelling: Baselines that are established through modelling approaches. These can simulate management practices and their impacts alongside external factors including policies and climate change.	- Complex (and potentially costly and time-consuming to develop). - Can have high uncertainty. + Can reflect policy developments and other exogenous factors	Future baseline (e.g. for next ten years) modelled using historic data and expected policy (e.g. CAP crop rotation standards).	Future baseline modelled based upon historic data and expected policy (e.g. CAP cross-compliance requirement for retainment of natural features).
Performance benchmark: Baselines can be performance-based, set at a level of emissions or removals using data from similar types of actors (e.g. a sector-level average of field vehicle traffic/soil compaction), or a **reference technology**.	- Adverse selection risk, where actors who are already better than the benchmark participate and are recognised for removals/emissions reductions without additional action. - Complex and costly to develop - Challenging to identify relevant benchmark + Once available, low costs for activity owners.	Baseline set at average soil carbon stocks of leading farms (e.g. top 20%) in a similar region and sector.	Baseline set at a minimum width and length of hedgerows on similar farm types in the region (and associated removals).

Baseline type	Strength/weakness	Example: Improved crop rotation	Example: Silvoarable agroforestry
Reference area: Baseline is set by monitoring what occurs in a separate, similar area, where the mitigation action does not occur.	- Only appropriate to set baselines for smaller, project-based scales (not for larger scales e.g. jurisdictions). - Hard to identify sufficiently "similar" area. - Additionality difficult to assess due to differences in area properties + Can reflect increasing policy developments and other exogenous factors	Baseline set by measuring soil carbon stocks on a similar, untreated reference area (e.g. neighbouring field or neighbouring farm).	Baseline set by monitoring agroforestry coverage (and sequestration) on a similar farm. This should also consider soil carbon stocks and other gas flows.

Source: Authors' own elaboration, based upon McDonald et al. (2021).

Baseline uncertainty: Baselines are always uncertain because they are an attempt to represent a counterfactual that is unknowable: it is not known how the future will develop or how actors would respond without the policy intervention. In addition, baseline estimation is subject to the same challenges as any monitoring, reporting and verification of nature-based solutions, such as high levels of data and quantification uncertainty. Baseline uncertainty can pose a fundamental challenge to certification when too high, i.e. if the uncertainty range is larger than the expected mitigation (when the 'signal' is smaller than the 'noise', Schneider et al. 2014).

Cost-benefit considerations: It can be complex and costly to define baselines. This is particularly true when **specific baselines** are established individually for each actor. While individual baselines can be more accurate and certain, developing them is costly, and the cost of establishing robust baselines (direct financial costs as well as indirect time costs) can act as a barrier to individuals taking up mitigation activities and reduce the net benefit to society. There is also the risk of inconsistencies between such individual baselines in case of different underlying information. Moreover, the risk of baseline inflation (overestimation) is higher with individual baselines. An alternative is to use **standardised baselines**, where a common baseline is used for every actor within a sector and/or geographic region (sometimes slightly adapted based on individual characteristics). These can reduce participant transaction costs and increase transparency and objectivity; however, these can involve high upfront development costs, can lead to adverse selection in voluntary results-based mechanisms, and may be inappropriate for complex, highly variable sectors (Schneider et al. 2012). The land sector, with its high variability in climate, precipitation, soil types, land management etc., poses a particular challenge for standardised baselines.

2.2.3.3 Example

The table on the previous page describes how the different types of baselines could be defined for two example solutions, improved crop rotation and silvoarable agroforestry.

2.2.3.4 Relevance for the EU

LULUCF Regulation (EU/2018/841) revisions: The EU Commission's proposed revisions to the LULUCF regulation[42] include a number of references to EU and Member State baselines:

- "No-debit rule": The EU is committed to LULUCF removals being at least equal to emissions from 2021-2025. This effectively forms a baseline that consists of different elements, including historic reference (in the case of cropland, grassland and wetland accounting), a projected reference level (in the case of forest accounting, see also below) and "gross-net" accounting (i.e. the baseline is zero in the case of other land use categories).
- 2026-2030 net removal targets: The Commission amendments set a baseline level of net LULUCF removals of 310 Mt CO_2e, which is broken down to the Member State level.[43] These national-level LULUCF baselines will be updated in 2025, based on data of net removals in 2021, 2022 and 2023. The baseline of -310 was derived from a policy scenario calculated using economic modelling. It can thus be interpreted as a projected modelled baseline.
- "Forest reference level": for the period 2021-2025 Member States have submitted projected trends of the forest net sink development. It is a projection of business as usual assuming the historic management intensity observed in 2000-2009.

[42] COM (2021) 554 final, https://ec.europa.eu/info/sites/default/files/revision-regulation-ghg-land-use-forestry_with-annex_en.pdf

[43] See Annex II

Common Agricultural Policy (CAP): The CAP has cross-compliance requirements that include soil management baselines; even though these do not consider carbon storage, they set implicit baselines for many CAP-regulated farmers. Additional CAP measures also impact soil carbon and GHG fluxes, and therefore must also be considered when setting baselines.

EU voluntary certification mechanisms: Many existing voluntary carbon markets in Europe rely on baselines to calculate additional removals/emissions reductions, e.g. MoorFutures, Label bas Carbone agroforestry, Woodland Carbon Code, etc. (McDonald et al. 2021).

2.2.3.5 Addressing challenges

Uncertainty may be managed using two common approaches:

- **Conservative baselines:** Baselines should be set "conservatively", i.e. assuming a low level of baseline emissions (or high level of baseline removals).
- **Updating baselines:** Baselines need to be updated at regular intervals (e.g. every five years). This enables erroneous baselines to be corrected, increases accuracy based on additional information, and enables the reflection of increasing climate ambition and other changing drivers.

However, due to the identified challenges, some degree of uncertainty is unavoidable. High baseline uncertainty is a particular problem for avoided emissions (e.g. avoided deforestation, avoided wetland drainage), which make these less suitable for crediting (Böttcher et al 2022a).

Baseline setting also poses political challenges, as it implicitly identifies a standard or minimum requirement. This can create 'winners' (i.e. those who can easily and at low cost meet and exceed the baseline) and 'losers'. An example of a potential 'loser' would be an actor who has always maintained their soil carbon, meaning their baseline is at or close to the maximum ('saturated') level of carbon storage that can be achieved on their land and, depending on the reward mechanism, could mean they have little opportunity to be rewarded. These political challenges should be addressed by carefully considering the implications of different types of baselines for different actors and through transparent communication.

2.2.4 Carbon leakage

2.2.4.1 Background

Definition: Carbon leakage can be illustrated by the 'waterbed' metaphor: It occurs when an activity reduces emissions or increases sequestration within the project's boundaries, but as a result emissions increase outside the project boundary, thus reducing the net mitigation effect The IPCC defines **carbon leakage** as a phenomenon "whereby the reduction in emissions (relative to a baseline) in a jurisdiction / sector associated with the implementation of mitigation policy is offset to some degree by an increase outside the jurisdiction / sector through induced changes in consumption, production, prices, land use and / or trade across the jurisdictions / sectors".[44] [45]

[44] Climate Change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Glossary, available at https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-i.pdf.

[45] As a particular case, carbon leakage is often referred to in the context of the shift of emissions intensive activities to jurisdictions with weaker regulation as a result of pricing CO_2 emissions through a climate policy instrument such as an emissions trading scheme. It can also refer to the leakage of stored CO_2 in technical carbon sinks. Here we focus on leakage that occurs as a result of implementing mitigation activities in a broader sense.

Importance: Carbon leakage decreases the net mitigation impact of carbon actions, as mitigation within the project boundary is offset by increased emissions outside the project boundary. It is particularly relevant to avoid carbon leakage in the context of offsetting mechanisms to make sure that the use of such mechanisms does not lead to higher total emissions than if no transfer of emission certificates had taken place. However, also for other funding mechanisms, carbon leakage undermines environmental integrity.

Relevance: Leakage is principally relevant for various types of mitigation activities including soil carbon mitigation projects that aim to reduce or avoid emissions as well as activities that aim to sequester additional carbon. The specific risks depend on whether the activity affects the way the land is used and whether the activity decreases the supply of products or services compared to the land use prior to the implementation of the activity.

