CLIMATE CHANGE
01/2025

Final report

Funding climate-friendly soil management

Appropriate policy instruments and limits of market-based approaches

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Abstract: Funding climate-friendly soil management

This report assesses how results-based and action-based funding approaches should be used to promote climate-friendly soil management in Europe to deliver climate mitigation and support the agriculture sector's transition to a net-zero future. We identify considerable potential but also significant challenges of promoting climate-friendly soil management measures with these funding approaches. Both approaches have strengths and weaknesses. Given the interest in offsetting and other crediting approaches, we investigate ten existing carbon crediting mechanisms related to climate-friendly soil management in depth, identifying many shortcomings. Based on our evaluations, we discuss the appropriateness of the two funding approaches to promote different types of climate-friendly soil management measures. We conclude that action-based funding approaches are appropriate for many climate-friendly soil management measures, where non-permanence risks are widespread and must be considered. Result-based (non-offset) funding approaches such as contribution claims and public result-based finance are mostly appropriate for some climate-friendly soil management measures. Offsetting approaches are not an appropriate instrument for funding climate-friendly soil management measures due to environmental integrity concerns (i.e. they will lead to higher aggregate emissions than without using offsetting) arising from non-permanence, additionality, and quantification uncertainty.

Kurzbeschreibung: Die Finanzierung von klimafreundlichen Bodenbewirtschaftungsmaßnahmen

In diesem Bericht wird bewertet, wie ergebnis- und handlungsorientierte Finanzierungsansätze zur Förderung einer klimafreundlichen Bodenbewirtschaftung in Europa eingesetzt werden sollten, um den Klimaschutz und den Übergang des Agrarsektors in eine Netto-Null-Zukunft zu unterstützen. Wir stellen fest, dass die Förderung klimafreundlicher Bodenbewirtschaftungsmaßnahmen mit diesen Finanzierungsansätzen ein erhebliches Potenzial, aber auch erhebliche Herausforderungen mit sich bringt. Beide Ansätze haben Stärken und Schwächen. Angesichts der starken Nachfrage nach Kompensationsmöglichkeiten und der Zertifizierung von Klimaschutzmaßnahmen untersuchen wir zehn bestehende Kohlenstoffprogramme, die klimafreundliche Bodenbewirtschaftung zertifizieren und stellen dabei viele Mängel fest. Auf der Grundlage unserer Bewertungen erörtern wir die Angemessenheit der beiden Finanzierungsansätze zur Förderung verschiedener Arten von klimafreundlichen Bodenbewirtschaftungsmaßnahmen. Wir kommen zu dem Schluss, dass handlungsorientierte Förderansätze für viele Maßnahmen der klimafreundlichen Bodenbewirtschaftung geeignet sind, wobei ein hohes Risiko besteht, dass die erzielte Klimawirkung nicht dauerhaft bestehen bleibt. Ergebnisorientierte Finanzierungsansätze, die nicht auf Kompensation abzielen wie *contribution claims* und öffentliche Finanzierung für erzielte Ergebnisse sind für einige klimafreundliche Bodenbewirtschaftungsmaßnahmen am besten geeignet. Kompensationsansätze sind kein geeignetes Instrument für die Finanzierung klimafreundlicher Bodenbewirtschaftungsmaßnahmen. Wenn Zertifikate zur Kompensation verwendet werden, bestehen zu hohe Risiken für die Umweltintegrität (höhere aggregierte Emissionen als ohne Kompensation) durch mangelnde Dauerhaftigkeit der Klimaschutzwirkung, fehlende Zusätzlichkeit und Unsicherheiten in der Quantifizierung dieser Wirkung.

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List of abbreviations

Abbreviation	Explanation
ACR	American Carbon Registry
BPS	Basic payment scheme
CAP	Common Agricultural Policy
CAR	Climate Action Reserve
CCQI	Carbon Credit Quality Initiative
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRCF	Carbon Removal Certification Framework
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
ECA	European Court of Auditors
ELM	Environmental Land Management
ERF	Emissions Reduction Fund (Australia)
EU	European Union
GAEC	Good agricultural and environment conditions
GHG	Greenhouse gas
Gt	Gigaton
ha	Hectares
HNV	High nature value
IFC	International Finance Corporation
LNR	Local Nature Recovery
LR	Landscape Recovery
LULUCF	Land use, land use change and forestry
MRV	Monitoring, Reporting and Verification
Mt	Megatonne
N	Nitrogen
N_2O	Nitrous oxide (laughing gas)
NbS	Nature-based Solutions
NDC	Nationally Determined Contribution

Abbreviation	Explanation
NGO	Non-governmental organisation
OIMP	Other international mitigation purposes
RBP	Result-based payment
RDP	Rural development programme
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDG	Sustainable Development Goals
SFI	Sustainable Farming Incentive
SOC	Soil organic carbon
t	Tonne
TFEU	Treaty on the Functioning of the European Union
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verra Verified Carbon Standard
yr	Year

Summary

This report assesses how results-based and action-based funding approaches should be used to promote climate-friendly soil management in Europe to deliver climate mitigation and support the agriculture sector's transition to a net-zero future. We identify considerable potential but also significant challenges of promoting climate-friendly soil management measures with these funding approaches. Both approaches have strengths and weaknesses. Given the interest in offsetting and other crediting approaches, we investigate ten existing carbon crediting mechanisms related to climate-friendly soil management in depth, identifying many shortcomings. Based on our evaluations, we discuss the appropriateness of the two funding approaches to promote different types of climate-friendly soil management measures and conclude with recommendations on how they should be used.

Climate-friendly soil management measures

Climate-friendly soil management measures aim to reduce emissions and/or sequester carbon. The measures can be distinguished into two categories: 1) Land-use change measures, such as conversion of arable land to grassland, prevention of land take, rewetting of peatlands and organic soils and 2) management measures, which adapt an existing form of land use, such as optimising crop rotations, or incorporating residue or inputs into soil. The mitigation contribution of management measures often depends on the continuation of these measures as their effects might end if the management is altered again. The risk of reversing mitigation outcomes of management measures is therefore particularly high.

Many climate-friendly measures are **nature-based solutions**[1] that deliver biodiversity enhancement and increase societal well-being alongside mitigation. Climate-friendly soil management is important as soils play a central role in climate change mitigation as a major reservoir of carbon, and due to their great spatial extent they have significant potential for increased mitigation both globally and in the EU.

Different types of climate-friendly soil management measures are more or less attractive as mitigation options. Their differences also affect their appropriateness for using different funding approaches. We identify six key issues to consider when deciding which climate-friendly soil management measures should be promoted, and how. Based on a literature review and expert judgment, we assess fifteen nature-based climate-friendly soil management measures against these key issues, and conclude the following:

- **Mitigation potential**: Those measures that deliver the most climate impact (total EU potential) should be prioritised.
- **Co-benefits/environmental risk assessment**: While we assess only measures that are nature-based solutions[2], those measures that offer greater co-benefits (such as climate adaptation, biodiversity enhancement, water quality) and fewer risks of negative environmental impacts should be prioritised.

[1] A working definition of nature-based solutions has been developed for the purposes of this research project in Reise et al. (2022). A multilaterally agreed definition of NbS that resembles this definition was adopted by the United Nations Environment Assembly in 2022, see https://wedocs.unep.org/bitstream/handle/20.500.11822/39864/NATURE-BASED%20SOLUTIONS%20FOR%20SUPPORTING%20SUSTAINABLE%20DEVELOPMENT.%20English.pdf?sequence=1&isAllowed=y.

[2] Biochar is assessed separately in a box text in section 2.2.7, as it does not qualify as a nature-based solution.

- **Non-permanence**: Soils are relatively unstable stores of carbon meaning that all measures that store carbon in soils pose a significant risk of non-permanence; promoting these measures must be accompanied by incentives to ensure long-term storage.
- **Leakage risk**: Some measures pose a significant risk that their implementation will result in increased emissions elsewhere, which must be managed and controlled for.
- **Quantification**: The climate impact of some measures cannot be robustly and cost-effectively measured, posing challenges for some funding approaches.
- **Additionality**: Measures should be promoted if they generate mitigation that would otherwise not have occurred; the likelihood of this varies considerably across measures, with implications for funding approaches.

Funding instruments for climate-friendly soil management

Climate-friendly soil management measures can be promoted using different policy instruments. We focus on incentive-based approaches that create economic incentives to implement measures, which can be divided into two categories, with different strengths and weaknesses:

- **Action-based approaches**: Farmers are paid for implementing a defined agricultural management measure (e.g. planting hedgerows, implementing cover crops). Action-based payments have low transaction costs for farmers and administrators, offer predictable payments for farmers, and can support maintenance of carbon stocks. However, the environmental outcome is uncertain and the lack of flexibility for farmers reduces attractiveness and opportunity to innovate.
- **Result-based payments:** Farmers are rewarded in the form of payments that reflect the mitigation results achieved. Result-based payments offer greater environmental certainty as impact is measured. They can therefore better incentivise low-cost mitigation, and thus be more efficient and cost-effective, with greater flexibility for farmers. However, they rely on monitoring, reporting, and verification, which can pose significant costs, and farmers may dislike the uncertainty of payments (which depend on results achieved rather than implementation). Result-based payments can take the form of offsetting or result-based finance/contribution claims, which pose different risks and advantages.

Offsetting is a subset of result-based payment approaches, where buyers use the credits to achieve their own mitigation targets or goals. The concept of environmental integrity is critical when considering offsetting: **environmental integrity requires that offsetting must not lead to aggregated GHG emissions that are higher than they would have been without use of the mechanism.**

Analysis of selected carbon crediting methodologies

To understand the appropriateness of result-based and particularly offsetting approaches to promote climate-friendly soil management, we selected and evaluated ten crediting mechanisms. Our selection includes leading mechanisms (e.g. American Carbon Registry, Climate Action Reserve, Gold Standard and Verra Voluntary Carbon Standard) as well as mechanisms with smaller market sizes (Care Peat, Nori, Ökoregion Kaindorf). In addition to these non-governmental mechanisms, we assessed climate-friendly soil management methodologies linked to three governmental mechanisms: the Alberta Offset System, Australian Emissions Reduction Fund, and the French Label bas Carbone. Using a structured set of guiding questions, we evaluated specific methodologies within these mechanisms to understand how they address key issues, including quantification, additionality, non-permanence, double-counting, environmental and social safeguards, and governance.

Our evaluation of crediting methodologies identified many weaknesses with current crediting mechanisms for climate-friendly soil management:

- **Quantification:** Overall, weak monitoring and sampling requirements and inadequate baselines fail to robustly and conservatively quantify mitigation outcomes, endangering the environmental integrity of the carbon credits issued.
- **Additionality:** Overall, the methodologies we assessed are unlikely to ensure that projects and their mitigation are additional, though the likelihood of additionality is higher with some methods than others.
- **Non-permanence:** Overall, the assessed methodologies fail to ensure that mitigation outcomes are sustained for long time periods. Only three of the assessed mechanisms have measures in place to protect mitigation for at least 40 years, and these have other shortcomings. Non-permanence is fundamental for environmental integrity but difficult to achieve for climate-friendly soil management measures, due to the carbon storage of soil being so sensitive to management changes.
- **Double-counting:** Overall, the methodologies show significant weaknesses in terms of avoiding double counting of mitigation outcomes (e.g. among multiple crediting mechanisms, with other funding instruments, or with national climate targets), with insufficient information on credits and their use.
- **Environmental and social safeguards:** Overall, the methodologies are unlikely to ensure environmental and social safeguards and deliver positive sustainable development impacts, though we did identify good examples that could be implemented by all methodologies.
- **Governance:** For the majority of the programmes considered, the available information on the governance of the programmes suggests that institutional arrangements and processes are strong or mostly comprehensive.

Appropriate funding instruments to promote climate-friendly soil management

Climate-friendly soil management measures are diverse. Their differences affect their suitability for action-based or result-based funding. We perform a stepwise evaluation that considers the requirements of different funding approaches and the attributes of different measures to identify what climate-friendly soil management measures are appropriate for promoting through action-based, result-based (non-offset), or offsetting funding. We conclude:

- **Action-based funding approaches are appropriate for many climate-friendly soil-management measures.** Most measures we assessed offer some mitigation potential and positive environmental and social impacts. Non-permanence risks are widespread and must be considered.
- **Result-based (non-offset) funding approaches are mostly appropriate for some climate-friendly soil management measures** (e.g. rewetting of organic soils, conversion of arable land to grassland, buffer strips), and also somewhat appropriate for other measures. A lack of cost-effective and robust quantification approaches limits the appropriateness of other measures for promoting in this way.

- **Offsetting approaches are not an appropriate instrument for funding climate-friendly soil management measures** due to environmental integrity concerns arising from non-permanence, additionality, and quantification uncertainty.
- **Other result-based approaches (contribution claims and public result-based finance) offer an attractive way forward for some climate-friendly soil management measures to deliver mitigation with environmental integrity.**

Broader conclusions

- Nature-based climate-friendly soil management measures offer a significant potential to mitigate climate change, while at the same time enhancing biodiversity and supporting attainment of other societal objectives.
- Additional private funding instruments are only part of the puzzle – there is a need for a wider supportive EU and Member State regulatory environment. Other approaches, including command-and-control regulations and facilitating instruments (e.g. that support farmer upskilling) will be more cost-effective for some measures, and should be considered alongside funding approaches. Ensuring that Common Agriculture Policy funding structures reflect sustainability will be central.
- Agricultural sustainability requires system-wide change. Alongside incentives for farmers, policy must promote change along the value chain and with consumers.

The promotion of climate-friendly soil management measures must be future-focused: this includes supporting innovation (in the form of new monitoring technologies, and changes in farmer practices) and developing adaptable funding approaches to adjust to future regulatory changes and increasing climate ambition.

Zusammenfassung

In diesem Bericht wird bewertet, wie ergebnis- und handlungsbasierte Finanzierungsansätze zur Förderung einer klimafreundlichen Bodennutzung in Europa eingesetzt werden sollten, um zum Klimaschutz beizutragen und den Übergang des Agrarsektors in eine Netto-Null-Zukunft zu unterstützen. Die Förderung klimafreundlicher Bodenbewirtschaftungsmaßnahmen mit diesen Finanzierungsansätzen birgt ein großes Potenzial, aber auch erhebliche Herausforderungen. Beide Ansätze haben Stärken und Schwächen. Angesichts des Interesses an Kompensations- und anderen Zertifizierungsansätzen untersuchen wir zehn Kohlenstoffzertifizierungssysteme im Zusammenhang mit klimafreundlicher Bodennutzung detailliert und stellen dabei viele Mängel fest. Auf der Grundlage unserer Bewertungen erörtern wir, wie die beiden Finanzierungsansätze zur Förderung verschiedener Arten von klimafreundlichen Bodenbewirtschaftungsmaßnahmen geeignet sind, und schließen mit Empfehlungen, wie sie eingesetzt werden sollten.