2.2.4.2 Key issues

Different types of leakage (Böttcher et al. 2022a; Schwarze et al. 2002):

- *Direct or primary leakage* occurs if the implementation of an activity directly causes a shift in the supply of products or services from one area to another. Direct leakage often occurs at a local and national scale. If the supply of a product or service is displaced by an activity, resulting in primary leakage, the design of the activity is likely to be flawed.
- *Indirect or secondary leakage* refers to a situation where the implementation of an activity in one area indirectly creates incentives for changes in activities in other areas. The reduction in the supply of products or services in one area leads to a shift in markets. Conservation activities avoiding the expansion of commercial agricultural production are more likely to lead to secondary leakage. It is most likely to occur on a national or international scale.
- *Ecological leakage* occurs if the implementation of an activity in one area affects natural processes in surrounding ecosystems outside an activity's boundary which in turn causes emissions, e.g. if organic soils in an area are rewetted and this affects the hydrological properties of ecosystems in other areas resulting in tree dieback.

System/project boundary: System boundary refers to the scope of a mitigation activity and thus defines the removals and emissions that are included in the quantification of net mitigation effects. The boundary can include or exclude particular gases, carbon pools, or geographic areas. While broader system boundaries leave less space for leakage, narrower ones involve greater leakage risks (McDonald et al. 2021). Possible carbon leakage risks are usually accounted for in the quantification methodology.

Types of activities causing leakage: Leakage is not linked to specific activity types (with the exception of ecological leakage caused by wetland activities). Any activity changing the level of supply of products or services from affected areas can result in leakage. The way the land has been used prior to the activity, the properties of products and services from affected areas and the characteristics of related markets as well as the design of the activity and underlying drivers are important factors influencing the risk of leakage (Böttcher et al. 2022a). The risk of leakage is lower if an activity is implemented in abandoned areas (UBA 2019).

Environmental integrity: Carbon leakage generally undermines the environmental integrity of a mitigation activity. If it is not avoided or accounted for, leakage leads to overestimating the mitigation impact on the atmosphere. Leakage can also be positive (also referred to as spill-over), if the implementation of a mitigation activity induces additional removals/emission reductions that are not accounted for (e.g. by inducing neighbouring farmers to implement removal activities) (McDonald et al. 2021).

Challenges of identifying leakage: As it is difficult to identify impacts outside of an activity's boundaries which are not monitored, it is challenging to identify leakage (McDonald et al. 2021).

2.2.4.3 Examples

Low-input grasslands / set-aside areas: By taking arable land out of production and out of crop rotation for a certain time, carbon sequestration on this area can be increased. However, the cultivation of crops or grazing of animals might be displaced to other areas as a result (with a resulting decrease in mitigation on those sites), providing an example of direct leakage. Landscape approaches that extend sequestration activities to larger areas can help to address direct leakage risks (Jacobs et al. 2020). When assessing leakage risks, all impacts on emissions or sequestration need to be considered, including potential increased numbers of ruminants and related emissions resulting from the expansion of grasslands used as pasture, for example. Stringent planning of measures to increase soil carbon stocks through ex-ante impact assessments can help to address such risks (Thamo and Pannell 2016). Indirect leakage could occur if the displacement of crops or grazing of animals would induce deforestation elsewhere. In such instances, leakage emissions may even exceed the increases in soil carbon achieved on the project areas.

External organic inputs: Import of organic inputs such as manure, compost, biochar from elsewhere may lead to carbon accumulation in the targeted site but lead to a carbon loss at the place of origin. Whole-farm approaches can help to account for all emissions and removals or carbon losses at a farm by measuring a farm's overall GHG emissions occurring within the boundary of the farm. Mixed farms which produce their own manure can ensure more closed nutrient and carbon cycles.

Rewetting of peatlands: In the context of rewetting peatlands, there is a risk of ecological leakage. This would occur if raising the water table within the project boundary resulted in water table levels dropping and increased emissions on hydrologically connected fields. To avoid such forms of leakage, the project design needs to account for possible leakage, e.g. by establishing a project boundary wide enough to capture expected water level changes that are linked to project activities (UBA 2019).

2.2.4.4 Relevance for the EU

Existing EU voluntary carbon mechanisms have different ways of addressing leakage. These include qualitative approaches for reducing leakage, or estimating the extent of leakage and discounting it when quantifying net mitigation. Some mechanisms simply assume that no leakage occurs (McDonald et al. 2021).

Indirect land use change (ILUC) can be considered as a specific form of leakage. ILUC can occur when pasture or agricultural land previously used for the production of food or feedstock is diverted to the production of biofuels. As a result, the previous agricultural activities may shift to forests, wetlands and peatlands that are cleared or dried and thus lead to additional emissions that negate emission savings from the use of biofuels instead of fossil fuels. To address this risk, the revised Renewable Energy Directive (RED II)[46] includes three mechanisms:

1. The EU has set a quota for advanced biofuels made from feedstocks listed in Annex IX of the RED II, e.g. biowaste, crop residues and wood from forests except saw logs and veneer logs. ILUC effects are supposed to be low for these feedstocks.

[46] See Directive (EU) 2018/2001, available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.

2. The EU limits the contribution of biofuels made from food or feed crops to renewable energy targets of its Member States in RED II, as these fuels imply a risk of causing ILUC.
3. Feedstocks that qualify as high ILUC-risk feedstock for which a significant expansion into land with high-carbon stock is observed, shall decline to zero until 2030. Until now, palm oil has been identified as high ILUC-risk feedstock.[47] However, the Directive exempts certain biofuels, bioliquids and biomass fuels from these limits if they are certified to present a low ILUC risk according to the Delegated Regulation 2019/807[48], including palm oil produced e.g. by small holders or on degraded land.

The proposal for adapting the RED II as part of the Fit for 55 package published in July 2021 sets limits on the use of high ILUC-risk feedstocks, regardless of whether they are produced within the EU or are imported.[49] However, until the adoption of revised legislation, no rules on the import or use of high ILUC-risk fuels, e.g. on the basis of palm oil, exist.[50] The risk of additional emissions caused by indirect land use change effects as a result of the production of biofuel therefore currently persists.

2.2.4.5 Addressing challenges

To minimise leakage risks to the extent possible, the following hierarchy describes possible approaches to be taken (see Böttcher et al. 2022a):

1. **Identify** possible leakage risks related to land-use activities, including not only emission leakage but also ecological leakage and potential spillover effects where relevant;
2. **Exclude activities** with material risks of global leakage (the risk varies for different types of activities, therefore it is not possible to exclude a certain type of climate-friendly soil management because of high leakage risks but the risks need to be evaluated in the specific context of a project);
3. **Mitigate** leakage risks to the extent possible through the careful design of activities, e.g. through the implementation on abandoned land, or the introduction of buffer zones;
4. **Quantify** leakage appropriately using case-specific quantification methods; if default factors are applied, they need to be differentiated as much as possible (e.g. by type of activity/products affected);
5. **Include** leakage transparently in determining total net emission reductions or removals.

There is, however, a lack of methods to address international leakage (Henders and Ostwald 2012), so that the risk cannot be ruled out completely.

2.2.5 Non-permanence

2.2.5.1 Background

Definition: Non-permanence refers to a situation where the emission reductions or removals generated by a mitigation activity are reversed at a later point in time relative to the baseline scenario. A reversal can occur due to natural processes such as natural disturbances, or human-induced factors including mismanagement of the project or changes in local conditions that make it no longer attractive to keep carbon stored (Böttcher et al. 2022a).

[47] See report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the status of production expansion of relevant food and feed crops worldwide, COM(2019) 142 final, available at https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52019DC0142.

[48] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.133.01.0001.01.ENG.

[49] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0557.

[50] The current RED II only limits the amount of such fuels that can be counted when calculating the share of renewables used in transport, see https://ec.europa.eu/commission/presscorner/detail/en/memo_19_1656.

Importance: Addressing non-permanence is crucial for the environmental integrity of offsetting approaches as net global emissions will ultimately increase if credits are used to compensate for emissions but the corresponding mitigation is reversed at a later point in time (Schneider and La Hoz Theuer 2019). For other results-based financing, a reversal of mitigation results does not present a risk to environmental integrity, but it would undermine efforts to meeting long-term climate objectives as well as the effectiveness of the climate finance used.