Klimafreundliche Bodenbewirtschaftungsmaßnahmen

Klimafreundliche Bodenbewirtschaftungsmaßnahmen zielen darauf ab, Emissionen zu verringern und/oder Kohlenstoff zu binden. Die Maßnahmen können in zwei Kategorien unterteilt werden: 1) Maßnahmen zur Änderung der Landnutzung, wie z. B. die Umwandlung von Ackerland in Grünland, die Vermeidung von Flächenverbrauch, die Wiedervernässung von Mooren und organischen Böden, und 2) Bewirtschaftungsmaßnahmen, mit denen eine bestehende Form der Landnutzung angepasst wird, wie z. B. die Optimierung von Fruchtfolgen oder die Einarbeitung von Ernterückständen oder externen Einträgen in den Boden. Bei vielen klimafreundlichen Maßnahmen handelt es sich um **naturbasierte Lösungen**, die neben der Minderung von Emissionen auch die biologische Vielfalt fördern und das gesellschaftliche Wohlbefinden steigern. Eine klimafreundliche Bodennutzung ist wichtig, da die Böden als bedeutender Kohlenstoffspeicher eine zentrale Rolle bei der Eindämmung des Klimawandels spielen. Sie bergen aufgrund ihrer großen Flächenausdehnung sowohl weltweit als auch in der EU ein erhebliches Potenzial für verstärkte Emissionsminderungen.

Verschiedene Arten von klimafreundlichen Bodenbewirtschaftungsmaßnahmen sind als Minderungsoptionen mehr oder weniger attraktiv. Ihre Unterschiede wirken sich auch auf ihre Eignung für verschiedene Finanzierungsansätze aus. Zur Bewertung, welche klimafreundlichen Bodenbewirtschaftungsmaßnahmen wie gefördert werden sollten, haben wir sechs zentrale Aspekte herausgearbeitet. Auf der Grundlage einer Literaturrecherche und der Einschätzung von Experten*Expertinnen bewerten wir fünfzehn naturbasierte klimafreundliche Bodenbewirtschaftungsmaßnahmen anhand dieser Schlüsselaspekte und kommen zu folgenden Ergebnissen:

- **Minderungspotenzial**: Die Maßnahmen mit der größten Klimaschutzwirkung (EU-Gesamtpotenzial) sollten priorisiert werden.
- **Co-Benefits/Umweltrisikobewertung**: Zwar sind alle Maßnahmen naturbasierte Lösungen, doch sollten die Maßnahmen, die einen größeren Zusatznutzen (z. B. hinsichtlich Klimaanpassung, Verbesserung der biologischen Vielfalt, Wasserqualität) und ein geringeres Risiko negativer Umweltauswirkungen bieten, vorrangig gefördert werden.
- **Nicht-Dauerhaftigkeit**: Alle Maßnahmen, die Kohlenstoff in Böden speichern, bergen ein erhebliches Risiko der Nichtdauerhaftigkeit; die Förderung dieser Maßnahmen muss mit Anreizen zur Gewährleistung einer langfristigen Speicherung einhergehen.

- **Leckagerisiko**: Bei einigen Maßnahmen besteht ein erhebliches Risiko, dass ihre Umsetzung zu einem Anstieg der Emissionen an einem anderen Ort führt, dies muss gesteuert und kontrolliert werden.
- **Quantifizierung**: Die Klimawirkung einiger Maßnahmen kann nicht zuverlässig und kosteneffizient gemessen werden, was einige Finanzierungsansätze vor Herausforderungen stellt.
- **Zusätzlichkeit**: Maßnahmen sollten gefördert werden, wenn sie zu einer Emissionsminderung führen, die andernfalls nicht eingetreten wäre. Die Wahrscheinlichkeit dafür variiert je nach Maßnahme erheblich, was sich auf die Finanzierungsansätze auswirkt.

Finanzierungsinstrumente für klimafreundliche Bodennutzung

Klimafreundliche Bodenbewirtschaftungsmaßnahmen können mit verschiedenen politischen Instrumenten gefördert werden. Wir konzentrieren uns auf anreizbasierte Ansätze, die ökonomische Anreize zur Umsetzung von Maßnahmen schaffen. Sie lassen sich in zwei Kategorien mit unterschiedlichen Stärken und Schwächen einteilen:

- **Handlungsbasierte Ansätze**: Landwirte werden für die Umsetzung einer definierten landwirtschaftlichen Maßnahme (z. B. Anpflanzung von Hecken, Anbau von Deckfrüchten) bezahlt. Handlungsbasierte Zahlungen verursachen geringe Transaktionskosten für Landwirte und Verwaltungen, sind für Landwirte vorhersehbar und können den Erhalt von Kohlenstoffvorräten unterstützen. Das Umweltergebnis ist jedoch ungewiss, und der Mangel an Flexibilität für die Landwirte verringert ihre Attraktivität und die Möglichkeit, Innovationen vorzunehmen.
- **Ergebnisbasierte Zahlungen**: Die Landwirte erhalten Zahlungen, die auf den erzielten Minderungsergebnissen beruhen. Ergebnisbasierte Zahlungen bieten eine größere Sicherheit in Bezug auf die Umwelt, da die Auswirkungen der Maßnahmen gemessen werden. Sie können daher kostengünstige Minderungsmaßnahmen anreizen und somit effizienter und kostengünstiger sein, sowie Landwirten eine größere Flexibilität bieten. Sie sind jedoch auf Überwachung, Berichterstattung und Überprüfung angewiesen, was wiederum kostspielig sein kann, und die Landwirte mögen vielleicht nicht die Unsicherheit der Zahlungen (die von den erzielten Ergebnissen und nicht von der Umsetzung der Maßnahmen abhängen). Ergebnisbasierte Zahlungen können in Form von Kompensationszahlungen oder ergebnisbasierten Finanzierungen/Beitragsforderungen erfolgen, die unterschiedliche Risiken und Vorteile mit sich bringen.

Die **Kompensation** (Offsetting) ist eine Untergruppe der ergebnisbasierten Zahlungsansätze, bei denen die Käufer die Gutschriften zum Erreichen ihrer eigenen Minderungsziele verwenden. Umweltintegrität ist bei Offsetting von entscheidender Bedeutung: **Umweltintegrität bedeutet, dass Offsetting nicht zu aggregierten Treibhausgasemissionen führen darf, die höher sind, als sie ohne die Nutzung des Mechanismus gewesen wären**.

Analyse ausgewählter Kohlenstoffzertifizierungssysteme

Um die Eignung von ergebnisbasierten und insbesondere Offsetting-Ansätzen für die Förderung einer klimafreundlichen Bodennutzung einzuschätzen, haben wir zehn Zertifizierungssysteme ausgewählt und bewertet. Unsere Auswahl umfasst sowohl führende Mechanismen (z. B. American Carbon Registry, Climate Action Reserve, Gold Standard und Verra Voluntary Carbon Standard) als auch Mechanismen mit kleinerem Marktumfang (Care Peat, Nori, Ökoregion Kaindorf). Zusätzlich zu diesen nichtstaatlichen Mechanismen haben wir klimafreundliche Bodenbewirtschaftungsmethoden im Zusammenhang mit drei staatlichen

Systemen bewertet: dem Alberta Offset System, dem Australian Emissions Reduction Fund und dem französischen Label bas Carbone. Anhand von strukturierten Leitfragen haben wir spezifische Methoden innerhalb dieser Mechanismen bewertet, um einzuschätzen, wie sie zentrale Aspekte wie Quantifizierung, Zusätzlichkeit, Nicht-Dauerhaftigkeit, Doppelzählung, ökologische und soziale Standards und Governance behandeln.

Unsere Evaluierung der Zertifizierungsmethoden zeigte viele Schwachstellen bei den derzeitigen Zertifizierungssystemen für eine klimafreundliche Bodennutzung auf:

- **Quantifizierung**: Schwache Anforderungen an die Überwachung und Probenentnahme sowie unzureichende Baselines ermöglichen keine solide und konservative Quantifizierung der Minderungsergebnisse und gefährden die Umweltintegrität der ausgestellten Emissionsgutschriften.
- **Zusätzlichkeit**: Insgesamt ist es unwahrscheinlich, dass die von uns bewerteten Methoden gewährleisten, dass Projekte und ihre Minderungswirkungen zusätzlich sind, auch wenn die Wahrscheinlichkeit der Zusätzlichkeit bei einigen Methoden höher ist als bei anderen.
- **Nicht-Dauerhaftigkeit**: Insgesamt stellen die bewerteten Methoden nicht sicher, dass die Minderungsergebnisse über lange Zeiträume hinweg Bestand haben. Nur drei der bewerteten Mechanismen verfügen über Maßnahmen zum Schutz von Minderungsmaßnahmen über einen Zeitraum von mindestens 40 Jahren, und diese weisen andere Mängel auf. Die Dauerhaftigkeit ist für die ökologische Integrität von grundlegender Bedeutung, aber bei klimafreundlichen Bodenbewirtschaftungsmaßnahmen nur schwer zu erreichen, da sie dauerhaft umgesetzt bleiben müssen.
- **Doppelzählung**: Insgesamt weisen die Methoden erhebliche Schwächen auf, wenn es darum geht, eine doppelte Anrechnung von Minderungsergebnissen zu vermeiden (z. B. innerhalb mehrerer Zertifizierungsmechanismen, mit anderen Finanzierungsinstrumenten oder mit nationalen Klimazielen), zudem sind die Informationen über Gutschriften und ihre Verwendung nicht ausreichend.
- **Umwelt- und Sozialstandards**: Insgesamt ist es unwahrscheinlich, dass die Methoden Umwelt- und Sozialstandards gewährleisten und positive Auswirkungen auf die nachhaltige Entwicklung haben, obwohl wir gute Beispiele identifiziert haben, die von allen Methoden umgesetzt werden könnten.
- **Governance**: Bei der Mehrzahl der untersuchten Programme deuten die verfügbaren Informationen über deren Governance darauf hin, dass die institutionellen Vorkehrungen und Prozesse solide oder recht umfassend sind.

Geeignete Finanzierungsinstrumente zur Förderung einer klimafreundlichen Bodennutzung

Maßnahmen zur klimafreundlichen Bodenbewirtschaftung sind verschieden. Ihre Unterschiede wirken sich auf ihre Eignung für eine handlungs- oder ergebnisorientierte Finanzierung aus. Wir führen eine schrittweise Bewertung durch, die die Anforderungen verschiedener Finanzierungsansätze und die Eigenschaften verschiedener Maßnahmen berücksichtigt, um herauszufinden, welche klimafreundlichen Bodenbewirtschaftungsmaßnahmen für eine Förderung durch eine handlungsbasierte oder ergebnisbasierte (ohne Offsetting) Finanzierung oder eine Finanzierung durch Offsetting geeignet sind. Wir kommen zu dem Schluss:

- **Handlungsorientierte Finanzierungsansätze sind für viele klimafreundliche Bodenbewirtschaftungsmaßnahmen geeignet.** Die meisten von uns bewerteten Maßnahmen bieten ein gewisses Minderungspotenzial und positive ökologische und soziale

Auswirkungen. Risiken der Nicht-Dauerhaftigkeit sind allerdings weit verbreitet und müssen berücksichtigt werden.

- **Ergebnisorientierte Finanzierungsansätze (ohne Offsetting) sind für einige klimafreundliche Bodenbewirtschaftungsmaßnahmen** (z. B. Wiedervernässung von organischen Böden, Umwandlung von Ackerland in Grünland, Pufferstreifen) **überwiegend geeignet**, für andere Maßnahmen teilweise. Aufgrund fehlender kostengünstiger und robuster Quantifizierungsmöglichkeiten sind andere Maßnahmen für eine Förderung auf diese Weise weniger geeignet.
- **Kompensationsansätze sind kein geeignetes Instrument zur Finanzierung klimafreundlicher Bodenbewirtschaftungsmaßnahmen**, da Bedenken hinsichtlich der Umweltintegrität aufgrund der Nicht-Dauerhaftigkeit, der Zusätzlichkeit und der Quantifizierungsunsicherheit bestehen.
- **Andere ergebnisorientierte Ansätze (Beitragsforderungen und öffentliche ergebnisorientierte Finanzierung) bieten für einige klimafreundliche Bodenbewirtschaftungsmaßnahmen einen attraktiven Weg, um einen umweltverträglichen Klimaschutz zu erreichen.**

Übergreifende Schlussfolgerungen

- Naturbasierte, klimafreundliche Bodenbewirtschaftungsmaßnahmen bieten ein erhebliches Potenzial zur Eindämmung des Klimawandels, während sie gleichzeitig die biologische Vielfalt fördern und die Erreichung anderer gesellschaftlicher Ziele unterstützen.
- Zusätzliche private Finanzierungsinstrumente sind nur ein Teil des Puzzles - es bedarf eines umfassenderen, unterstützenden Regulierungsumfelds auf EU-Ebene und in den Mitgliedsstaaten. Andere Ansätze, wie z. B. ordnungsrechtliche Vorschriften oder Förderinstrumente (z. B. zur Weiterbildung von Landwirten), werden für einige Maßnahmen kostengünstiger sein und sollten neben Finanzierungsansätzen in Betracht gezogen werden. Es muss sichergestellt werden, dass die Finanzierungsstrukturen der Gemeinsamen Agrarpolitik auf Nachhaltigkeit abzielen.
- Nachhaltigkeit in der Landwirtschaft erfordert einen systemweiten Wandel. Neben den Anreizen für Landwirte muss die Politik den Wandel entlang der Wertschöpfungskette und bei den Verbrauchern fördern.

Die Förderung klimafreundlicher Bodenbewirtschaftungsmaßnahmen muss zukunftsorientiert sein: dazu gehört die Unterstützung von Innovationen (in Form neuer Überwachungstechnologien oder veränderter Praktiken der Landwirte) und die Entwicklung anpassungsfähiger Finanzierungsansätze, damit eine Anpassung an künftige regulatorische Veränderungen und steigende Klimaambitionen möglich ist.

1 Introduction

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. Globally, soils store at least as much carbon as the vegetation and the atmosphere combined (Crowther et al. 2019). The IPCC (2022) conclude that the expected technical global potential from agricultural carbon sequestration 2020-2050 is 9.5 Gt CO_2e/yr, with 3.4 Gt CO_2e/yr economically feasible at costs of less than 100USD/t CO_2e (IPCC 2022, p. 776). In the EU, modelling suggests that at costs of €100/t CO_2e, action on agricultural land can deliver more than 50 Mt CO_2e/yr by 2030, equivalent to increasing the current LULUCF net sink by 20% (EC 2021, p. 77).

Climate-friendly soil management measures aim to reduce emissions and/or sequester carbon. The measures can be distinguished into two categories: 1) Land use change measures e.g. conversion of arable to grassland, prevention of land take, rewetting of peatlands and organic soils and 2) management measures, which adapt an existing land use e.g. crop rotations, incorporating residue or other inputs into soils, and also include technical fixes such as biochar or reduced compaction (Ecologic Institut; Universität Gießen; Oeko-Institut 2022). The mitigation contribution of management measures often depends on the continuation of these measures as their effects might end if the management is altered again. The risk of reversing mitigation outcomes of management measures is therefore particularly high.

Climate-friendly soil management measures can be **nature-based solutions**, that is "appropriate, adaptive actions to protect, sustainably manage or restore natural or modified ecosystems in order to address targeted societal challenge(s) - such as climate change mitigation -, while simultaneously enhancing human well-being and providing biodiversity benefits" (Oeko-Institut; Ecologic Institut 2022).[3] However, care must be taken to avoid non-NbS measures, some of which can have negative social or environmental impacts (Rumpel et al. 2020). The unique characteristics of individual measures makes them more or less suited to being promoted through different types of policy instruments.

To promote the implementation of climate-friendly soil management measures, different policy instruments are available. These include incentive-based approaches as well as other approaches, including command-and-control instruments, subsidy reform, and facilitating instruments (OECD 2022). Incentive-based approaches create economic incentives to implement climate-friendly soil measures. These can be further differentiated into result-based payment approaches, which make a payment dependant on the achievement of a mitigation result, and action-based approaches, where payments are made ex ante for implementing specific activities whose effects are not necessarily monitored (COWI, Ecologic Institute, IEEP 2021). Offsetting approaches are a specific subset of result-based payment schemes, which are often promoted as an opportunity to generate private funding for climate-friendly soil management through voluntary carbon markets. Under offsetting approaches, a buyer pays others to mitigate as a substitute for mitigating themselves (or within their own value chain), and then count that towards their own (voluntary) climate target. Offsetting has been promoted as an effective way to generate economic incentives for farmers to sequester carbon in soils (Keenor et al. 2021) .

While offsetting can be attractive to policy makers, a number of specific challenges must be addressed to ensure that they offer "environmental integrity" (that is, they must lead to

[3] This working definition has been developed for the purposes of this research project in 2021. A multilaterally agreed definition of NbS that resembles this definition was adopted by the United Nations Environment Assembly (UNEA) in 2022, see https://wedocs.unep.org/bitstream/handle/20.500.11822/39864/NATURE-BASED%20SOLUTIONS%20FOR%20SUPPORTING%20SUSTAINABLE%20DEVELOPMENT.%20English.pdf?sequence=1&isAllowed=y.

aggregate global GHG emissions that are lower than they would have been without the use of the offsetting mechanism) (Schneider and La Hoz Theuer 2019). The quantification of carbon stored in soils, the challenges of ensuring additionality, carbon leakage, non-permanence and double counting can be particularly challenging to address in the case of climate-friendly soil management (Paul et al. 2023). These, along with other risks related to promoting climate-friendly soil management (including land use competition, impacts on soil health, biodiversity impacts, ownership and rights to use of soils and social impacts) must be carefully managed to ensure that they are socially beneficial and effective (Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

Despite these concerns, the last decade has seen increased interest in offsets generated through climate-friendly soil management.[4] This is particularly visible in the voluntary carbon market, with numerous new voluntary carbon mechanisms and new methodologies being developed (Environmental Defence Fund 2021b). For example, since its 2018 launch, the French Government's voluntary carbon mechanism Label bas Carbone has released five methodologies related to climate-friendly soil management.[5] At the European level, in 2024 the EU agreed upon a regulation establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products (EU 2024). This framework will certify removals and emission reductions generated by "carbon farming" (including soil carbon sequestration and reduced emissions from soils, e.g. through rewetting of organic soils or reduced fertiliser use). This framework leaves open the potential for these certified removals to be used for different uses, including meeting national climate targets and offsetting.

This use of offsetting to promote climate-friendly soil management has been criticised. This includes a general critique of offsets and particularly those generated by nature-based solutions as being over-credited and non-permanent (see e.g. Greenfield 2023). Specific to soil carbon, the Environmental Defense Fund (Environmental Defence Fund 2021a) have argued that "market interest is running ahead of the foundational and carbon accounting science". Critics argue that this manifests as flawed voluntary carbon market soil carbon methodologies, which fail to adequately address the risk of sequestered carbon being reversed to the atmosphere, have high uncertainties regarding the quantification of carbon stock changes over time, and inadequately assure that credited mitigation is additional (i.e. goes beyond what would have occurred in the absence of the carbon market incentives) (Environmental Defence Fund 2021b; CarbonPlan 2021b; Paul et al. 2023). Oldfield et al. (2022) argue that, accordingly, current soil carbon crediting mechanisms pose a significant risk of generating credits that are non-equivalent (i.e. they are not comparable to emissions reductions in other sectors), and therefore risk undermining confidence in soil carbon crediting programmes.

This report evaluates how climate-friendly soil management in Europe should be funded to deliver climate mitigation and support the agriculture sector's transition to a net-zero future. The report proceeds as follows:

- **Chapter two evaluates 15 climate-friendly soil management measures** in terms of their mitigation potential, co-benefits, quantifiability, leakage, non-permanence, and additionality, to identify which measures should be promoted, using what funding instruments, and under what conditions.

[4] Ecosystem Marketplace report „Agriculture" sector credits transacted increased from the equivalent of 0.5 $MtCo_2$-e in 2020 to 1 $MtCO_2$-e in 2021 (Forest Trends Ecosystem Marketplace 2022)

[5] CarbonAgri, Hedges, Plantation of orchards, SOBAC'ECO TMM (input management), Field crops (see https://label-bas-carbone.ecologie.gouv.fr/presentation-des-methodes-du-label-bas-carbone)

- **Chapter three assesses the main incentive-based approaches to promote climate-friendly soil management practices (action- and result-based)**, highlighting the main advantages and disadvantages associated with each approach, and summarising past experience with public result-based approaches.
- **Chapter four synthesises our assessment of ten carbon crediting methodologies for climate-friendly soil management.**[6] We assess how they address the challenges of quantification, additionality, non-permanence, double-counting, environmental and social safeguards, and governance.
- **Chapter five evaluates the appropriateness of funding instruments in the context of climate-friendly soil management,** assessing which measures are best suited to action- or result-based payments. Drawing on our evaluation of crediting methodologies, we identify the unaddressed challenges of offsetting for climate-friendly soil management.
- **Chapter six** concludes and identifies potential pathways forward for funding climate-friendly soil management.

[6] The detailed assessments of the ten methodologies are published separately as an Annex to this report, see https://www.umweltbundesamt.de/publikationen/annex-analysis-ten-crediting-methodologies-soil-management.

2 Measures to promote climate-friendly soil management

2.1 Climate-friendly soil management measures

There are many climate-friendly soil management measures that could be implemented by European land users to reduce emissions from soils and sequester carbon. The measures have different attributes that make them more or less attractive as mitigation options to promote. For example, an important consideration is their mitigation potential, i.e. how many tonnes of carbon dioxide removals or emissions reductions from soils they could realistically deliver across Europe. Other issues are also important to consider when assessing which measures should be promoted, including environmental impact, additionality, quantifiability, leakage, and duration of emissions reduced from soils or carbon storage.

In this chapter, we introduce 15 climate-friendly soil management measures, and then evaluate them against six assessment criteria that are important to consider when deciding which measures should be promoted. This supports our evaluation in section 6.1.2, which concludes on which climate-friendly soil management measures should be promoted, using what funding instruments, and under what conditions.

Our evaluation draws on Frelih-Larsen et al. (2022), who identified and described climate-friendly soil management implementable in Europe, supported by additional literature review and expert judgment.[7] Drawing on Frelih-Larsen et al. (2022) we identify 15 climate-friendly soil management measures that can be implemented within Europe to reduce GHG emissions from soils or remove carbon from the atmosphere (see Table 1).[8, 9] We have selected only measures that can be considered as nature-based solutions[10] and implemented by individual farmers or project developers, i.e. at the farm scale. The measures are a mix of land use change and agricultural management change measures (i.e. where the land use remains the same). Land use change measures are often more significant in scale, cost and complexity of implementation. The measures also differ in terms of whether they reduce current GHG emissions from soils or will remove carbon from the atmosphere.[11] Our evaluation assesses each measure as a standalone action, however, when considering results it is important to recognise that they will often be

[7] We carried out an initial evaluation of the evidence gathered in Frelih-Larsen et al. (2022), augmenting with additional literature. Evaluations were summarised in a table, which was then presented to three soil experts (Dr. Ana Frelih-Larsen, Prof. Dr. Andreas Gattinger, Dr. Wiebke Niether). The experts assessed and gave feedback on the initial evaluations, and discussed them in a workshop to reach an agreed evaluation, which we report here, along with key references from the literature. To increase the robustness of our results, it would be useful to repeat the expert workshop but feature a greater number and breadth of experts in the evaluations and peer review.

[8] Frelih-Larsen et al. (2022) identify 22 measures. From that list, we exclude precision farming and nitrification inhibitors (due to them not being nature-based and being primarily emissions-focussed), organic farming (due to it being a collection of multiple individual actions already represented in our list), and prevention of land take (to keep focussed on actions implementable by farmers; prevention of land take in section 2.2.7). We also group some individual measures: Silvoarable agroforestry (including hedgerows) and silvopastoral agroforestry; inclusion of forage legumes in crop rotations and Inclusion of grain legumes in crop rotations. Some minor edits to definitions were made to improve clarity.

[9] Ten of these measures are described in detailed factsheets in Frelih-Larsen et al. (2022): Silvoarable agroforestry, silvopastoral agroforestry, prevention of land take, improved crop rotation, mixed crop-livestock systems, reduced soil compaction, nitrification inhibitors, precision farming, low-input grasslands, organic farming, critical external inputs (off-farm compost, off-farm manure and biochar). The factsheets describe the measure, assess mitigation potential, evaluate co-benefits and trade-offs, and identify implementation challenges.

[10] Nature-based solutions are "locally appropriate, adaptive actions to protect, sustainably manage or restore natural or modified ecosystems in order to address targeted societal challenge(s) – such as climate change mitigation, while simultaneously enhancing human well-being and providing biodiversity benefits" (Oeko-Institut; Ecologic Institut 2022). This working definition developed for the purposes of this research project resembles the multilaterally agreed definition of NbS adopted by UNEA in 2022, see footnote 3 above. Some types of mulching (plastic mulching) are not nature-based.

[11] In this report we refer to reduced emissions and removals, where reduced emissions are a reduction relative to current emissions (i.e. reduced loss of stocks), and removals are the sequestration of carbon (i.e. adding to stocks). "Avoided emissions" are considered the same as reduced emissions; we do not use this term.

implemented as part of a suite of measures. Our evaluation considers the EU scale: it is important to note that the impacts of the measures may differ considerably depending on local context (e.g. soil type, starting point, farmer skill, etc.). Under section 2.2.7 we evaluate biochar separately as this measure does not meet the requirements of nature-based solutions.

Table 1: Climate-friendly soil management measures in the EU

	Mitigation measure	Description
Land use change, grasslands and set-aside areas	**Conversion from arable land to grassland**	Converting arable land for the purpose of grazing or fodder production to sequester carbon and reduce emissions (Vleeshouwers and Verhagen 2002; Don et al. 2009).
	Rewetting of organic soils	The deliberate action of raising the water table on drained soils to re-establish water-saturated conditions to restore wetlands and reduce emissions from drainage (Tiemeyer et al. 2020; Schumann and Joosten 2008). Rewetting these soils also creates suitable conditions for removing carbon from the atmosphere (Wilson et al. 2016a).
	Silvoarable and silvopastoral agroforestry	Silvoarable agroforestry consists of woody perennials such as trees or hedges and agricultural, usually annual, crops grown on the same cropland in a specific spatial and/or temporal fashion to sequester carbon and reduce emissions (e.g. from fertiliser use) (Cardinael et al. 2017; FAO; ICRAF 2019). Silvo-pastoral agroforestry refers to a mild-successional system of grasslands interspersed with trees and shrubs (Jose and Dollinger 2019).
	Mixed crop-livestock systems	Farm-scale systems where livestock and cash crop production are combined to optimise resource efficiency, sequester carbon, and reduce emissions (e.g. from off-farm fertiliser) (FAO 2001; Ryschawy et al. 2012; EIP-AGRI Focus Group 2017).
	Permanent grassland management	Managing grasslands to sequester carbon, i.e. in habitats with a mixture of native grasses, herbs and a low proportion of woody species (Gibson 2009).
	Low input grasslands / set-aside areas	Grassland managed with minimal or no external production inputs (e.g. mineral fertiliser and pesticides) to reduce emissions (e.g. from applying fertiliser) (Henderson et al. 2015).
	Buffer strips	Riparian buffers consist of woody and/or herbaceous crops located along water courses, maintained with permanent vegetation to control soil and water quality, erosion and other agricultural benefits, and to sequester carbon (Gilley 2005; Englund et al. 2021).
Management: Crop rotations	**Use of cover crops**	Cover crops are "plants that are grown in order to provide soil cover and to improve the physical, chemical, and biological characteristics of soil"(FAO 2011, p. 9) and sequester carbon. They can be sown independently or combined with the main crops. Also known as catch or green manure crops.
	Improved crop rotation	Crop rotation means cultivating different crops in a temporal sequence on the same land, compared to monocultures continuously growing the same crop, e.g. primary (wheat, maize) and secondary cereals (e.g. spelt, barley, triticale, oat), grain legumes, and temporary fodders, including forage legumes (Sumner 2018; Barbieri et al.). More complex crop rotations sequester more carbon (West and Post 2002). Note: some overlap with cover crop measures.

Mitigation measure		Description
	Include forage or grain legumes in crop rotations	Forage legumes (e.g. Alfalfa, white and red clover) are planted to provide ruminant animal feed and beneficial nitrogen fixation in soils (Graham and Vance 2003; Phelan et al. 2015). Grain legumes are members of the Fabaceae (Leguminosae), also called pulses, and are grown primarily for their edible seeds for humans and livestock, as well as providing nitrogen fixation in soils (Graham and Vance 2003). Inclusion of grain and forage legumes increases SOC sequestration (King and Blesh 2018).
Management: Residue, inputs	**Residue management**	Also known as green manuring, this includes all field operations from planting to harvest that affect the amount and distribution of all types of on-field residues, including crop, forest, sawmill, residues, etc. (NRCS 2006; Biala 2016). Incorporation of residues has been found to increase SOC (Lehtinen et al. 2014).
	Mulching*	The artificial application of off-site mulches (organic plant-/animal-derived like paper and stubble mulch, or inorganic-synthetic materials like plastic) to separate the soil surface from the atmosphere (Kader et al. 2017b). It may promote SOC sequestration by lowering SOC depletion and incorporation of organic matter (Zhang et al. 2017).
	Applying manure / compost	The use of biologically decomposed organic nutrients derived from organic waste materials mainly via the process of composting, for the purpose of soil amendment, which increases SOC (Doble und Kumar 2005; Bihn et al. 2014). Manure/compost can also be sourced from off-farm, e.g. municipal compost, though this poses some risks.
Management: Technical	**Contour farming / terracing**	Contour farming and terracing involve farming along the lines or constructing terraces on a slope in order to enable farming and e.g. reduce soil loss or water run-off (Britannica 2019; Petanidou et al. 2008), with potential impacts on carbon sequestration and GHG emissions (e.g. by reducing topsoil loss and increasing water retention) (Otieno 2018).
	Reduce soil compaction	Managing vehicle traffic to reduce soil compaction and thus protect soil functions and reduce N2O emissions (Horn et al. 1995; Schmeer et al. 2014).