Relevance: Non-permanence is a relevant risk for mitigation activities that enhance or preserve carbon reservoirs. It is a crucial issue to address for mitigation activities in the land use sector including soil management activities, in particular where carbon stored in soils can be released very quickly.

2.2.5.2 Key issues

Environmental integrity: If credits are used to offset emissions in other sectors or areas but the underlying mitigation results are reversed at a later point in time, the total amount of GHG emissions in the atmosphere will be higher than if no trade had taken place under an offsetting mechanism. In this case, the mechanism will effectively have over-issued credits (Schneider and La Hoz Theuer 2019).

Factors influencing the risk of non-permanence:

- The risk of non-permanence is impacted by the **extent to which carbon reservoirs are susceptible to natural or human-caused processes that reduce these reservoirs**. Carbon stored in soils (as one sort of biospheric reservoirs) can be depleted by natural disturbances like fire or drought (Anderegg et al. 2020; Deng et al. 2017). Demand for wood or for land are human drivers that can deplete biospheric reservoirs as well as fossil fuel reserves.[51] Additionally, short-term land tenure can pose practical challenges for maintaining climate-friendly soil management over long time periods (OECD 2017).
- The **size and scale of carbon reservoirs** impacts the risk of reversals. For small-scale projects (e.g. rewetting of peatland), a natural disturbance such as a drought or wildfire could reverse the achieved sequestration entirely. At a jurisdictional scale[52], such a disturbance is more likely to only reduce net mitigation temporarily (see section 2.2.7). Also, human activities such as the intentional change of management practices as well as changes in land use can lead to quickly depleting small-scale natural carbon reservoirs.
- It also matters **whether and how human-caused drivers of reducing carbon reservoirs are addressed**. If carbon reservoirs are preserved without addressing drivers like human demand for land, wood or fuel, there is a high risk that mitigation results will be reversed later. While activities that reduce fossil fuel demand, e.g. through enhancing energy efficiency, increase fossil fuel carbon stocks compared to a baseline scenario over time, carbon in biospheric reservoirs such as forests can be reduced by multiple drivers such as demand for woody biomass, land or timber (as well as natural disturbances). By reducing demand for land, carbon reservoirs are indirectly preserved (e.g. by increasing agricultural

[51] This risk is much lower for carbon stored in fossil fuel reservoirs and for CO_2 stored in geological reservoirs.

[52] Jurisdictional approaches refer to land-use activities implemented at the scale of a jurisdiction. The jurisdiction may be at the national level, including an entire country, or at a sub-national administrative level.

productivity). All of these drivers need to be addressed in order to reduce the risk of reversals effectively and to prevent leakage to other geographical areas (see section 2.2.4).[53]

- Most types of soil management activities pose significant reversal risks, including activities that aim to reduce or avoid emissions (e.g. mixed crop-livestock systems, prevention of land take, rewetting of organic soils, nitrification inhibitors) as well as activities that aim to sequester additional carbon (conversion from arable land to grassland, agroforestry, improved crop rotation, use of cover crops, organic farming, low-input grassland). Some activities that avoid or reduce emissions such as the use of nitrification inhibitors, precision farming or reduced emissions from rice cultivation do not imply reversal risks as they do not involve sequestration or storage of carbon that can be later released.

Time horizon for addressing non-permanence: Ideally, **emission reductions or removals should be preserved indefinitely** as the expected global warming depends on the level of cumulative carbon emissions, regardless of the timing of these emissions (Mackey et al. 2013; Ciais et al. 2013). In practice, however, it is not possible to eliminate reversal risks in perpetuity. A **time horizon of 100 years to monitor and compensate for reversals** can be considered a reasonable standard for evaluating approaches to address non-permanence by offsetting mechanisms (Böttcher et al. 2022a). From a private investment perspective, this time span resembles nearly an indefinite commitment. Shorter time horizons will under-value the costs of mitigation reversal because the future costs of preserving carbon stocks would not be accounted for when making investment decisions (Schneider et al. 2022; Böttcher et al. 2022a).

Maintaining climate-friendly soil management: For the preservation of carbon stocks, soil carbon mitigation activities that reduce the pressure on soils, forests, peatland or other land need to be **permanently sustained**. If, e.g., changes to agricultural practices shift back to more unsustainable habits, carbon stored in soils can be released quickly or indirect pressures through demand for more land for agricultural purposes could increase again (Böttcher et al. 2022a). If soils are or become carbon-saturated (i.e. soils reach an equilibrium where they are no longer able to store additional carbon), maintaining existing carbon needs to be the priority.

Long-term role of carbon credits: To mitigate the climate crisis, it is of utmost importance to reduce GHG emissions rapidly and permanently (Seddon et al. 2021). Carbon dioxide removal through enhancing natural and technical sinks will be required to meet the goals of the Paris Agreement. It is therefore crucial that **measures to enhance carbon sequestration are integrated into long-term mitigation strategies**. However, relying on offsetting to achieve mitigation targets risks to divert attention from the fact that considerable ambition raising is necessary in order to reach climate neutrality. The risk of non-permanence of land sector mitigation – along with other integrity challenges - suggests that offsetting with land-based mitigation **should play only a limited role in reaching long-term mitigation targets** (Jeffery et al. 2018).

2.2.5.3 Examples

Crop rotation means cultivating different crops in a temporal sequence on the same land, compared to monocultures continuously growing the same crop. Integrating legumes (e.g. alfalfa) and fallow periods as well as grass ley can increase the carbon stocks in soils. Particularly in organic farming, extended and complex crop rotations with high diversification of

[53] The displacement of products or services to other geographical areas as a result of a mitigation activity is referred to as “carbon leakage”. In contrast to leakage, reversals can occur within the geographical boundaries of a mitigation activity, can happen immediately or at a later point in time and are not necessarily caused by the mitigation activity but can be the result of unrelated drivers or natural disturbances.

crops play a crucial role to keep soils fertile and plants healthy. However, the sequestration gained through crop rotation can be reversed quickly by tilling/ploughing the soils due to fast mineralisation processes of organic compounds. If the agricultural management practices change, mitigation through crop rotation might therefore be only temporary.[54]

Agroforestry with cropland or silvoarable agroforestry is a system where woody perennials such as trees or hedges and agricultural, usually annual crops are grown on the same cropland in a specific spatial and/or temporal fashion. Besides above-ground carbon storage by trees, agroforestry can also increase below-ground carbon stocks. However, the carbon sequestered can be reversed due to various natural or human-caused processes including harvesting of trees, cutting trees or fires.[55]

2.2.5.4 Relevance for the EU

LULUCF Regulation (EU/2018/841) revisions: The EU Commission's proposed revisions to the LULUCF regulation[56] includes a proposal with implications regarding non-permanence:

- **Combining the agriculture and LULUCF sectors into a single land sector:** Full flexibility between the two sectors implies full fungibility between fossil and non-permanent and relatively uncertain biogenic emissions through carbon markets for accounting at EU and Member States level. It will be essential to differentiate between units of carbon from land use and those from fossil fuels in a regulatory framework that accounts for the risk of non-permanence (Böttcher et al. 2022c).[57]
- **For other sectors, it remains unclear whether there will still be flexibilities with the combined land sector**. The Commission proposal for the revision of the LULUCF Regulation envisages a "robust carbon removal certification system" with sectors other than agriculture that "have exhausted their emission reduction possibilities" or achieved more than 90% emission reductions that could participate in a carbon market mechanism at EU level (Böttcher et al. 2022c). For such a mechanism, it will be essential to set robust rules for addressing the risk of non-permanence.

Common Agricultural Policy (CAP): In the CAP, standards on good agricultural and environmental conditions of land (GAEC) are defined that farmers need to respect. These standards i.a. relate to maintaining soil organic matter and soil structure as well as maintaining permanent grassland.[58] Maintaining SOC stocks is thus an integral component of an environmentally-friendly agricultural practice. However, there is no focus on achieving and maintaining mitigation results, and changes to SOC stocks are not measured under the CAP. In the revised CAP (2023-2027), farmers are rewarded for implementing eco-scheme measures, including a number of soil management activities.[59] Yet, these payments are provided on an annual basis without providing incentives for ensuring long-term climate-friendly management practices. Risks of non-permanence are thus not addressed under the CAP.

[54] See factsheet on improved crop rotation, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[55] See factsheet on silvoarable agroforestry, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[56] COM (2021) 554 final, https://ec.europa.eu/info/sites/default/files/revision-regulation-ghg-land-use-forestry_with-annex_en.pdf

[57] The legislative proposal to set rules for carbon markets is scheduled for end of 2022.

[58] See https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/cross-compliance_en#gaec.

[59] See https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en.

Voluntary certification mechanisms operating in Europe and supporting climate-friendly soil management have different approaches in place for addressing non-permanence (Böttcher et al. 2022a; McDonald et al. 2021).

2.2.5.5 Addressing challenges

To address the risk of non-permanence, the following approaches are used by different mechanisms already in place (see Schneider et al. 2022; McDonald et al. 2021):

- **Reducing non-permanence risks** by conducting non-permanence risk assessments and either excluding mitigation activities with higher risks from eligibility or requiring measures to mitigate the risks;
- **Compensating for reversals** by monitoring carbon stocks over long time periods and provisions for cancelling other credits in case a reversal occurs or by **issuing temporary carbon credits** that expire after a certain time period and need to be replaced by other credits in any case;
- **Limiting credit issuance** by issuing only a discounted number of credits to account for possible future reversals or tonne-year accounting which issues only fractional amounts of credits for each year that carbon remains stored;
- **Participant liability** by making projects/participants liable for any removals within the duration of the project or beyond;
- **Contractual or legal approaches** by relying on contracts, legal restrictions or land use or other existing legislation that minimises the risk for reversals.

For soil management activities, the reversal risks are particularly high so these activities should be excluded from offsetting emissions elsewhere and be supported by other types of financing mechanisms.

2.2.6 Double counting

2.2.6.1 Background

Definition: Double counting occurs if a single emission reduction or removal is counted more than once towards the achievement of a mitigation goal (Fearnehough et al. 2020; Schneider et al. 2019).

Importance: Double counting can lead to higher global emissions, ultimately undermining the achievement of climate targets.

Relevance: Double counting is a particular risk for the land-use sector because land ownership, land use and land management often lie in the hands of different stakeholders with overlapping rights.[60] As a result, it may not always be straightforward for an entity to demonstrate that it has the sole right to claim the emission reductions or removals, raising risks that the same mitigation is claimed by multiple entities (Schneider et al. 2018; see Böttcher et al. 2022a). Double counting is therefore relevant for all types of soil carbon mitigation, including removals as well as emission reductions/avoided emissions. Double counting is particularly relevant for offsetting mechanisms as it can undermine the environmental integrity of such mechanisms.

[60] This mainly holds true for countries in the global South, while in jurisdictions with clear ownership to land, the risk of double counting may be lower than for other project types because all emission reductions or removals occur onsite rather than claiming indirect effects upstream or downstream.

2.2.6.2 Key issues

Types of double counting: Double counting can occur in three different ways (Prag et al. 2013; Fearnehough et al. 2020; Schneider et al. 2015; Böttcher et al. 2022; Schneider et al. 2022):

- **Double issuance of units** occurs if more than one carbon credit is issued for the same emission reduction or removal. If these credits are counted towards achieving mitigation targets, double counting occurs. Double issuance can occur due to double registration where a project is registered more than once under different carbon crediting programmes or due to indirect overlaps between different projects (e.g. where both the producer and the consumer of a biofuel issue carbon credits).
- **Double use** occurs if the same carbon credit is used twice to achieve a climate target or the same credit is cancelled twice.
- **Double claiming** occurs if the same emission reduction or removal is claimed both by the host country, jurisdiction or other entity that reports lower emission levels as well as by another country or entity that purchases the carbon credit. Double claiming can occur with respect to the NDCs, if the host country reports lower emissions when accounting for its NDCs, and with respect to domestic climate policies, for example, if a project reduces emissions in an emissions trading system (ETS) or other regulatory schemes with quantified targets such as the EU LULUCF regulation.

Main challenges:

- It is particularly challenging to avoid double claiming of emission reductions and removals with **NDCs**. First, this is because countries' NDCs are defined in different ways (Schneider et al. 2019). For example, accounting for single-year targets poses particular challenges (Siemons and Schneider 2022). Second, rules for avoiding double claiming through the authorisation of mitigation activities and the application of so-called 'corresponding adjustments' under Article 6 of the Paris Agreement have only been adopted at COP26 in Glasgow in November 2021. Countries still need to implement these rules before they authorise carbon credits for Article 6 and implement corresponding adjustments. Therefore, carbon credits that are authorised under Article 6 – and for which thus double claiming with the host country is avoided – are not yet widely available on the market.
- When monitoring and claims to land and mitigation effects occur at multiple levels, such as project and jurisdictional or farmer and national level, the situation becomes more complex. In the context of the **land-use sector**, particular challenges arise from the fact that project level mitigation and jurisdictional approaches may overlap (see section 2.2.7), which makes it more difficult to avoid double counting. Additionally, landowners and customary users of the land such as indigenous peoples or local communities might both claim emission reductions and removals realised (Böttcher et al. 2022a).[61]

Environmental integrity: Double counting is a risk to environmental integrity. If the same emission reductions or removals are counted towards two mitigation goals (e.g. to meet national climate goals as well as by a company using the resulting carbon credits as offsets instead of reducing their own emissions), this could lead to more carbon in the atmosphere than if the emission reductions or removals were only counted once. The specific effect depends on how different actors respond to a reduction in emissions resulting from the purchase of carbon credits (e.g. whether a private actor lowers its climate actions and whether a country decreases

[61] Finding ways to share the benefits will be necessary for these actors to participate in the credit revenue.

the level of ambition of its climate policy as a result of using carbon credits) (Fearnehough et al. 2020).

Unless the risks associated with double counting are appropriately managed by a crediting programme and the host country, any related credits should not be used for reaching long-term mitigation targets through offsetting neither by private entities (e.g. companies) nor by public actors (states).

2.2.6.3 Examples

If two actors register the same peatland restoration project under two different carbon crediting programmes, this can lead to double issuance. To avoid this, the UK Peatland Code requires projects to exclusively register under the UK Land Carbon Registry which records all transactions with 'peatland carbon units' based in the UK and keeps track of ownership in its registry so that there can only be one owner at a time of a credit (McDonald et al. 2021).[62]

Under the German Federal Climate Change Act adopted in 2019 and revised in 2021[63], measures to avoid double counting of mitigation actions towards the German emission reduction targets as well as towards the targets of other actors remain to be adopted.[64]

2.2.6.4 Relevance for the EU

In the context of the **Paris Agreement**, double claiming can occur if private actors purchase and claim credits from projects on the voluntary market**,** and the same removals/emissions reductions are claimed by EU Member States towards the EU's NDC. To avoid this form of double claiming, the EU would need to authorise these mitigation activities under Article 6 of the Paris Agreement and apply 'corresponding adjustments', i.e. by making additions to its reported emissions (Schneider et al. 2022).

At EU level, double claiming could occur if emission reductions or removals, e.g. by a project to restore wetlands, are accounted by a Member State to achieve its obligation under the **EU LULUCF Regulation (2018/841)** on the basis of reporting of emissions in its GHG inventory and are at the same time issued as a carbon credit and used by a private actor to achieve a mitigation target.[65] To avoid this, the EU would need to put provisions in place to authorise issued carbon credits and cancel a respective amount of units under the EU LULUCF Regulation.

Under Joint Implementation under the Kyoto Protocol, some EU Member States established provisions for cancelling ETS allowances if emission reduction units (ERUs) were issued for reductions that occurred within the scope of the EU ETS (Böttcher et al. 2022a). Some carbon crediting mechanisms also have procedures in place that forbid the issuance of carbon credits which overlap with ETS, or they require that a respective amount of allowances be cancelled (Böttcher et al. 2022a).