Source: Authors' own compilation, based on Ecologic Institut; Universität Gießen; Oeko-Institut (2022)

Notes: *Non-organic mulch does not meet the criteria for nature-based solutions

2.2 Key issues to evaluate climate-friendly soil management measures

While all identified measures offer some potential for sequestering additional carbon or for reducing or avoiding emissions (from existing carbon stocks or release of other GHGs), they are not equally attractive as mitigation options. In this section, we identify key issues to consider when deciding which measures should be promoted, explain their relevance, and use them as criteria to evaluate measures.

Table 2 summarises our evaluation of measures using a traffic-light assessment. The specifics of each categorisation are described in the following sections of the report, but green indicates a positive assessment, yellow a mixed one, and red a negative one. For the mitigation potential, the understanding is slightly different: green indicates a high potential (H), yellow a medium potential (M), red a low potential (L); for the mitigation potential we also indicate the certainty of our evaluations (***high, **medium, *low, grey: very uncertain). A more detailed description of the definition and challenges around these key issues are included in the following sections. A more detailed version of the table is provided in Annex A.

Table 2: Evaluation of climate-friendly soil management measures

Measures	Mitigation potential		Co-benefits	Quantifiability	Leakage risk	Non-permanence risk	Additionality
	EU total	Per ha					
Conversion of arable land to grassland	M*	H***	H	M	H	L	M
Rewetting of organic soils	H***	H***	H	M	H	L	H
Silvoarable and silvopastoral agroforestry	H**	H**	H	L	M	L	M
Mixed crop-livestock systems	U	L*	H	L	M	M	M
Permanent grassland management	**	L***	H	M	L	M	M
Low input grasslands / set-aside areas	L*	L*	H	M	M	H	M
Buffer strips	M*	H**	H	M	H	M	L
Use of cover crops	M**	M**	H	M	L	H	L
Improved crop rotations	M**	M**	H	M	M	H	M
Inclusion of forage and grain legumes in crop rotations	M**	M***	H	M	M	H	L
Residue management	M**	M*	H	M	M	H	L
Mulching	U	U	M	M	M	H	L
Applying manure / compost	M**	M*	M	M	M	H	M
Contour farming / terracing	U	U	H	L	M	H	M
Reduced soil compaction	M*	M*	M	L	L	H	M

Source: Authors'own compilation and partly based on Ecologic Institut; Universität Gießen; Oeko-Institut (2022).
H = High, M = Medium, L = Low, U = Uncertain

2.2.1 Mitigation potential

A key factor for prioritising which measures to promote is their mitigation potential (including both carbon sequestration and reduced emissions). Here, two factors are important to consider: total mitigation potential, and mitigation per hectare (ha).

2.2.1.1 Total mitigation potential across Europe

To evaluate the total mitigation potential across Europe, we draw on the literature review in Frelih-Larsen et al. (2022) to identify best scientific estimates for expected GHG mitigation potential including increased carbon sequestration, reduced emissions from existing stocks, and indirect impact of other GHGs. These estimates are not available for all measures at the European scale, and where available are not consistently presented.[12] Accordingly, we use

[12] For example, some estimates are only available at the global scale, or if available at the EU scale, some calculate the technical potential, while others make more realistic assumptions to calculate the "economic" potential (i.e. those that may be realistically

expert judgment to assess the available literature and categorise each measure into three categories based on the expected additional Europe mitigation potential in 2030: high (more than 20 $MtCO_2e$/yr in Europe in 2030); medium (5-20 $MtCO_2e$/ yr); low (less than 5 $MtCO_2e$/yr). We also identify our confidence in our estimations.[13] Results are summarised in Table 2.

As shown in Table 2, measures offer a range of mitigation potentials. Particularly high total mitigation potentials are offered by rewetting of organic soils and agroforestry (Jia et al. 2019; Bossio et al. 2020; EC 2021). Most options are seen as individually offering medium total amounts of mitigation in 2030 (see Ecologic Institut; Universität Gießen; Oeko-Institut 2022). Our expert review concluded that low input grasslands offer a low mitigation potential, with the potential of three options so uncertain that we offer no estimate (mixed crop-livestock systems, mulching, and contour-farming/terracing). The potentials are reported at the EU scale; the relative potential of different measures may differ considerably in different Member States or regions. Accordingly, a low EU potential does not mean that the measure should have a low priority in all regions of the EU; but it is important to consider the local context. Overall, the results suggest that most measures should continue to be explored and promoted and there is no single solution alone to reducing emissions from and enhancing carbon sequestration in soils. This also suggests that funding schemes should promote multiple measures at once (rather than focussing on single activities; though rewetting of organic soils may be an exception).

Table 2 also reports the certainty of our estimates. Nine of the estimates are of medium certainty (i.e. we assess there is sufficient evidence for an informed guess). Only one estimate is of high certainty, rewetting of organic soils, which is based upon a number of global (e.g. Leifeld and Menichetti 2018; Griscom et al. 2017) and EU-specific studies (European Commission 2016). Seven estimates are of low (little evidence) or very low certainty (no good data). Overall, there is a high uncertainty in our estimates. To help guide policy, it is important to improve understanding of the potential of different measures, both through increased research in the realistic potentials of different measures, and increased standardisation of approaches to enable comparisons of different measures.

2.2.1.2 Mitigation per hectare

Mitigation per hectare offers another assessment of mitigation potentials. It is an indicator of value for investment: higher mitigation per hectare means that actions on smaller areas (or involving fewer land users) can deliver significant mitigation. This can be particularly important for farmers under result-based payments schemes, as high mitigation potential per hectare measures offer them greater income potential. It is also an indicator of affordability: implementing climate-friendly soil management measures can involve significant fixed costs (e.g. of learning, transaction costs), which are more likely to be offset by high mitigation per ha measures. Affordability and efficiency in this context though disregard any other positive effects resulting from the implemented measure, which might distort the overall economic benefits of an NbS measure.

Again drawing on the literature review in Frelih-Larsen et al. (2022), we identify best scientific estimates for per ha mitigation potential.[14] We categorise these into high, medium, and low

expected to be achieved, given barriers including cost). There are also different system boundaries applied, with some considering just carbon sequestration, others also including other gases and the net GHG effect, and different (or unclear) soil depths. Accordingly, while expert judgment has been applied to evaluate the differing data, results should be interpreted with considerable caution. Also the extent to which estimates consider expected carbon losses from soils (i.e. are net estimates) or whether they assume a baseline of zero losses from soils is inconsistent or unclear.

[13] High (good evidence), medium (reasonable evidence for educated guess), low(little evidence), very low (no good data)

[14] The same uncertainties apply to the mitigation per ha data, see discussion in previous footnote. We consider current estimates of mitigation potential per ha.

potential: high (more than 4 tCO_2e/ha/yr), medium (1-4 tCO_2e /ha/yr in Europe), low (less than 1 tCO_2e/ha/yr); we indicate the results and our certainty in our estimates in Table 2.

Table 2 shows that per ha mitigation rates vary quite evenly across the different measures. Four measures are classified as having a high mitigation per ha potential: the land use change actions of conversion from arable land to grassland (Vleeshouwers and Verhagen 2002), rewetting organic soils (UBA 2019), and agroforestry (Kay et al. 2019), as well as buffer strips (Borin et al. 2010). Six measures have a medium potential, including cover crop rotation measures (Abdalla et al. 2019; Poeplau et al. 2021), and with low certainty residue management, manure/compost application, and reduced soil compaction. The remaining measures offer low per ha mitigation, though the certainty of estimates is also low.

Overall, the certainty of mitigation per ha evaluations is higher than total EU mitigation evaluations. There is a high certainty of the mitigation per ha evaluation on conversion from arable land to grassland, rewetting organic soils, permanent grassland management, and inclusion of forage or grain legumes in crop rotations. Five measures were assessed as having a medium certainty. Only two measures were assessed as providing a very low certainty (mulching and contour farming). Two measures were assessed as having a medium mitigation per ha potential but a low certainty (residue management and reduced soil compaction); these should be prioritised for further research.

2.2.2 Co-benefits/environmental risks assessment

Agriculture is a key driver of pressures on the natural environment, placing pressures on biodiversity, soil health, water, and air (EEA 2019). Climate-friendly soil management measures that are nature-based solutions can deliver climate mitigation whilst improving social well-being and biodiversity enhancement (Reise et al. 2021). It is important that measures also avoid negatively impacting other environmental and social objectives, especially soil health and climate adaptation, that is, pose few environmental risks. Accordingly, at a minimum, climate-friendly soil management measures should do no significant harm to environmental objectives, as defined in the EU Taxonomy (Art. 17, EU 2020/852), including climate change mitigation, sustainable use of water and marine resources, the circular economy, pollution prevention and control, and biodiversity protection and restoration. Accordingly, a more stringent minimum standard that only supports actions that deliver climate mitigation and environmental benefits may be necessary to successfully transform the agriculture and land sector to sustainability. Nature-based solutions are intended to support the objectives simultaneously. Other environmental and social benefits, including climate change adaptation and yield, can also be particularly important to farmers, and should be taken into account when considering which measures should be promoted.

The measures differ in terms of the degree and type of co-benefits and environmental risks they offer. We draw on Frelih-Larsen et al. (2022) as well as expert judgment and wider literature to assess the balance of co-benefits and environmental risks posed by each measure. We categorise each measure as follows: green (delivering co-benefits and posing no significant environmental risks); orange (delivering co-benefits but posing some environmental risks in some contexts); red (posing significant environmental risks). We evaluate measures taking into account the EU scale but local context is important when assessing environmental risks.

As shown in Table 2, the majority of measures we consider deliver co-benefits with few environmental risks. A few, however, pose environmental risks. Mulching can pose risks if synthetic/non-organic mulches such as plastic are used (Kader et al. 2017a). Applying external inputs poses some risks to soil health (Chen et al. 2017), as does over-application or poorly timed application of manure to soils (Stock et al. 2019). We excluded from the main assessment of this report any measures that are not nature-based solutions; many of these pose more significant risks to biodiversity, e.g. synthetic nitrification inhibitors[15], which, while reducing nitrous oxide emissions, may negatively impact water and soil biodiversity, with further research required (Corrochano-Monsalve et al. 2021; Kösler et al. 2019). Similarly, biological nitrification inhibitors change natural soil functioning and can therefore be harmful, with further research also required (see factsheet in Frelih-Larsen et al. 2022 for further reading). Biochar is assessed separately in section 2.2.7, as it does not meet the definition of nature-based solution.

Generally, all measures must be implemented in such a way that they align with local soil and climatic conditions, and considering local environmental and social context. If not, even those measures we marked as green may pose some risks in specific contexts. For example, when converting arable land to grassland, care must be taken to ensure that this measure is locally appropriate and does not negatively impact endangered bird populations (Dicks et al. 2020). Rewetting organic soils must be done mindful of adapting to climate change and of local social and farmer impacts (Wilson et al. 2016; Leifeld and Menichetti 2018). While all other measures are assessed as being positive, providing environmental co-benefits, care must still be taken to ensure that the measures are locally adapted.

Those measures that pose significant environmental risks should not be promoted. Instead, a focus should lie on those that can deliver multiple societal benefits, rather than climate mitigation at the expense of biodiversity and other societal concerns. Some NGOs argue that instead of centring mitigation, policies should focus on restoring healthy agricultural and forestry ecosystems, with climate mitigation as a co-benefit (see e.g. EEB; FeedbackEU; Fern; FÖP; IFOAM; IATP 2023).

2.2.3 Robust quantification

Quantification refers to determining the mitigation impact of a measure, that is the change in soil carbon content and resulting carbon sequestration and/or emissions reductions. Quantifiability is essential to enable result-based carbon payments (see section 5.2) (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Other types of funding instruments (e.g. action-based payments) do not rely as much or do not rely at all on quantifying the mitigation impact. However, a number of evaluations of result-based approaches to soil carbon sequestration have identified that quantification is problematic and requires further research and development (Environmental Defence Fund 2021a; 2021b; CarbonPlan 2021b). Quantification can be based on direct measurement, modelling or combined measurement and modelling approaches, each of which has strengths and weaknesses (McDonald et al. 2021).[16] Since quantification is often challenging due to limited data availability, the principle of conservativeness should be applied in robustly quantifying the mitigation impact of a measure. Three aspects play a key role in quantifying mitigation impacts: the level of uncertainty of quantification (i.e. the expected error of measurement or modelling of emissions reductions and carbon sequestration and data availability), whether reliable baselines can be set,;[17] and leakage, which is considered separately in 2.2.4.

[15] See a detailed factsheet on nitrification inhibitors in Ecologic Institut; Universität Gießen; Oeko-Institut (2022).

[16] In-field measurements for soil carbon relying on remote sensor technique are under development and could potentially complement measurement and modelling approaches in the future, though their accuracy and cost are still under investigation.

[17] 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 that would occur without the policy intervention. Baselines can also be performance-based, setting a minimum standard (see also Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

The mitigation impact of different climate-friendly soil management measures can be quantified with different degrees of certainty. We draw on a literature review and expert judgment to assess how robustly the mitigation impact of each measure can be quantified, assessing against two criteria: the level of uncertainty of quantification, including baseline setting[18], and whether standardised approaches to quantification exist (i.e. are there existing methodologies and models).[19] We combine both criteria using expert judgment into an overall evaluation of robust quantification. In our evaluation, we consider each measure separately.[20]

Table 2 indicates the results of the assessment. For most of the agricultural measures assessed (11 out of 15) there are limits in robustly quantifying mitigation impacts (marked in orange). Measures are allocated an "orange" score due to our expert assessment that the measure can only be quantified with an uncertainty band of 20-60% and/or a lack of well-tested models for estimating mitigation impact. We find that the mitigation impact of four measures can only be quantified with high uncertainty:

- Agroforestry approaches are diverse across Europe, and there are few examples and a lack of experience quantifying agroforestry mitigation impacts and standardised approaches, with further research needed (Environment Agency Austria 2021);
- Mixed-crop livestock systems are complex and there is limited knowledge on the GHG impact of such systems (EIP-AGRI Focus Group 2017);
- Contour farming/terracing is infrequently implemented in Europe, with corresponding knowledge gaps (Panagos et al. 2015);
- Reduced soil compaction has overall positive outcomes related to soil health with limited information on the effects on SOC sequestration rates available in the literature (Frelih-Larsen et al. 2022).