In the context of the EU LULUCF Regulation, double counting in the land-use sector (but not specifically in the context of soil carbon mitigation approaches) can also occur in the context of **harvested wood products** (HWPs) at global level. The so-called production approach laid down in the EU LULUCF Regulation for accounting requires to include all HWPs from wood harvested

[62] See https://woodlandcarboncode.org.uk/standard-and-guidance/2-project-governance/2-6-registry-and-avoidance-of-double-counting.

[63] See https://www.gesetze-im-internet.de/ksg/BJNR251310019.html#BJNR251310019BJNG000200000.

[64] In §3a, the law specifies that the Federal Government is authorised to regulate crediting and accounting of units in accordance with EU law as well as to prescribe more detailed provisions on the methodologies and bases for comprehensive reporting of GHG emissions and removals in the LULUCF sector.

[65] Double claiming between governmental actors and private actors is strongly related to the question of additionality of mitigation actions, see section 2.2.1.

in a country, ignoring imports and exports of wood and wood products. To avoid double counting by different countries, it is important to apply consistent approaches for accounting for HWPs on a global scale (Böttcher et al. 2022c). The introduction of new categories of carbon storage products as proposed by the European Commission's proposal to revise the LULUCF Regulation[66] would exacerbate these challenges.

2.2.6.5 Addressing challenges

To avoid the different forms of double counting, several approaches need to be pursued:

- To avoid double issuance, **projects need to be excluded** from registering under a funding mechanism when they are already registered elsewhere, or issued credits need to be cancelled. In order to do so, a procedure to check for any double registration and to document cancellations for the purposes of registering elsewhere needs to be in place. Also, procedures or requirements need to be in place to **ensure that project owners have the sole right to implement and profit from the project activity on the respective land** before credits are issued. Mechanisms can also require **legal attestations** from project owners that they will not engage in practices that lead to double counting. Procedures to **avoid indirect overlaps** between different projects should also be in place (ClimateWorks Foundation; Meridian Institute; Stockholm Environment Institute 2019; Schneider et al. 2015; Böttcher et al. 2022a).
- To avoid double use, a **publicly accessible registry** needs to be in place which allows clear identification of each carbon credit by means of a unique serial number. In the registry, the purpose for retiring or cancelling a carbon credit needs to be publicly disclosed and recorded (Böttcher et al. 2022a).
- To avoid double claiming with host countries' NDCs, **'corresponding adjustments'** need to be applied, such that Parties to the Paris Agreement adjust their reported emission levels according to the emission reductions or removals sold or purchased. Carbon crediting mechanisms as well as countries also need to have rules in place to track emission reductions and removals that are authorised and transferred for Article 6 purposes. In the case of CORSIA, credits need to be earmarked for use under the scheme in the registries of carbon crediting mechanisms (Böttcher et al. 2022a).

2.2.7 Jurisdictional vs. project-based approaches

2.2.7.1 Background

Definition: Project-based approaches focus on developing and funding individual projects aiming at mitigating climate change at a specific location with a limited geographical scale. In contrast, jurisdictional approaches are implemented at a larger scale by incentivising and monitoring mitigation efforts across a large geographical area. The government of the jurisdiction is a key actor in implementing jurisdictional approaches not only by defining the measures through which mitigation effects are to be achieved. The government is also in the position to enforce law and regulate land use. Under jurisdictional approaches, mitigation impacts are quantified relative to a baseline for an entire economy or economic sector across a political area, e.g. at the national, state or provincial level (Schwartzman et al. 2021). Under jurisdictional approaches, crediting takes place at the aggregate level (i.e. based on the net carbon stock changes of the whole jurisdiction), with baselines and MRV systems also developed

[66] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0554.

and carried out at the respective level. Jurisdictional approaches may support the achievement of sectoral or jurisdictional mitigation targets.

Importance: Jurisdictional approaches could potentially provide a very large amount of emission reductions and removals. They could reduce domestic leakage risks (see section 2.2.4) but also pose particular challenges with regard to ensuring additionality (see section 2.2.1) and establishing baselines (see section 2.2.3).

Relevance: Jurisdictional approaches can in principle be relevant for all types of soil carbon mitigation including removals as well as emission reductions/avoided emissions. Existing jurisdictional approaches so far focus on mitigation measures in the forestry sector while accounting for soil carbon effects of such measures. They could be applied under various funding mechanisms including subsidies or taxes but are particularly relevant to address challenges that arise in the context of offsetting mechanisms.

2.2.7.2 Key issues

Context of existing jurisdictional approaches: So far, jurisdictional approaches are exclusively employed for activities to reduce emissions from deforestation and forest degradation. Jurisdictional approaches were first developed under the Warsaw Framework for REDD+ under the UNFCCC[67] as a form of results-based payment mechanisms. They emerged as a reaction to the limited success of previous approaches to slowing deforestation and ecosystem degradation. Also, avoided deforestation was not eligible as a project type under the CDM and Parties to the UNFCCC sought to identify new means to scale up funding for mitigation action in the forestry sector. More recently, four crediting approaches operating at jurisdictional scale have emerged that allow for offsetting (ART TREES[68], VCS JNR[69], FCPF[70], California Tropical Forest Standard[71]). While three of them (VCS JNR, FCPF and California Tropical Forest Standard) focus on emission reductions from reducing deforestation and forest degradation, ART TREEs also supports the implementation of forestation and forest restoration efforts.

Environmental integrity: Jurisdictional approaches are associated with similar risks that can undermine the environmental integrity of carbon crediting as project-based approaches, but can potentially address some risks better than project-based crediting:

- **Additionality:** Additionality needs to be ensured if credits are transferred from a seller to a buyer under offsetting approaches (see also section 2.2.1). Stand-alone projects are vulnerable to the problem of 'adverse selection' where those who participate voluntarily are likely to have reduced emissions anyway. It has been argued that jurisdictional baselines and monitoring can capture any adverse selection and therefore better ensure that achieved mitigation is additional (Schwartzman et al. 2021). However, **the risk of non-additionality of a jurisdictional approach remains**, as adverse selection can also occur at jurisdictional level. It cannot be determined with sufficient certainty that the government involved would not have implemented the mitigation activities without the funding generated by the jurisdictional approach (i.e. in the baseline scenario) as the behaviour of governments may not always be rational and is hard to predict. Furthermore, factors that are beyond the control of governments can impact the mitigation action taken and the level of emissions in

[67] REDD+ is a forest conservation framework based on payment-for-ecosystem-services schemes that creates financial incentives for conservation projects through the sale of certified emission reductions (von Essen and Lambin 2021), see https://redd.unfccc.int/.

[68] See https://www.artredd.org/trees/.

[69] See https://verra.org/project/jurisdictional-and-nested-redd-framework/.

[70] See https://www.forestcarbonpartnership.org/.

[71] See https://ww2.arb.ca.gov/our-work/programs/california-tropical-forest-standard.

the jurisdiction (e.g. climate impacts, food prices) which makes it difficult to determine the development of emissions in a baseline scenario.

- **Leakage:** By accounting for all potential shifts in emissions inside the jurisdiction, jurisdictional crediting can capture any leakage occurring within the jurisdiction, reducing leakage risks relative to project-based approaches. In terms of leakage outside of the jurisdiction, **it depends on the drivers behind the leakage to what extent a jurisdictional approach can address the leakage**. If the drivers can be addressed at jurisdictional scale, such forms of leakage can be identified, quantified and addressed, e.g. through compensation; if the drivers are global, the leakage risk is likely to remain undetected.
- **Non-permanence: The risk of reversals might be reduced to some extent** when mitigation activities are designed at larger scales. Natural disturbances cause relatively less harm to activities at jurisdictional level, where it is more likely that they lead to reduced net mitigation for a certain time rather than causing complete reversals of achieved mitigation at aggregate level. On the other hand, **the reversal risk through human-induced drivers might be high** as the mitigation results of jurisdictional approaches are subject to political and policy changes that may affect the entire jurisdiction (Böttcher et al. 2022a; Schwartzman et al. 2021).

Applicability of jurisdictional approaches to soil-related mitigation activities: For soil-related mitigation activities, the following aspects need to be considered:

- **High variability of soil types and conditions:** As the carbon stored in soils is highly variable and dependent on specific site factors, it can be challenging to estimate carbon stocks across jurisdictions. Biophysically defined agroecological zones with similar soils, climate and agricultural/land-use potential or constraints could be determined for soil-related activities in order to robustly define baselines and estimate the effects on emissions/sequestration (also referred to as stratification). Standards setting criteria for the generation and independent verification of soil-related carbon credits that are applicable across regions would need to be developed. A regional accounting system could add credibility to investment in land-based mitigation strategies (Oldfield et al. 2022).
- **Funding:** Soil-related mitigation activities at jurisdiction level may involve a larger number of actors such as small-scale farmers. A regional framework for climate-friendly soil management could therefore provide opportunities for public-private partnerships or large-scale private funding initiatives. For instance, corporations that have defined sustainability commitments could be interested to support regional initiatives in order to demonstrate that they use and supply commodities with improved sustainability (Oldfield et al. 2022).
- **MRV costs:** Due to the high variability of carbon stocks in soils, measurement at larger scales is more efficient as the variance per unit area decreases at broader spatial scales. Spreading monitoring costs over larger areas implies lower per unit MRV costs (Oldfield et al. 2022).
- **Alignment with existing policies or measures:** In the case of soil-related mitigation activity, there is a risk that its objectives contradict existing (e.g. agricultural) policies and measures. To avoid implementation challenges, alignment between existing regulation and new crediting incentives needs to be ensured. Jurisdictional approaches imply a broader scope than project-based activities and need to rely on laws, regulations, support programmes or other forms of financial incentives to induce local actors to change

management practices. They might therefore involve a change of contradicting policies or measures and could potentially lead to less conflicts with existing rules.

Nested approaches: If individual projects register for crediting on an area covered by jurisdictional crediting, these projects are integrated or 'nested' within the larger jurisdictional accounting to avoid double-counting (Schwartzman et al. 2021; Pedroni et al. 2009; see also section 2.2.6). The experience of REDD+ suggests that individual mitigation projects are often frontrunners and that national and jurisdictional programmes are generally likely to react to such projects.

Table 3: Advantages and disadvantages of project-based and jurisdictional approaches for soil-related mitigation activities

	Project-based approaches	Jurisdictional approaches
Advantages	• Relatively easy to implement	• Lower risk of leakage at jurisdictional scale • Potentially lower risk of reversals through natural drivers at aggregate level • Potentially higher impact by implementing improved practices at scale • Lower average monitoring costs per ton of emission reduction or removal • Can be aligned with and support long-term mitigation strategies of the respective jurisdiction by implementing changed practices at scale • Potentially better incentives for landowners or farmers
Disadvantages	• Limited opportunities to scale up • Higher average monitoring costs • Risks related to additionality, leakage, non-permanence	• Additionality very difficult or impossible to ensure • High uncertainty in baseline level • Risk of reversals through human-induced drivers • Higher dependency on external factors such as political willingness, larger amounts of funding • More complex design, need to reconcile priorities of many stakeholders • Complex methodologies (in particular in the case of 'nesting') and measurement tools required • Greater societal consensus required • Alignment with other local and national initiatives can be complex

Sources: Own compilation, based on Oldfield et al. 2022; Schwartzman et al. 2021; von Essen and Lambin 2021; Seymour 2020.

2.2.7.3 Examples

As an example of a **jurisdictional approach** in the forestry sector, Verra released rules and requirements for '*Jurisdictional REDD+ programmes and Nested approaches*' in 2017 (**JNR**), as an alternative to the project-based Verified Carbon Standard (VCS).[72] The JNR covers reduced emissions from deforestation and forest degradation; jurisdictional initiatives may also include improved forest management, afforestation, reforestation and revegetation. Jurisdictional initiatives can include carbon stored in soils (including peat) next to aboveground and belowground biomass, litter, dead wood and wood projects. Initiatives must include all pools that are expected to potentially decline below a de minimis exception level of 10% (e.g. they must include peatlands if present in the area). Jurisdictional approaches are applied at a national or sub-national level. The smallest allowed scale is two levels below the national level. The programme offers three ways to set up a jurisdictional initiative: 1) setting a jurisdictional baseline while crediting takes place in individual standalone projects within the jurisdictional area without monitoring at jurisdictional scale; 2) setting a jurisdictional baseline and direct crediting of nested projects with monitoring occurring both at project and jurisdictional scale; 3) baseline, monitoring and crediting all occur at the jurisdictional level.

A number of existing programmes implement soil carbon mitigation activities at **project level**, including for example IndigoAg[73], Label Bas Carbone[74]; ACR's methodology for avoided conversion of grasslands and shrublands to crop production[75] or Gold Standard's soil organic carbon framework methodology[76].

2.2.7.4 Relevance for the EU

Payments under the EU's **common agricultural policy (CAP)**[77] follow the logic of a **project-based approach** (i.e. at the farm scale). Under 'Pillar I' of the CAP, farmers receive direct payments which are reduced if they do not adhere to environmentally-friendly farming practices, defined as standards of 'good agricultural and environmental conditions' (GAEC). Several of these standards directly contribute to climate mitigation including, for instance, maintaining soil carbon stocks. Additionally, under the 2023-2027 CAP[78], payments are granted to farmers for implementing climate- and environmentally-friendly practices under a new instrument called 'eco-schemes'. Such practices include, among others, organic farming, agroforestry, or changes in crop rotation including legumes. However, the impacts of implementing these practices are not measured. Funding under the CAP is therefore not results-based, but **action-based**.

Additional **EU project-based funding** for soil carbon mitigation is channelled through the EU's LIFE programme[79], the Cohesion Fund[80], the Just Transition Fund[81] as well as the European

[72] See https://verra.org/project/jurisdictional-and-nested-redd-framework/ and https://verra.org/wp-content/uploads/2018/03/JNR_Requirements_v3.4.pdf.

[73] See https://www.indigoag.com/carbon/science/advancement?hsLang=en-us.

[74] See https://www.ecologie.gouv.fr/label-bas-carbone.

[75] See https://americancarbonregistry.org/carbon-accounting/standards-methodologies/methodology-for-avoided-conversion-of-grasslands-and-shrublands-to-crop-production.

[76] See https://globalgoals.goldstandard.org/standards/402_V1.0_LUF_AGR_FM_Soil-Organic-Carbon-Framework-Methodolgy.pdf.

[77] See https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en.

[78] See https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en.

[79] See https://ec.europa.eu/growth/industry/strategy/hydrogen/funding-guide/eu-programmes-funds/life-programme_en, and https://www.st1.com/st1-life as an example.

[80] See https://ec.europa.eu/regional_policy/en/funding/cohesion-fund/.

[81] See https://ec.europa.eu/regional_policy/de/funding/jtf/.

Regional Development Fund[82]. In the future, funding for soil carbon mitigation through the CAP, other sources of public funding by Member States as well as funding through private crediting schemes could operate in a complementary fashion. An example could be the use of hybrid schemes where a basic payment is provided for employing climate-friendly management practices (as currently implemented under the CAP) and additional results-based payments if climate benefits can be demonstrated. To reduce monitoring costs such demonstration could be at jurisdictional level, e.g. by a regional pool that is monitored. Under the CAP, as well as under state aid regulations, double funding must be avoided in cases where different sources of funding are used in the EU (EC 2021).

Jurisdictional approaches have not been implemented in the EU for soil carbon yet.

2.2.7.5 Addressing challenges

Not applicable as jurisdictional approaches are a form of solution approach for various risks related to project-based crediting as outlined above.

2.2.8 Ex ante vs. ex-post crediting

2.2.8.1 Background

Definition: When mitigation is recognised and rewarded after it has occurred and been verified, this is referred to as **ex post**. However, in some mechanisms, actors are rewarded in advance for the expected level of mitigation their activities will lead to in the future (**ex ante**).

Importance: Ex ante crediting comes with risks of under-delivery (where the expected and credited mitigation is not achieved). There is also the risk that ex ante-approved mitigation may not be additional in the future (e.g. due to future regulatory changes) or that it may be double-counted if mitigation is later included in a cap-and-trade scheme. For these reasons, ex ante credits should not be used for offsetting in other sectors or locations. This generates uncertainty and the potential for low environmental integrity, so it needs to be critically assessed. Despite these downsides, ex ante certification is sometimes used in voluntary carbon markets for nature-based solutions, as ex post payments are considered insufficient to incentivise landowners to implement mitigation activities involving high upfront costs or long payback times (Cevallos et al. 2019).