2.2.4 Leakage risk

Leakage occurs when a mitigation activity leads to an increase in emissions (or decrease in sequestration) outside the activity boundary, thus reducing the net mitigation effect (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Three types of leakage can occur. **Direct leakage** occurs if the implementation of an activity directly causes a shift in the supply of products or services from one area to another (e.g. animals are moved outside the areas under consideration). **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. We categorise this into market leakage (i.e. if, by decreasing supply, the measure induces higher market prices and increased production and therefore emissions elsewhere) and upstream/downstream leakage (i.e. if the measure induces increased emissions up or down the value chain). **Ecological leakage** occurs when a measure induces emissions in hydrologically connected areas (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). If it is not appropriately managed or deducted, leakage will result in an overestimation of the measure's

[18] Green (no or low uncertainty, considering model/measurement and baseline setting - less than 20%), orange – (medium uncertainty, considering model/measurement and baseline setting - 20-60%), red – high uncertainty, considering model/measurement and baseline setting - more than 60%).

[19] Assessment score: Green (Well tested standardised approaches), orange (standardised approaches but no models), red (no standardised approaches).

[20] This can be inconsistent with how quantification is done through measurement, e.g. in some voluntary carbon market methodologies. There, multiple measures can be implemented simultaneously, with the overall mitigation impact quantified by measuring the change in soil carbon content.

impact on the atmosphere. While activity shifting can be effectively managed through mechanism rules, other types of leakage are more challenging to manage.

Different climate-friendly soil management measures pose differing leakage risks. While activity shifting can be effectively managed through mechanism rules, other types of leakage are more challenging to manage. Leakage assessments are often considered part of robust quantification of mitigation measures. Here we discuss leakage separately to bring more attention to and compare specific leakage risks of climate-friendly soil management measures.

We draw on expert judgment to assess each measure's risk of leakage. To assess the risk, we focus on two criteria. The first considers indirect leakage risk, i.e., whether the measure reduces agricultural production (which, by decreasing supply, can induce higher market prices and increased production and therefore emissions elsewhere).[21] The second criterion considers whether there is a significant risk of either ecological leakage or an increase in upstream or downstream emissions.[22] We combine these measures into an overall evaluation of leakage risk. We do not consider direct leakage in our evaluation, as this generally depends on the specific rules for policy implementation, rather than differing according to measure (see section 5.2).

Table 2 shows that most measures pose some risk of leakage. Only permanent grassland management, use of cover crops, and reduced soil compaction pose low leakage risks, as they do not reduce production and are unlikely to induce upstream emissions. Leakage risks are most pressing for the conversion of arable land to grassland (Milne et al. 2010), which decreases production and therefore poses market leakage risks. Rewetting organic soils potentially reduces production (depending on the use after rewetting e.g. paludiculture) and may in some instances cause ecological leakage risks that should be addressed (rewetting can affect water levels in ecologically linked areas) , however, given the high emissions reductions and relatively small change in land use associated with peatland rewetting, the estimated leakage effects are small (Willenbockel 2023).[23] Market leakage risks are significant for all measures that reduce production, e.g. through land-use change or land retirement (for buffers) or set-aside areas. Crop rotation measures can also pose some leakage risks if they reduce production. This risk is highly dependent on local context. Upstream/downstream leakage risks are less certain, with a potential risk apparent for all measures that use external inputs, such as fertiliser, manure application, residue management and mulching – here, it is crucial to consider the source material for these inputs and what they otherwise would have been used for and the associated mitigation impact of this alternate use, e.g. if manure is added to soil, but alternatively would have been used in a bio-gas unit, this could increase net emissions.

Measures with a high risk of leakage must not necessarily be excluded, however, it is important that mechanisms incentivising measures with a high risk of leakage understand this risk and develop appropriate approaches to manage and adjust for leakage as part of their approach to quantification. Section 5.2 discusses leakage at the level of result-based funding mechanisms and identifies how and to what degree leakage can be managed through mechanism design.

[21] Experts categorise each measure against this criterion as follows: green (measure does not reduce production); orange (uncertain impact on production and some risk of market leakage); red (measure reduces production, significant risk of market leakage).

[22] Green (no risk of ecological leakage or inducement of increases upstream/downstream emissions); orange (some risk of ecological leakage or inducement of increases upstream/downstream emissions); red (high risk of ecological leakage or inducement of upstream/downstream emissions).

[23] It is important to note that this evaluation does not consider other policy or societal changes that may reduce leakage pressures, e.g. falling demand for agricultural products could reduce the amount of leakage that eventuates.

2.2.5 Non-permanence

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. 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 (UBA 2022). While it is impossible to guarantee the permanent storage of stored carbon or carbon from removals by climate-friendly soil management activities, it is crucial to ensure storage for long time periods. This is because a reversal of mitigation results undermines efforts to meet long-term climate objectives, especially if removals or reduced emissions are used for offsetting, undermining the environmental integrity and leading to higher emissions to the atmosphere (Ecologic Institute; Oeko-Institut 2023). There is an ongoing discussion as to what can be considered "long-term" or permanent storage. Some argue that the definition of these terms should ideally match the life-time of CO_2 in the atmosphere before it is absorbed i.e. 300-1000+ years (which could be considered as permanent) (e.g. Ecologic Institut 2023), though this will be very difficult to make practicable for soil carbon removals due to e.g. risks of natural disturbances, shifting tenure rights, shorter planning horizons of farmers (Ecologic Institute; Oeko-Institut 2023). While the term "permanence" is often used in the debate about result-based funding mechanisms, we refer to "long-term storage" in this section in order to compare the time horizon for which individual climate-friendly soil carbon measures are likely to keep carbon stored.

Different climate-friendly soil management measures offer different potentials for carbon to be stored in soils over a period of time or to preserve carbon stocks. While removals or carbon stocks should ideally be preserved indefinitely from a climate perspective, this is not compatible with decisions on soil management and land use in practice. Nevertheless, climate-friendly soil management practices that increase soil organic carbon should be preserved as long as possible.[24] Therefore, measures with the highest potential for carbon to be stored in soils over a period of time should be prioritised. In the context of climate-friendly soil management, whether mitigation occurs through emissions reductions or removals does not affect the potential for non-permanence, as this is independent of the storage medium the mitigation is stored in (e.g. soil, above-ground biomass).[25]

We draw on expert judgment and a literature review to assess each measure's potential for long-term carbon storage. The assessment criterion considers how difficult it is to reverse the carbon stored.[26]

As shown in Table 2, we evaluate that nine out of 15 measures with carbon stored can easily be reversed (red). These measures are all management changes, that is agricultural practices that require management decisions on a year-to-year basis and therefore have a high potential for reversal. For example, the use of cover crops can be decided and changed on a yearly basis with many different influencing factors (weather condition, type of main crop, utilisation of the cover crop, etc.). We identify four out of 15 measures that are difficult or costly to reverse quickly (orange), increasing the likelihood that they could deliver relatively long-term carbon storage (mixed crop-livestock systems, permanent grassland management, and buffer strips). Only three

[24] Section 5.4 discusses how reversal risks can be managed by carbon crediting mechanisms to promote long-term storage.

[25] The mitigation achieved through climate-friendly soil management for carbon that is stored in soils and biomass is less permanent than reductions in emissions from fossil fuels. Reductions in emissions from fossil fuels are considered permanent based upon the assumption that fossil fuel reservoirs will not be exhausted, so any emissions reductions today will not be associated with later release of unused fossil fuels.

[26] Green (permanent storage), Orange (relatively difficult or costly to reverse quickly), Red (Easy to reverse, and few incentives to maintain stored carbon after funding ends)

measures are evaluated as being likely to offer long-term carbon storage (green). All of these measures are land-use changes, which usually involve intensive advisory services before and during the land-use change, complex implementation procedures and monitoring requirements, and often face legal restrictions for reversal (Paul et al. 2023). For example, rewetting drained peatlands on agricultural land is a highly effective mitigation measure, whose implementation results in an immediate cessation of carbon dioxide emissions that would otherwise continue (JRC 2020; Greifswald Mire Centre 2020). In most cases an individual farmer is not able to rewet their land without the collective participation of other landowners in the neighbouring area, who share the same drainage system, as well as the consent and cooperation of the local authorities. Large upfront costs also apply to the conversion of arable land to grassland and to agroforestry. High upfront costs and related high costs of reversal mean the likelihood of reversal once implemented is relatively low.

As discussed in more detail in section 5.44.4 the risk of reversal can be managed to some degree through design elements within the policy instrument, while long-term carbon storage and emissions reductions from soils can be incentivised. The fact that reversals can always occur due to natural processes or human-induced factors needs to be acknowledged in the policy instruments. Climate-friendly soil management practices with a high potential for long-term carbon storage and/or emission reductions from soils should be prioritised, while practices with a high risk of reversals should be treated with caution (including necessary safeguards) or excluded through eligibility criteria.

2.2.6 Additionality

Emission reductions or removals from climate-friendly soil management measures are additional if they would not have occurred without the incentives from the policy intervention (e.g. subsidies, or revenues from carbon credits) (Ecologic; Ramboll; Carbon Counts 2021). Additionality implies causality, i.e., the carbon funding is the reason the measure is implemented (UBA 2022).

Additionality is especially important if the mitigation generated by measures is to be used to offset emissions reductions elsewhere: in this case, non-additional mitigation would increase the total amount of GHGs in the atmosphere (Schneider and La Hoz Theuer 2019). However, even if mitigation is not used for offsetting, additionality is important for cost-effectiveness reasons; to maximise climate impact, carbon payments should go to those who deliver new, additional mitigation (Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

Additionality is inherently difficult to assess, as it implicitly demands considering a counterfactual (i.e. what would have happened without the policy incentive e.g. carbon payment). The complexity of the land sector, with its multiple drivers for actions, dysfunctional general economic principles of supply and demand and its dependency on EU and national subsidies, make it difficult to identify a single policy intervention as causal (UBA 2022). Furthermore, changes to EU policy on soils are expected over the coming years, as the EU Commission has defined the improvement of soil health as an essential mission; this may increase soil carbon storage or result in more ambitious policy, affecting additionality (Paul et al. 2023).

In this assessment we give an indication on how likely it is that an agricultural measure is additional or non-additional within the EU. We use a literature review and expert judgment to assess three separate predictors or elements of additionality, which we combine into a composite additionality score.

- The first criterion assesses whether the measure is **common practice** in Europe, which we assess based on expert judgment.[27]
- The second criterion assesses **financial additionality**, i.e. whether the measure is financially viable and attractive to farmers without carbon payments.[28]
- The third criterion considers **regulatory additionality**, i.e. whether there are regulations that require farmers to implement the measure or if the measure is a mandatory or voluntary element in the Common Agricultural Policy (CAP). Where measures are already funded through the CAP they would not be considered as additional.[29]

Table 2 shows a composite of these three elements: if the measure scores badly against any of these predictors, there is a high risk of non-additionality. While this could be to some degree managed by funding mechanism design, a high risk of non-additionality would make the measure inappropriate for generating offsets.

Results shown in Table 2 illustrate that almost all measures pose a significant risk of non-additionality. Only rewetting organic soils poses a low risk. It is not a common practice, due to generally high economic costs to farmers, and it is not required by regulation or significantly funded by existing EU policy. Many measures pose some risk of non-additionality. The most concerning are those with a high risk of non-additionality. Measures such as use of cover crops, inclusion of forage and grain legumes in crop rotations, and buffer strips score poorly against each indicator of non-additionality, and therefore should be considered to include a very high risk of non-additionality – our expert assessment identifies that these are often common practice, financially viable, and supported by CAP. Other measures such as residue management and mulching can have low costs and may be financially viable without carbon credits, i.e. pose a significant risk of not being financially additional. Overall, financial additionality and regulatory additionality pose the most significant risk, emphasising that common practice assessments alone will be insufficient to weed out non-additional measures. Generally, the large number of medium- and high-risk measures in our assessment underlines the need for any policy instrument promoting measures to thoroughly assess the additionality of individual projects, and exclude those that are found to be non-additional. Our assessments are based on current policy and economics – the dynamic nature of agricultural markets and policy mean these assessments will be quickly out-of-date. For example, the EU Soil Law was proposed in June 2023 and may establish new minimum regulatory standards. Shifting economic conditions will also likely influence additionality: even those measures that currently have a low risk of non-additionality will need to be regularly reassessed.

[27] We categorise these using thresholds applied by the Clean Development Mechanism: Green: Not common practice (less than 2.5% of farmers); orange: relatively uncommon (less than 20% of farmers); Red: Common practice: more than 20% (UNFCCCC 2015). For most of the measures assessed, there is little data to accurately evaluate these on field level (e.g. how many farms/ha in Europe apply agroforestry). More accurate and granular GHG inventories are needed for a better understanding of the degree to which specific management practices are widespread or implemented at large scale. Accordingly, our assessment relies on expert judgment, though with some uncertainty.

[28] This criterion also considers any public payments for the measure (e.g. through CAP), as well as whether there are other significant barriers to implementation: green (economic costs outweigh benefits and/or significant barriers for all farmers); orange (economic costs outweigh benefits and/or medium barriers for most farmers); red (economic benefits outweigh costs and no significant barriers for most farmers).

[29] Evaluation: Green (no regulatory requirements or existing funding); orange (voluntary measures in CAP in some Member States, e.g. rural development/eco-schemes; red (regulatory requirements in some Member States or part of CAP cross compliance standards (Good Agricultural and Environmental Conditions). We include consideration of CAP due to its central role in establishing and supporting agricultural practice in Europe. See Annex A for evaluation of regulatory additionality of different measures.

2.2.7 Other considerations

A number of other criteria could be considered to evaluate which climate-friendly soil management measures should be supported as a priority. Here, we focus on three: profitability, scope of action, and economic considerations. These criteria are not part of the evaluation of climate-friendly soil management measures and are therefore not reflected in Table 2.

Profitability (and cost-effectiveness, e.g. costs per tonne of mitigation) can be an important criterion for policymakers prioritising measures to support, in particular as it is important for farmer uptake. This element is somewhat captured in previous criteria (mitigation potential: mitigation per ha; additionality: financial additionality). Profitability of measures depends on benefits (e.g. productivity increases) and costs, which in the agriculture sector are driven by opportunity costs, as well as costs of implementing measures (including farmer time), and for some measures, cost of inputs (e.g. seedlings for agroforestry systems). Farmers should also consider the benefits of reducing risks (e.g. preventing yield loss due to climate change or deterioration of soil health and quality over time). Consistent, EU-wide data on costs is difficult to gather, and may not be applicable in all EU contexts (e.g. due to the driving role of local context in determining opportunity costs).[30] Cost will be an important criterion for targeted public or private funding.