Relevance: Either ex ante or ex post crediting can be used in any type of mechanism and to fund any type of mitigation action; this is an open design decision for the mechanism developer and therefore a relevant topic for all mechanisms, regardless of the sector (i.e. land use or other sectors). The risks of ex ante crediting are highest for offsetting mechanisms, where potentially uncertain or non-realised ex ante credits would substitute for mitigation in other sectors.

2.2.8.2 Key issues

Table 4 Ex post and ex ante crediting: Definitions and strengths and weaknesses

Ex post crediting	Ex ante crediting	
Ex post Actors are only recognised and rewarded for mitigation after it has occurred and been verified. This verification can be of differing stringency, depending on the	**Ex ante – differentiated credits** Actors who implement a mitigation action receive credits equivalent to their expected mitigation impact. However, these credits are marked as “non-verified”, or are otherwise	**Ex ante – undifferentiated credits** The same as ex ante – differentiated credits, except actors receive standard credits (i.e.

[82] See https://ec.europa.eu/regional_policy/en/funding/erdf/.

Ex post crediting	Ex ante crediting	
mechanism and methodology, potentially including site visits, measurement and sampling, distance observation, or self-reporting. This may occur once at the end of the project, or intermittently during the crediting period (e.g. every five years). Actors receive payment equivalent to the results achieved by their mitigation activities over the verification period.	differentiated from standard credits. For example, mechanisms such as the Woodland Carbon Code and Gold Standard, create ex ante credits, which can be sold but not retired as offsets until the projects have been verified, at which point the ex ante credits are transformed into standard credits (Cevallos, Grimault & Bellassen 2019).	credits that are undifferentiated from verified, ex post-certified mitigation). This poses an increased risk to environmental integrity, as buyers can use ex ante credits as offsets.
+ High certainty and environmental integrity, as mitigation is only recognised and rewarded when it has occurred and been verified. **- Slow payoff times** for actors implementing mitigation activities, as they must wait until mitigation activities have been verified. Given the slow and long-term nature of many soil-related mitigation activities, this can pose a significant barrier to uptake (Cevallos et al 2019). **- Higher transaction costs** for participants and administrators, due to strict verification requirements.	**+ Directly provides upfront funding**[83]**,** which is important for mitigation activities that have slow pay-off times or require large upfront investment (e.g. agroforestry). **- Risk of under-delivery**, where the actual mitigation is less than the mitigation expected (and rewarded) ex ante, either due to underperformance or discontinuation of the mitigation activity, or due to future removals being non-additional owing to future regulatory changes. This risk is high for non-differentiated credit approaches, though somewhat lower for differentiated credit schemes. Under-delivery leads to low environmental integrity (where the total level of atmospheric emissions is higher than without the mechanism) and low cost-effectiveness. **- Poor reputation,** owing to the risk of under-delivery, associated with lower demand and lower prices for credits.	

Source: Authors' own compilation

2.2.8.3 Examples

Mixed crop-livestock systems refer to farm-scale systems where livestock and cash crop production are combined to optimise efficiency, commonly delivering mitigation through the application of livestock manure, perennial grasslands, and forage legumes.[84] A hypothetical climate-friendly soil mechanism could reward actors in advance for shifting to mixed crop-livestock systems based on an estimate of their expected net soil carbon accumulation and net emissions. **An ex ante system** would reward farmers up front, based on the estimated mitigation expected in the future. Given the complex nature of mixed crop-livestock systems, and the need to dynamically optimise farms to external factors such as changing prices and weather, an ex ante system would be very uncertain. **An ex post system** would reward farmers only once mitigation has been achieved and verified.

External inputs involve the application of off-farm organic nutrients or biochar to amend soil.[85] In an **ex ante** system, actors could be rewarded for biochar application upfront at a level equivalent to the amount of biochar they apply (and the carbon storage of that biochar), based upon assumptions about its residence time. An **ex post** system would require verification that

[83] Upfront funding can also come through other means, e.g. through futures or other contracts; this also applies to ex post payment approaches.

[84] See factsheet on mixed crop-livestock systems, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[85] See factsheet on critical external inputs, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation

the biochar has not degraded (or negatively affected soil carbon stored) before actors are rewarded.

2.2.8.4 Relevance for the EU

EU voluntary certification mechanisms: Existing voluntary carbon market mechanisms in the EU use both ex ante and ex post crediting systems.

- **Ex ante example:** The Woodland Carbon Code features differentiated ex ante credits (‘Pending Issuance Units’, PIU), which are awarded to validated projects based upon their expected mitigation; these credits are converted into verified credits once the mitigation has been verified. The ex ante PIU credits are effectively a promise to deliver mitigation in the future, and they cannot be used to offset other emissions until the mitigation has been verified. There are also limits on how buyers can communicate the purchase of PIUs (McDonald et al 2021).
- **Ex post example:** Verra (formerly Voluntary Carbon Standard) is an international voluntary carbon crediting mechanism covering many mitigation activities, including soil carbon sequestration methods. Actors only receive credits for mitigation activities following verification of their project and its results (McDonald et al 2021).

Common Agricultural Policy (CAP): Activity-based payments for implementing climate-friendly soil activities under the CAP are similar to ex ante payments with no verification; landowners are paid to implement activities that are expected to deliver mitigation, with no verification of actual results (Radley et al. 2021).

2.2.8.5 Addressing challenges

As explained in section 2.2.8.2, **ex ante crediting creates risks for environmental integrity**. A number of potential solutions have been identified, such as **buffer accounts**, where certificates associated with a certain percentage of the expected ex ante mitigation are held back (e.g. 20%). This buffer is then drawn down to cover under-delivery of already credited projects. However, the simplest and best solution is to rely on the more certain ex post crediting, which does not pose the same risks as all credits are verified.

Some solutions have also been suggested to cover upfront costs or slow payback times, including mechanisms offering upfront support (such as training) and hybrid approaches, which consist of upfront payments with top-up ex post payments or adjustments based upon results achieved (Radley et al 2021). Alternatively, differentiated ex ante credits reduce the risks.

3 Conclusion

Our review of key issues related to the design of instruments to promote climate-friendly soil management identifies a number of challenges that must be overcome to successfully incentivise high quality mitigation through climate friendly soil management. The factsheets identify some potential approaches for **addressing challenges**. However, for many issues identified, the approaches are unlikely to totally overcome the challenges, but rather reduce the risks to some extent. In addition, no one-size-fits-all solution was identified for any of the issues, with pros and cons for different approaches. Accordingly, instruments to promote climate-friendly soil management will need to be designed taking into account the specific context of the envisaged mitigation measures.[86]

All of the identified challenges are also **relevant within the EU**. For some challenges, existing voluntary carbon market mechanisms operating within the EU as well as some existing EU policies offer examples of how the issues arise within the EU-context or are handled by EU policy. The Common Agriculture Policy (CAP) and LULUCF Regulation (2018/841) were commonly identified as likely to interact with any climate-friendly soil management instruments. In some cases, these also offer examples of established approaches to managing the identified challenges, e.g. the EU Commission's proposed revisions to the LULUCF Regulation[87] describe different baseline approaches at Member State level. For the design of funding for carbon farming activities within the EU and the planned Carbon Removal Certification Framework, it will be crucial to take the risks discussed in this report into account. Given the challenges identified in this report, there is a considerable risk that the environmental integrity of EU climate policy would be undermined if mitigation results from carbon farming projects were used to offset emissions reductions in other sectors. Additionally, interactions with other existing and planned EU policies need to be considered to design effective funding for climate friendly soil management.[88]

Characteristics particular to the land use sector pose **cross-cutting challenges** to the design of funding approaches for climate-friendly soil management. As noted by the IPCC, "land provides the principal basis for human livelihoods and well-being" (IPCC 2019b, p. 1). As the site of crop and biomass production and livestock rearing, land (and the soils upon it) is the central node in global food supply, as well as a key site of material and energy production, and the site of human settlements. Land is also finite, meaning that the demand for these multiple outputs results in **competition for land**; any policies aiming to influence land management must consider competing policy objectives and aim to affect a policy space buffeted by multiple economic drivers. These decisions are further complicated by **complex and variable ownership, tenure and rights that exist in the land sector**, which can limit the adoption of sustainable soil management and effectiveness of related policies (IPCC 2019b). Land management also generates significant **externalities, affecting local and distant water quality and availability as well as biodiversity**, among others (Roy et al. 2018). Collectively, this means that soil management has significant direct and indirect effects on society, and land (and soil) management policies and instruments must be designed and implemented with these broader **environmental and social impacts** in mind. Soil-related mitigation measures in Europe might also imply a decrease of yields and thereby increase the pressure on food producers worldwide

[86] An analysis of the methodologies and regulations of selected funding approaches is to be carried out under the present research project.