Scope of action: Our evaluation focuses on actions implementable by an individual farmer. These actions can be effectively incentivised by market-based or other individual incentive-based funding mechanisms. However, other scopes of action are possible and offer significant potential. Land take poses a significant source of emissions within the EU, as agricultural land is sealed as part of transition to housing, industrial, or other use – between 2012 and 2018, land take around urban areas alone reduced soil carbon sequestration capacity by 4 Mt (EEA 2021). Land take cannot be addressed by individual incentives but instead requires regional or Member State regulatory approaches, such as restrictions on development, binding limits, and strategic planning to reduce pressures (Naumann et al. 2018). Relatedly, while our evaluation considers measures in isolation, farmers are likely to implement these as part of a package of measures; their combined impact should be considered.

Economic considerations: There are also other economic effects that need to be taken into consideration such as the abatement costs for climate change mitigation in other sectors, the external costs of environmental degradation which are not reflected in the consumption prices and the positive economic benefits of integrating social and environmental services into result-based payment schemes.

In section 6.1.2, we reflect on the conclusions of the above considerations regarding which climate-friendly soil management measures should be prioritised in being promoted by different types of funding instruments.

Biochar

Biochar is an external input that consists of charcoal produced by pyrolysis (heating under limited or no oxygen conditions), that stores carbon and can be incorporated into soils (Doble and Kumar 2005; Cornell CALS 2014; Beusch 2021).

[30] Some studies are available at national level: For example, SRUC; Ricardo-AEA (2015, p. 140) develop a marginal abatement cost curve for the UK. Their selection of measures is broader and with some differences to our selections. They find that in the UK context negative or low cost options include manure management, improved crop rotations, reduced soil compaction, and afforestation (potentially including agroforestry). They find cover crops and integration of legume in crop rotations to be the most expensive.

Biochar does not meet the criteria for nature-based solutions. It is not a removal method in itself but a form of carbon storage as the removal occurs during biomass growth (Oeko-Institut 2023). While emission reductions associated with biochar are well studied, the evidence of the long-term impact on soil carbon sequestration rates within the EU remains scarce (Griscom et al. 2017) (Ding et al. 2016). Further, biochar mitigation potential estimates are contested due to competition for biomass, the environmental impacts of biochar on the soil microbiome and air quality, as well as albedo effects (Fuss et al. 2018). Characteristics of biochar differ depending on source material and how it is produced (especially related to pyrolysis temperature). Criteria related to soil and climate conditions as well as biomass origin and energy used for the pyrolysis remain to be defined to clarify the conditions under which biochar may be a sustainable and environmentally-sound mitigation option.

In particular, uncertainties about the impacts of biochar on soil health and biodiversity argue for restricting funding for the widespread upscaling of biochar until further research identifies the conditions (soil type, climatic conditions etc.) under which biochar may safely be applied and establishes sustainability criteria for its implementation (e.g. in terms of the origin of biomass and the production process).

Nevertheless, biochar remains a soil management practice intensively discussed in scientific literature and as part of the EU Carbon Removal Certification Framework. Therefore we evaluated biochar against the same assessment criteria from Chapter 2. The assessment can be found in Table 3.

Table 3: Evaluation of biochar as a soil management measure

Measure	**Mitigation potential** (system boundary including source biomass)[31]		**Co-benefits**	**Quantifia-bility**	**Leakage risk**	**Non-perma-nence**	**Additio-nality**
	EU total	**Per ha**					
Biochar	High**	**	Low	Medium	Medium	Low	High

Source: Authors' own compilation and partly based on Ecologic Institut; Universität Gießen; Oeko-Institut (2022)
See section 2.2 for description of interpretation.

2.3 Conclusions: Prioritising climate-friendly soil management measures

Climate-friendly soil management measures can deliver climate mitigation as well as a suite of co-benefits, generating significant net social benefit. Frelih-Larsen et al. (2022) suggest that in Europe these measures could deliver 71 to 113 Mt of mitigation, supporting the attainment of EU climate objectives. However, climate mitigation, as well as social benefits such as biodiversity provisions, generate few financial rewards for farmers. Furthermore, according to Jackson Hammond et al. (2021), the implementation of regenerative agricultural practices often involves high costs, including changes to equipment to plant into heavier residue, or operational costs for

[31] The mitigation potential of biochar depends on the system boundary considered, and the source of biomass. Our evaluation here includes the source biomass (e.g. straw, crop remains) that would relatively quickly break down and emit carbon if not transformed into biochar. Fuss et al. (2018) raises concerns regarding the availability of source biomass, given competing biomass demands (Fuss et al. 2018). As mentioned in the box text, evidence on biochar's effects on soil carbon sequestration is scarce (Griscom et al. 2017); (Ding et al. 2016). Our evaluation of mitigation potential assumes no additional soil carbon arises following biochar application ("priming").

e.g. purchases of cover crop seed. Funding instruments for the implementation of measures could support their uptake.

In this section, we draw conclusions from the above analysis regarding which climate-friendly soil management measures should be promoted with regard to the six key criteria. However, other criteria could lead to a different result. Climate-friendly soil management measures are diverse and offer different opportunities and risks for funding through different types of funding instruments. When considering which of the 15 measures analysed above to promote at all, four criteria are crucial: mitigation potential, co-benefits/environmental risks, leakage, and long-term carbon storage.

Co-benefits/environmental risks should be an exclusionary criterion: only measures that pose no significant risks to other environmental objectives (e.g. biodiversity, water quality/quantity, etc.) should be promoted. **Those measures that deliver greater co-benefits should be prioritised**.

Long-term carbon storage is a key concern: only measures that keep GHGs out of the atmosphere cumulatively in the long term will deliver climate benefits. This is a challenging criterion for climate-friendly soil measures, given the high risk of reversal for soil carbon sequestration measures (Paul et al. 2023). Our assessment in section 2.2.5 identified three out of 15 measures that are difficult or costly to reverse quickly, increasing the likelihood that they could deliver relatively long-term carbon storage (mixed crop-livestock systems, permanent grassland management, and buffer strips). Only three measures were evaluated as more likely to offer long-term carbon storage (rewetting organic soils, agroforestry and grassland conversion). Other measures are easily reversed and therefore unlikely to offer permanent storage. **If measures with high risks of non-permanence were to be promoted, they would need to be accompanied by incentives to support long-term storage** (e.g. those described in section 5.4.1).

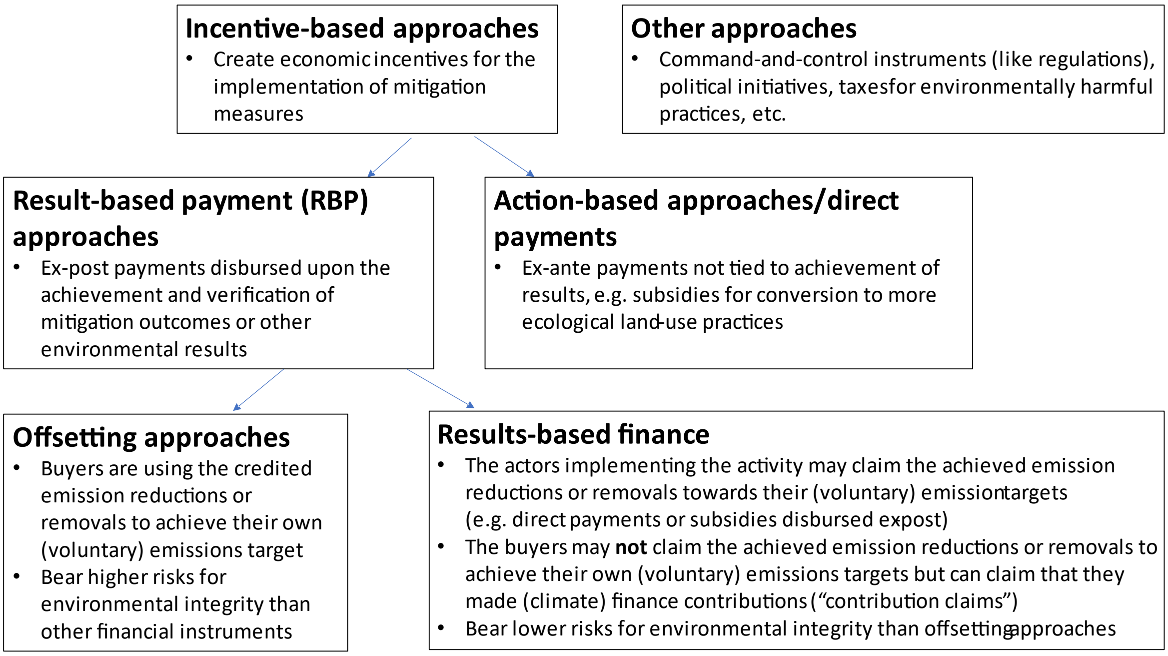
Mitigation potential indicates which measures deliver the most climate impact, and can therefore be used to order which measures are prioritised. Those measures with low mitigation potential should not be excluded, as they may still deliver significant societal benefits once co-benefits are considered. When considering potential, the context of the policy instrument should be considered: our evaluation considers the EU potential. In some local contexts, measures that we assess as offering a high potential at the EU scale may deliver little benefit and vice versa, e.g. peatland rewetting will deliver limited mitigation outside of peatland-rich areas in Europe's north (Tanneberger et al. 2017).

Leakage should also be considered when prioritising which measures to promote. Many measures pose risks of leakage, which would undermine the positive mitigation impact of climate measures. In particular, the conversion of arable land to grassland, rewetting of organic soils, and buffer strips pose significant leakage risks. Any funding of these measures must adjust for leakage and should be accompanied by measures to reduce leakage, as discussed in section 2.2.6.

3 Funding instruments for climate-friendly soil management

Different types of instruments have been used over time to promote the adoption of climate-friendly soil management - with varying levels of success (Figure 1). These include incentive-based approaches, which are at the focus of our analysis, and a range of other approaches, such as regulations or political initiatives. Incentive-based approaches create economic incentives to implement climate-friendly soil measures. These can be further differentiated into result-based payment approaches, under which a payment is made upon the achievement and verification of a mitigation outcome (or other environmental result,)[32] and action-based approaches (or direct payments) where the payment is received in return for certain actions being taken or practices being avoided. Under both approaches, the payments could be made by international institutions, governmental authorities, or non-governmental actors such as companies. Result-based payment approaches include result-based finance as well as offsetting approaches. Under result-based finance approaches, the donors or buyers do not claim the achieved emission reductions or removals to achieve their own emissions targets but may claim that they made (climate) finance contributions (also referred to as "contribution claims"). Under offsetting approaches, the buyers may use the credited emission reductions or removals to achieve their own emission targets. Ten selected crediting methodologies applying these approaches are analysed in detail in Chapter 5.

Figure 1: Differentiation of types of funding instruments



Source: Authors' own illustration

In the following sub-sections, we further describe action-based and result-based funding approaches in the context of climate-friendly soil management practices (section 3.1). We then

[32] The concept of result-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 (New Climate Institute 2020a). Additionally, it is extensively discussed in the context of funding for REDD+ activities (see e.g. Wong et al. 2016).

highlight their main advantages and disadvantages. We compare action-based and result-based approaches with regard to:

- their **environmental integrity** (see Box below), focusing on the degree of certainty to which it is ensured that mitigation results are actually achieved; the additionality of mitigation activities; non-permanence risks; and the risk of creating perverse incentives for participants;
- their **economic efficiency** in terms of transaction costs' cost-effectiveness and their ability to provide innovation incentives over time (see Oeko-Institut 2015, p. 28); and
- other considerations, including **acceptance of such approaches by land managers as well as social and environmental impacts.**

The analysis focuses on these general features of these instruments and does not limit the consideration to the specific policy context of the EU. Section 6.1 draws conclusions from the analysis in this chapter and discusses the appropriateness of these funding instruments in the context of promoting climate-friendly soil management measures. Further note that this section focuses on incentive-based approaches and does not discuss other approaches, such as regulations. Section 6.3 briefly discusses the use of other approaches to promote the adoption of climate-friendly soil management practices.

Environmental integrity

The concept of *integrity* is used differently in different contexts of environmental policies. In the context of carbon markets, the term **environmental integrity** is used to refer to the aim that **a crediting mechanism must not lead to aggregated GHG emissions that are higher than they would have been without the use of the mechanism**. This is similar to the definition in international climate negotiations on carbon market approaches where environmental integrity is considered to be fulfilled if "there is no net increase in global emissions within and between NDC implementation periods" (Decision 3/CMA.3)[33]. In this context, four matters are critical for ensuring environmental integrity: robust accounting; the quality of credits; the ambition and scope of the mitigation target of the transferring country; and incentives or disincentives for future mitigation action (Schneider and La Hoz Theuer 2019)[34].

An alternative understanding suggests that environmental integrity does not only require that aggregated global emissions do not increase as a result of using a crediting mechanism but that they must decrease emissions and therefore **lead to enhanced ambition**. While there is no question that environmental policies should at least have a positive impact on climate mitigation, in contexts of carbon markets this is usually captured by the term **environmental effectiveness** rather than environmental integrity (Betz et al. 2022). Moreover, in the international negotiations under the UNFCCC, enhancing ambition and environmental integrity are laid down as two separate objectives for cooperative approaches under Article 6.2 of the Paris Agreement.[35]

In contexts beyond international climate policy, the concept of environmental integrity can have different meanings. From an **ecological perspective**, for example, the term can be understood to

33 UNFCCC (2021): Decision 3/CMA.3 - Rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement. Downloadable under https://unfccc.int/event/cma-3#decisions_reports

34 Schneider and La Hoz Theuer (2019) focus on the context of international trade of credits; here we adapt their conclusions for the context of this paper.

35 UNFCCC (2015): Adoption of the Paris Agreement. Downloadable under https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

embrace "a complex set of concepts that describe a healthy natural system that can support essential processes" (Payne 2017, p. 42). From this understanding, it can be derived that a specific policy instrument or measure achieves environmental integrity if it does not cause environmental harm in a broader sense. In the context of carbon markets and international climate negotiations, such environmental harm is usually considered as part of environmental and social safeguards and impacts.

In an even broader sense, integrity may also consider social impacts in addition to environmental impacts in order to address all three dimensions of sustainability. This is an approach that is, for example, pursued by the Gold Standard for the Global Goals[36] in the context of carbon markets and by the IFC Performance Standards[37] in the context of private sector investments in countries in the Global South.

In the context of this paper, we use the term environmental integrity drawing on the definition in international climate negotiations, meaning **that the use of the instrument actually achieves the credited or envisaged greenhouse gas emission reductions**. We separately consider social and environmental impacts beyond climate mitigation.

3.1 Description of action-based and results-based approaches

3.1.1 Action-based approaches

The key characteristic of an action-based approach is that the payment is linked to the implementation of a specific type of measure. In the context of climate-friendly soil management, farmers or landowners receive payments that relate to the implementation of defined agricultural management requirements (e.g. taking field margins out of production or the planting / maintaining of hedgerows).

It is possible that the payment is contingent upon conditions for how a measure must be implemented, for example payments could be tied to requirements to implement buffer strips for wildflowers to enhance biodiversity. However, it is not necessarily monitored whether such conditions are actually fulfilled.

The vast majority of environmental schemes that have been implemented in the EU over the last thirty years have been action-based (Teagasc; NPWS 2020). Currently, the EU's Common Agricultural Policy (CAP) is largely based on action-based payment schemes (see section 4.1).

In principle, action-based approaches could be suitable for both private and public funding, though in practice mainly public funding is used because private funders often wish to claim that they supported specific mitigation outcomes or use the mitigation outcomes to achieve their own mitigation targets.

3.1.2 Result-based approaches

Result-based approaches are relatively recent innovations. The key characteristic of a result-based approach is that the recipient receives a payment for the achievement of a pre-defined environmental outcome, such as achieved emission reductions or carbon sequestration. Payments are generally made ex post, upon the achievement of results, but they can also be made ex ante, conditional upon the achievement of results which are verified at a later point in

[36] See https://www.goldstandard.org/articles/gold-standard-global-goals.

[37] The IFC handbook with the Performance Standards can be downloaded from https://www.ifc.org/en/types/insights-reports/2012/publications-handbook-pps.

time. Result-based payments rely upon the quantification of environmental outcomes through the use of measurable indicators. Unlike action-based approaches, result-based approaches leave it to the farmer or landowner how to best achieve the environmental outcome (Teagasc; NPWS 2020).

Carbon crediting approaches are a visible example of result-based approaches. In the case of carbon crediting for climate-friendly soil management measures, farmers would implement measures and then receive credits for the level of the mitigation they achieved, determined in accordance with a carbon crediting methodology. Farmers can then sell these credits to buyers. Carbon credits may be purchased by private or public entities to achieve voluntary targets or goals, commonly referred to as the voluntary carbon market (VCM), or by companies or governments to achieve mandatory targets or goals, referred to as compliance markets. Carbon crediting standards may be established by non-governmental organisations (e.g. Verra VCS, GoldStandard), by public authorities (e.g. the French government's Label bas Carbone), or by multilateral organisations (e.g. the Article 6.4 mechanism under the Paris Agreement). Public authorities can also seek to influence private markets by establishing voluntary certification criteria, such as through the EU Certification Framework for Carbon Removals. Result-based payments are not exclusively linked to carbon crediting approaches, with other models e.g. result-based payments possible within the CAP.

Result-based approaches can be further differentiated regarding the use of the measured and quantified outcomes that are to be achieved (GHG mitigation results in our case):

- **Offsetting approaches**: Carbon credits are generated for the achievement of mitigation results which are transferred from a seller to a buyer.[38] The buyer uses the carbon credits towards its own (voluntary) climate mitigation target. Buyers of carbon credits often make claims about climate neutrality of their activities, products, services or an entire organisation or institution by offsetting GHG emissions.

- **Result-based finance/contribution claim**: Actors are rewarded in the form of payments that reflect the mitigation results achieved. However, unlike offsetting approaches, the buyers do not use the emission reductions or removals to achieve their own mitigation targets (or to meet neutrality or carbon zero objectives), but rather report that they have made a contribution towards financing mitigation (a "contribution claim").

  Result-based finance approaches include publicly funded result-based payments such as CAP subsidies where no carbon credits are issued but results must be demonstrated to receive public funding. For example, the agri-environment (ENVCLIM) scheme for soil quality (70.08) in the French CAP Strategic Plan promotes soil cover through the support of practices that limit erosion, maintain soil organic matter and biological activity and avoid soil compaction and is partly result-based. It requires farmers to do humus balance assessments[39] and to have a net-zero humus balance after 5 years (i.e. no loss of soil organic matter), with payment dependent on achieving this target. It also requires them to provide estimates for an earthworm indicator in three different sampling points within the farm.

  Similarly, in the case of results-based finance payments through the voluntary carbon market, (private or public) funders do not claim these mitigation results towards any (voluntary) climate mitigation target but can make claims that they provided financial

[38] These are also known as "transfer-based payments", which emphasises that the legal titles for the achieved reductions or removals is transferred to the buyer (Oeko-Institut; CIFOR 2023).

[39] The humus balance predicts the development of the soil organic matter by comparing the humus lost with the humus restored following different agricultural interventions.

contributions ("contribution claims") that achieved climate mitigation elsewhere (see e.g. New Climate Institute 2023; New Climate Institute 2015; NewClimate Institute; Schneider 2020; Gold Standard 2017). Such claims can be advertised on products or included in companies' sustainability reports.

3.2 Environmental integrity

In this section, we compare action-based and result-based approaches with regard to key aspects related to environmental integrity, including the ability of approaches to achieve the mitigation results, ensure additionality, address potential non-permanence of mitigation outcomes, and avoid perverse incentives.

3.2.1 Achievement of mitigation results

Under action-based approaches the achievement of mitigation results is not monitored. Therefore, the degree of certainty to which it can be ensured that mitigation results are achieved is comparatively low. Furthermore, since mitigation impacts are not quantified, leakage risks can hardly be addressed.

A key factor for the achievement of mitigation results is the variability in soil properties. Generally, action-based approaches are more effective in delivering mitigation outcomes if spatial heterogeneity across the area where measures are implemented is low. Pre-existing soil characteristics should be similar across the area eligible under the scheme, since otherwise a management measure that leads to enhanced SOC stocks on one plot of land might not have any effect on another plot with a substantially different soil structure (Bartkowski et al. 2021).

Action-based approaches for climate-friendly soil management should therefore target specific measures or types of land. A wide range of eligible climate-friendly soil management measures could imply that land managers implement those measures with the best cost-benefit ratio which may not coincide with the highest impact in terms of preserving or increasing SOC stocks. Spatial targeting can offer a means to increase the certainty of achieving mitigation results: Identifying and prioritising those areas that face the greatest environmental needs and the highest density of environmental services is likely to shift attention to those areas that bear the greatest potential of sequestering additional carbon in soils (Paustian et al. 2019). The type of soil management measures that are eligible for funding for a certain type of landscape should be based on established scientific consensus (Reed et al. 2014), which is still rather low for various determinants of SOC dynamics, such as micro-scale soil processes (e.g. Bispo et al. 2017; Bradford et al. 2021).

Generally, results-based approaches provide higher certainty about achieving certain mitigation outcomes than action-based approaches since payments are contingent on the delivery of results (Hampicke 2013; COWI 2021; Olivieri et al. 2021). However, the quantification of results involves a number of challenges. As a precondition for quantifying mitigation impacts, these impacts need to be measurable, and methods and technologies need to be available for this purpose. In the context of soils, this is associated with many challenges in practice. Determining the SOC content of soils is inherently challenging (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). This is because it takes time for carbon to accumulate in soils and sequestration rates can differ greatly between different sites and management practices (West and Six 2007). Additionally, high soil heterogeneity across areas can result in a high variance of measured carbon stocks. The more heterogenous the soil in a specific area is, the more soil samples would be required in order to robustly quantify the change in soil carbon stocks in response to changing management practices. Other field conditions like stony or dry soils may pose further technical obstacles to sampling (Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

As a more cost-efficient approach to sampling, soil carbon stocks and changes could also be modelled. This requires existing high-quality input data. Moreover, it leads to lower precision and robustness compared to sampling approaches, depending on the complexity of the model, as well as to what extent external influences such as effects of climate change are taken into account (Smith et al. 2020; Paul et al. 2023; Bartkowski et al. 2021). While technologies such as remote sensing have been developing rapidly in recent years, their potential and the accuracy of their results is currently still limited (Paul et al. 2023; Bartkowski et al. 2021). Quantifying SOC stocks is thus associated with considerable practical challenges and raises challenges for environmental integrity.

Establishing baselines is a further challenge of result-based approaches. Baselines are generally counterfactual scenarios that cannot be observed. While this is common for all crediting approaches, estimating baseline emissions may be associated with relatively high uncertainty for climate-friendly soil management.

Result-based approaches are generally better able to account for leakage risks than action-based approaches, though potential leakage effects need to be monitored and appropriately considered in the quantification of mitigation outcomes, which is not always the case (see Chapter 5 below).

3.2.2 Additionality

The environmental integrity of a funding mechanism strongly depends on whether the achieved mitigation results are additional to what would have happened in the absence of the economic incentive of the scheme. For both action-based as well as result-based payment schemes, additionality is often addressed by setting robust eligibility criteria. A key challenge is distinguishing which measures can be regarded as common or established practice and which are only implemented due to the incentives of the scheme (see section 2.2.6). In practice, many action-based payments for environmental purposes have been found not to be additional in the past (European Court of Auditors 2021b; Hampicke 2013). Additionally, there is the risk that mitigation activities funded by ex-ante payments may not be additional in the future (e.g. due to future regulatory changes) (Cevallos et al. 2019).[40]

Results-based approaches potentially provide the advantage that they could use project-specific tests to assess additionality of mitigation activities, considering the specific context and circumstances of the farmer. However, such tests, such as investment analysis, are also subject to challenges, such as subjectivity of the assumptions and information asymmetry. Empirical assessments of the additionality of result-based payment schemes are scarce; but experiences with carbon crediting approaches suggest that often common practice has been rewarded (Oeko-Institut 2016). Moreover, some carbon crediting programmes do not have robust procedures to assess additionality (see Chapter 5).

3.2.3 Addressing non-permanence of mitigation outcomes

Non-permanence is a key risk for climate-friendly soil carbon management under both action-based and result-based approaches. Potential reversals of achieved mitigation results at a later point in time would revoke the environmental outcome of a scheme and undermine its

[40] For a discussion of which climate-friendly soil management measures are likely to be additional in the EU, see section 2.2.6.

environmental integrity and effectiveness. Such reversals can occur unintentionally if caused by natural disturbances or can be caused by intentional human behaviour.

Action-based approaches do not have mechanisms in place to ensure that implemented activities are maintained over longer time periods beyond the funding contract, which would be necessary in order for enhanced soil carbon to remain stored. Given the absence of mechanisms to ensure the maintenance of activities over time, there could be a high risk of non-permanence under an action-based approach. In some cases, however, measures that are initially funded through action-based approaches may, at a later stage, become legal requirements. Moreover, action-based support may in some cases also be renewed after the end of a funding contract and may thus form a continuous revenue stream for farmers. In these cases, there could be higher assurances of the permanence of the mitigation outcomes.

Some results-based approaches have provisions to reduce reversal risks and to compensate for reversals. Some larger carbon crediting programmes have measures in place to reduce the risks from reversals. Towards this end, different approaches have been applied: requiring farmers to conduct non-permanence risk assessments; establishing mechanisms to monitor and compensate for reversals over longer time periods, including through the use of buffer pools; making farmers liable for reversals over longer time periods; or discounting of achieved mitigation (Ecologic; Ramboll; Carbon Counts 2021; CCQI 2022). However, these approaches are limited in their ability to ensure long-lasting mitigation outcomes in practice (see section 5.4). In principle, results-based approaches could thus be able to better account for reversal risks but this strongly hinges on their design.

3.2.4 Avoiding perverse incentives

Environmental integrity might also be undermined by perverse incentives for farmers, e.g. if they discontinue pre-existing climate-friendly soil management measures in order to become eligible under a payment scheme. To avoid such incentives, pre-existing climate-friendly management measures or high initial carbon stocks could be explicitly recognised and rewarded (World Bank 2004). While such an approach is suitable to reward early adopters, it might undermine the additionality of the scheme (Bartkowski et al. 2021). Under both action-based and result-based approaches, measures to prevent perverse incentives could include requirements to provide evidence that a certain practice was applied in the past, though this might negatively affect the additionality of a scheme (Bartkowski et al. 2021).

3.3 Economic efficiency

In this section, we compare action-based and result-based approaches with regard to key aspects for economic efficiency, including transaction costs, cost-effectiveness and innovation incentives.

3.3.1 Transaction costs

The major advantage of action-based payments are the low transaction costs for farmers or landowners and for administrators as they are simple to implement. This reflects the fact that under action-based approaches there is no need for complex indicators or field monitoring (Teagasc; NPWS 2020).

By contrast, result-based approaches require quantifying the mitigation outcomes. Measuring SOC stocks is, however, challenging (see section 2.2.3). The costs associated with direct measurements (both pre and post) are generally too high to use them as the basis for quantifying SOC stocks under result-based payment approaches (COWI 2021), even more so if sampling in deeper soil layers is required (Smith et al. 2020).

3.3.2 Cost-effectiveness

The cost-effectiveness of action-based approaches is limited in certain cases due to the uncertainty of environmental outcomes. Particularly, if action-based approaches feature uniform payments and do not account for cost-benefit differences at different sites, their efficiency is considered low (Armsworth et al. 2012; Vergamini et al. 2017; Bartkowski et al. 2021). In the literature, cost-benefit targeting, i.e. selecting applicant sites on the basis of costs and expected environmental benefits, is proposed to enhance the cost-effectiveness of action-based approaches. High requirements for data availability and administrative capacities pose limits to this approach though (Engel 2016; Wunder et al. 2018).

As result-based approaches have a higher certainty about achieving mitigation outcomes (see section 3.2.1), the cost-effectiveness of such approaches is comparatively high in theory. If payments are structured effectively to provide the right level of incentive, farmers may be motivated to go beyond their peers to achieve higher environmental outcomes in order to obtain higher payment rates (Nature England; Yorkshire Dales National Park Authority 2019). However, due to the challenges described above, the cost-effectiveness is limited in practice by high transaction costs and uncertainties in quantifying mitigation outcomes.

3.3.3 Innovation incentives

Another consideration is whether a funding instrument provides incentives for farmers to innovations to achieve higher environmental outcomes, such as testing new agricultural practices. Action-based approaches do not provide incentives for farmers or the sector to innovate by improving their environmental outcome in the long run if payments are only linked to adopting specific management measures but implementation is not further tracked (Bartkowski et al. 2021). The efficiency of action-based approaches may therefore be limited at times by the failure of schemes to influence the attitude of farmers towards the environment (Arnott et al. 2019) as there is often no requirement to demonstrate outcomes. Given that farmers are often not required to learn about good conservation practices but simply implement what is requested, innovation is not encouraged (Burton and Schwarz 2013).

In contrast to action-based approaches, result-based schemes are more likely to promote transformational change. This is because the level of environmental results determines the amount of payment received (Moran et al. 2021; Ferraro 2008). Result-based payments give farmers a certain flexibility to implement specific activities in a way that fits their local context, as long as they make sure to deliver certain environmental outcomes (GCF 2020). If payments are structured effectively to provide the right level of incentive, farmers may be motivated to go beyond their peers to achieve higher environmental outcomes in order to obtain higher payment rates (Nature England; Yorkshire Dales National Park Authority 2019). As a result, farmers are more likely to improve their skills and knowledge about the effects of certain activities which makes it possible to promote genuine behaviour change (Nature England; Yorkshire Dales National Park Authority 2019; COWI 2021). By making their environmental performance public, result-based approaches may further motivate farmers to improve environmental outcomes as these are related to enhanced status and prestige. This can also spur long-term cultural change on the farmers' side (Burton and Schwarz 2013; Fleury et al. 2015).