[87] COM (2021) 554 final, https://ec.europa.eu/info/sites/default/files/revision-regulation-ghg-land-use-forestry_with-annex_en.pdf

[88] A more detailed discussion on the potential use of offsetting credits from carbon farming projects and the interlinkages between different policy instruments will also be published as part of this research project.

which in turn can lead to negative social and environmental impacts in other parts of the world. Global implications of mitigation in the land use sector therefore need to be considered. Also, due to land's centrality to numerous policy areas, the effectiveness of soil management policies and instruments to fund these will also be determined in part by other policies and economic drivers relevant for land use.

The use of **results-based payment approaches** to promote climate-friendly soil management face a number of additional challenges that threaten the effectiveness of the finance to entail mitigation results. A fundamental challenge is posed by the **difficulty and cost of accurately quantifying changes in soil carbon** (Oldfield et al. 2022). This measurement of the mitigation result achieved is crucial for results-based payment approaches, as any uncertainty undermines confidence in the actual mitigation achieved. The costs of modelling, measuring or hybrid approaches to calculate changes in soil carbon – along with any other monitoring, reporting and verification (MRV) costs - also pose a significant problem, acting as a barrier for farmers to voluntarily participate in climate-friendly soil management schemes. In some areas, action-based approaches could be more cost-effective funding approaches, as they involve lower MRV costs. They may be appropriate for actions that are known to deliver positive environmental results but where the costs for complex monitoring systems would offset the benefits of mitigation, thereby reducing net societal benefits.

The issue of **additionality** also poses challenges for result-based payment approaches. Mitigation is considered additional if it occurs as a result of the result-based payment incentives. Additionality implies causality; without the results-based incentives, the mitigation would not have occurred (Böttcher et al. 2022a). A lack of additionality is a problem for environmental integrity and cost-efficiency reasons (Schneider and La Hoz Theuer 2019; McDonald et al. 2021). However, demonstrating additionality is inherently challenging, as it implicitly requires an understanding of a counterfactual, i.e. what would have occurred without the result-based incentive. While numerous additionality assessments offer different ways to evaluate additionality, they have weaknesses including high costs to develop or implement, high data requirements, information asymmetries, and susceptibility to being misled by actors who have incentives to provide favourable information. Additionality poses a particular challenge for some climate-friendly soil management actions, such as those with poor existing data, complex combinations of multiple actions, or those implemented over longer time scales. Also, interlinkages of mitigation actions with existing policies are difficult to disentangle in order to determine the additionality of such actions.

The related issue of establishing **baselines** poses similar challenges. It is methodologically difficult to set sufficiently conservative benchmarks against which observed emission reductions or removals can be compared, in addition to requiring reliable data. Baseline setting is also politically difficult, as it creates 'winners' who can exceed a baseline at low cost and 'losers' with little opportunity to be rewarded. These difficulties are compounded by uncertainties inherent in quantifying soil-carbon stocks and the high variability of participant contexts in the land sector (e.g. in terms of climate, rain, soil type, land management) (McDonald et al. 2021). Together, these additionality and baseline setting difficulties pose real challenges to the design of environmentally robust, cost-efficient result-based payment approaches for soil management (Böttcher et al. 2022a).

Design issues such as **double-counting**, **payment timing, and the geographic scale of results-based approaches (project vs. jurisdictional scale)** also must be carefully considered, as they can have significant impacts on the environmental integrity and costs of result-based mechanisms. For example, the selection of project-scale result-based approaches instead of a jurisdictional scale can increase the risk of **carbon leakage** (Oldfield et al. 2022), which is generally higher in the land-use sector than for other types of mitigation activities. Due to the ripple effects of land-use management change, actions taken on a farm due to a results-based incentive can lead to changes outside the farm boundaries. If these changes result in increased emissions or reduced carbon sequestration that is not controlled for, this will offset the mitigation occurring within the result-based mechanism, undermining the results it aims to deliver. These issues of double-counting and payment timing, are not specific to the land sector but exist for results-based payment instruments in all sectors.

A final key challenge is the risk of **non-permanence of sequestered soil carbon**, as well as carbon stored in biomass e.g. through agroforestry. To meet long-term climate objectives, mitigation must be permanent. However, the permanence of carbon removals can never be guaranteed in perpetuity and carbon stored in soils can be quickly reversed by natural disturbances such as fire or drought or through changes in soil management (Böttcher et al. 2022a). Climate change itself will disrupt the land sector's ability to sequester carbon over the long-term (IPCC 2019b). Recent research indicates that for tropical soils, warming will release soil carbon faster than previously assumed (Nottingham et al. 2020). While approaches to manage the risk of non-permanence are deployed in existing results-based mechanisms, such as pooled buffer reserves or requiring long-term rights to the land, the high risk of soil management reversals means that these must be critically assessed as to their adequacy to manage non-permanence risks, or non-permanence will endanger environmental integrity.

All of the challenges outlined above need to be taken into account in the design of funding instruments to promote climate-friendly soil management in order to preserve environmental integrity. Some of the challenges implying negative social and/or environmental impacts are common to all types of funding approaches (section 2.1). Other challenges are faced only under result-based payment approaches which generate monetary incentives for climate-friendly soil management by paying implementers for the mitigation result that is achieved (section 2.2). **Particular risks exist for offsetting mechanisms,** which are a subset of result-based payment approaches. Under such approaches the buyers use the removals or emissions reductions to offset their own emissions, that is, as a substitute for within value chain emissions abatement towards achieving their own (voluntary) mitigation target. Such approaches pose more risks for environmental integrity than other funding approaches. If the actual mitigation outcomes resulting from the use of offsetting mechanisms ends up being less than what is sold to buyers (e.g. due to non-additionality, inflated baselines, carbon leakage, double-counting, overestimation of SOC levels or non-permanence), then the total amount of greenhouse gases in the atmosphere will be higher than without the trade, as the use of the carbon credits displaces other mitigation efforts. Additionally, using credits for offsetting purposes might substitute rapid and ambitious emissions reductions in other sectors (Seddon et al. 2021; Dooley et al. 2022). The risks for environmental integrity related to offsetting are mitigated to some extent if results-based payments are made in the form of contribution claims where the buyers intend to demonstrate their financial contribution to climate action elsewhere without counting it towards their own mitigation target (see e.g. Warnecke et al. 2015; Fearnehough et al. 2020; Gold Standard 2017).

This means that for offsetting mechanisms, high and conservative standards must be set for all design elements. In particular, strict management of non-permanence, additionality, leakage, and measurement of soil carbon change are essential. Where these high standards cannot be met – which is likely for many climate-friendly soil management mitigation measures, for the reasons set out already in this conclusion – then offsetting approaches are inappropriate instruments to pursue climate mitigation.

In addition to the challenges outlined in this report, crediting soil carbon mitigation activities provide further implementation challenges from a farmer's perspective. The volatility of market prices for carbon credits may be a particular challenge for farmers as smaller economic actors than other project implementers in the carbon market. Changing agricultural practices may imply higher transaction costs compared to larger projects in e.g. the energy or industrial sector. Furthermore, crediting specific agricultural practices may not appropriately account for the overall environmental footprint of a farm and overlook sustainable agroecological practices have been already implemented in the past (WWF 2021). Offsetting approaches may therefore not provide the right incentives to farmers to stimulate environmentally necessary changes to agricultural practices.

Therefore, generally, we recommend that soil management mitigation should not be used to offset other emissions. Offset policies are not the only option: given the challenges identified, other policies and instruments, including action-based payments, should be considered to incentivise action for these measures in the context of soils.

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