3.4 Other considerations

In general, an important advantage of action-based approaches is that they are relatively simple to implement. Moreover, they provide **financial certainty** to farmers or landowners. This is likely to lead to a high level of uptake by farmers. Indeed, acceptance by farmers is often higher as action-based payments are perceived to be fairer, with payments not subject to change as a consequence of factors outside of their control such as variations in the climate (Hanley et al. 2012). However, the main limitation of action-based approaches consists in the fact that it is difficult for funders to evaluate effectiveness, or target funds to where they will be most effective. As a result, this can lead to poorly targeted action-based incentives that fail to deliver intended outcomes.

For climate-friendly soil management measures, it can take several years or even decades before environmental outcomes become measurable with sufficient confidence (Oldfield et al. 2022). Under result-based funding approaches, there is a higher uncertainty that the payment will be delivered (e.g. intended mitigation outcomes might not materialise due to unforeseen climatic events) than under action-based approaches. The time lag between changing management practices and achieving measurable environmental results combined with the higher degree of uncertainty about payments may negatively impact farmers' willingness to participate in soil-related result-based payment schemes (COWI 2021; Hampicke 2013).

Lastly, it is important to consider which broader environmental and social impacts incentive schemes for climate-friendly soil management might bring along. In principle, both action-based and result-based approaches may include eligibility requirements that aim to promote positive impacts on other policy objectives, such as enhancing biodiversity, water quality as well as income for farmers. Under result-based approaches, there is a risk that the rewarding of climate mitigation may lead to the implementation of measures at the cost of other objectives such as enhancing biodiversity. This risk could be mitigated by requiring monitoring of other outcomes and potentially also rewarding such outcomes, which, however, raises further methodological challenges and complexities.

4 Past experiences with public incentive-based approaches for climate-friendly soil management

In this chapter we discuss selected experiences made with public incentive-based approaches for climate-friendly soil management. A review of selected carbon crediting methodologies that implement result-based approaches mostly on the private, voluntary carbon market will follow in Chapter 5.

4.1 Common Agricultural Policy (CAP)

The CAP is the EU's main instrument providing funding for farming. It strongly impacts the EU's agricultural market, constitutes an integral part of many farmers' income and is a relevant factor in determining consumer prices. It represents almost one third of the EU's budget, meaning there are significant funds available for agriculture. The objectives of the CAP are as follows:[41]

- support farmers and improve agricultural productivity, ensuring a stable supply of affordable food;
- safeguard European Union farmers to make a reasonable living;
- help tackle climate change and the sustainable management of natural resources;
- maintain rural areas and landscapes across the EU;
- keep the rural economy alive by promoting jobs in farming, agri-food industries and associated sectors.

The financial architecture provided by the CAP is split between the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD) (co-financed by the Member States) and includes the following measures:[42]

Income support **through direct payments** that is intended to ensure income stability and remunerates farmers for delivering public services not normally paid for by the markets (first pillar). Direct payments comprise area-related lump sums which are contingent on fulfilling certain minimum standards and eco-schemes which support farmers who implement farming practices that contribute to environmental or climate goals.

- **Rural development programmes** with national and regional programmes to strengthen the social, environmental, and economic sustainability of rural areas (second pillar). EU countries implement EAFRD funding under this pillar through rural development programmes (RDPs), which are co-financed by national budgets and may be prepared on either a national or regional basis.

The majority of the financial support provided by the CAP in 2019 was via direct payments (€41 billion or 70% of funding) followed by funding for rural development (€14 billion) and then market measures (€2 billion).[43]

[41] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

[42] In addition to the measures that are listed here, the CAP comprises market measures by EU countries' governments to deal with difficult market situations such as a sudden drop in demand, or a fall in prices as a result of a temporary oversupply on the market by purchasing and storing agricultural products or supporting the private sector in doing so (also part of the first pillar).

[43] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

Direct payments were originally introduced as part of the 1992 CAP reform and were further developed under subsequent reforms. These direct payments are provided directly to farmers who meet the conditions of the applicable scheme. For eligibility for direct payments, farmers must perform an agricultural activity on an agricultural area (encompassing arable land, permanent crops and permanent grassland) that is at their disposal. Agricultural activities include the production, rearing or growing of agricultural products, etc. or maintaining land in a good agricultural state. Until 2023, all EU countries were obligated to offer a basic payment and a payment for sustainable farming methods (referred to as greening). Additionally, they may offer other payments that focus on specific sectors and types of farming, e.g. payments to support young farmers.[44] With the reform of the CAP for the period 2023-2027, each EU country is required to design a national CAP Strategic Plan that sets idividual national priorities and combines funding for income support, rural development and market measures. These plans also comprise so-called eco-schemes which each EU Member State must put in place. These schemes support farmers who voluntarily implement farming practices that contribute to environmental or climate goals.[45] **The large majority of CAP funding – direct payments, greening measures until 2023 as well as the majority of eco-schemes from 2023 onwards – is delivered as action-based payments.** As such, the CAP does not foresee measuring or monitoring the impact of specific agricultural measures. Generally, all climate-friendly soil management measures can be funded under the CAP. However, complex system re-design measures such as agroforestry and rewetting of organic soils are less likely to be supported and implemented through the CAP.

The per-hectare allocation of the majority of direct payments in the past resulted in a bias towards large farmers. As of 2018, 2.2% of farms in the EU-28 (receiving >€50,000) took a share of 28.2 % of all payments (Pe'er and Lakner 2020). According to estimates, out of a total of €59.4 billion of 2015 CAP payments, over €24 billion of direct payments were granted to EU regions with above average farm income (Scown et al. 2020). Moreover, direct payments have tended to support emissions-intensive farming practices. 70% of the €24 billion of direct payments that were granted to EU regions with above average farm income in 2015 was paid to the highest 50% of GHG emitting regions and almost 58% was paid to the 40% of regions maintaining the lowest fraction of high nature value (HNV) farmland (ibid). The effectiveness of the distribution of payments under the rural development pillar of the CAP was also challenged. Scown et al. (2020) found that €2.5 billion in rural development payments in 2015 went primarily to urban areas, which is not necessarily aligned with achieving environmental, sustainability and rural development goals.

As a consequence, the European Court of Auditors (ECA) concluded in 2021 that **while more than a quarter of the whole CAP budget in the period 2014-2020 was dedicated to mitigating and adapting to climate change, only little impact of the €100 billion attributed to climate action could be observed.** In this period, agricultural emissions from the three main emissions sources in the EU (livestock, application of chemical fertilisers and land use (change)) have not changed significantly. Environmental concerns have not been prioritised in the design of the CAP. Instead, the CAP has mostly been financing measures with a low potential to mitigate climate change. Measures to reduce livestock emissions or address emissions from drained peatlands were not supported (European Court of Auditors 2021c).[46] Additionally, no specific

[44] https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/income-support-explained_en

[45] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en.

[46] A study by Biffi et al. (2021) also finds that action-based payments in the EU and US did not always target the areas which needed improvements in environmental quality the most. They found that areas with high spending match with areas with high GHG emissions and low soil organic carbon as well as N surplus (in the EU), but not with areas of high biodiversity loss and water stress

incentives were set to enhance climate-friendly soil management. As payments were related to the farming area and not linked to implementing climate-friendly soil management measures, they did not encourage farmers to focus on preserving and enhancing carbon stored in soils (Verschuuren 2022).

For the subsequent funding period (2023-2027), the CAP has been reformed and will increasingly strengthen approaches to enhance the ambition of environmental outcomes. At least 25% of the budget for direct payments is allocated to **eco-schemes** which are voluntary for farmers and provide payments for practices that are beneficial to the environment and/or climate (primarily action-based, see below)**.** Furthermore**,** the budget for action-based approaches shall be better targeted through the setting of new conditionality rules for direct payments based on **good agricultural and environment conditions** (GAECs) on soil protection and quality (e.g. crop rotation required on all farms of at least 10 hectares) and biodiversity and landscape (e.g. 4% of land will be devoted to non-productive elements and areas, including fallow land, on all farms of at least 10 hectares).[47]

Member States are required to submit **National Strategic Plans** presenting planned approaches to contribute to the revised objectives of the CAP. **Some of the current Strategic Plans offer result-based approaches** such as the French strategic plan with its eco-scheme and the German eco-scheme for the extensive management of permanent grassland, which is result-based and requires farmers to have a least four plant species that are indicative of species-rich grassland in the area. **Most eco-schemes are payments per hectare for a given agricultural practice though and thus represent action-based payment approaches**. For a selected number of Member States it has been found that in many cases, farmers can receive payments under the new eco schemes without changing their farming practices. Additionally, several Member States have defined their GAEC standards only according to EU minimum requirements; missing a chance to make these requirements a strong lever to change agricultural practices. Overall, CAP funding as outlined in the National Strategic Plans remains focused on economic objectives rather than environmental ones (IEEP; Ecologic Institute 2023).

Additionally, it is estimated that the mitigation impact of the first pillar of the reformed CAP will be limited as the eco schemes primarily target other environmental goals than GHG mitigation (e.g. biodiversity) and mitigation effects are mainly the result of synergies between these other targets and climate protection. The aim set by the Commission that 40% of direct payments and 100% of payments under eco schemes shall contribute to climate-related objectives[48] will therefore likely not be fulfilled. Nevertheless, the CAP reforms strengthen the environmental performance of the CAP by increasing funds for environmental and climate goals and enhancing the monitoring of results (Oeko-Institut; Universität Rostock 2023). Yet, it will also be decisive to what extent these funds contingent upon achieving specific goals will be used by EU farmers in the future.

4.2 UK Agriculture Act

As a consequence of the decision to Brexit, the UK agricultural sector will no longer participate in the CAP. Given that as recently as 2019, farmers in the UK received £4.7 billion in CAP funding

(US) and soil erosion and P balance (EU). They did not examine the effects the spending had on actually improving the environmental conditions, they only measured the targeting (whether the right areas were targeted with the money).

[47] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-reforms-new-cap_en; https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en.

[48] See Art. 100, Regulation (EU) 2021/2115 of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans), see https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32021R2115.

with around 80 % of this in the form of direct payments under the basic payment scheme (BPS) this led to financial concerns about a future outside of the CAP amongst the farming community in the UK. In order to provide farmers in the UK with clarity over what will replace this financial support, the Agriculture Act was passed by the UK government in 2020 outlining a transition away from the direct payments previously associated with the CAP towards financial support more correlated to the provision of social goods, increasingly using a result-based approach. In the interest of continuity, the UK government initially guaranteed the current annual budget to farmers with 2023 the last year in which the BPS is paid (House of Commons Library 2023). However, a transition to new support schemes is already underway as part of a new approach referred to as Environmental Land Management (ELM) that consists of the following three components:

- **Sustainable Farming Incentive (SFI)** is eligible for all farmers who were previously paid under the BPS as long as specific 'standards' are met that comprise agricultural actions that are considered to contribute to environmental outcomes. A standard is defined as "a group of land management actions with a set of aims" (UK Government 2023). Three SFI standards (i.e. arable and horticultural soils, improved grassland soils and moorland) were initially available in 2022 at an introductory and intermediate level, however this list of standards and levels will expand up until 2025 based on further consultation with farmers.
- **Local Nature Recovery (LNR)** will pay for locally targeted actions to ensure that space is set aside for nature alongside food production (i.e. activities may include managing and creating habitats as well as adding trees or hedgerows to fields).
- **Landscape recovery (LR)** focuses on large-scale, long-term, significant habitat restoration and land use change and provides funds from 2022 onwards (CCC 2022; DEFRA 2022).[49]

The payments are action-based as they are linked to implementing a defined set of sustainable agricultural measures. The share of direct payments is envisaged to decrease from 2/3 in 2021 to 1/3 in 2025 and the Basic Payments scheme will be fully phased out by 2028 (House of Commons Library 2023). Given that these schemes are very much in their infancy, the level of assessment with regard to implementation is currently limited within the literature. A study commissioned by the Agriculture and Horticulture Development Board (2022) considers the expected impact of the implementation of the ELM in the UK. The initial conclusions from this study are that the "environmental goods produced as a result of the SFI are likely to be minimal at the current payment rates [and that] it is unlikely to be financially beneficial to farmers to participate in certain standards unless they are already undertaking at least some of the actions required" (AHDB 2022). This is reflected by voiced concerns by farmers and land managers about suffering from a loss of support in transitioning to the new schemes (House of Commons Library 2023). The introduction of the new payment schemes has experienced delays and important details of the policies still remain to be clarified (House of Commons Library 2023; CCC 2022). Nevertheless, the new system now much more prioritises environmental and climate concerns in agricultural practices than the previous basic payment scheme. The new support schemes are more focused on delivering environmental outcomes than the previous policy by linking larger shares of the budget available to support farmers to implementing sustainable measures and by specifying how to implement such measures. With sufficient financial incentives and clarification of the details of the new payment system, it is intended to contribute to reducing emissions from the agricultural sector (Carbon Brief 2023). To meet the targets for

[49] Additionally, the Farming Investment Fund provides grants to farmers for adopting sustainable practices on a competitive basis since 2021 (CCC 2022). Payments for animal health and welfare and grants to support new environmentally-friendly slurry stores are also available (DEFRA 2020).

the agricultural sector indicated in the Sixth Carbon Budget Report will require an even broader set of measures though, particularly including demand side-measures that reduce the consumption of animal products and food waste as well as measures to increase carbon sinks (CCC 2020).

5 Synthesis of analysis of selected carbon crediting methodologies

Result-based payment approaches bear specific risks for funding climate-friendly soil management measures that must be accounted for in the design of such instruments, particularly if credits are issued that may be used for offsetting (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Since there is an increasing interest in promoting climate-friendly soil management through funding through result-based payment schemes, including offsetting mechanisms, we took a closer look on the crediting methodologies of these mechanisms for this study. For this purpose, we selected ten result-based payment mechanisms operating on the voluntary carbon market as well as on compliance markets and evaluated their rules and methodologies with regard to their approaches for dealing with the identified risks and challenges.[50] This assessment was structured using a set of guiding questions which build upon the methodology for assessing the quality of carbon credits developed under the Carbon Credit Quality Initiative (CCQI)[51]. The guiding questions were structured around seven major topics:

1. General characteristics of the mechanisms;
2. Approaches for quantifying emission reductions or removals;
3. Approaches for assessing additionality;
4. Approaches for assessing non-permanence;
5. Approaches for avoiding double counting;
6. Analysis of environmental and social safeguards and;
7. Governance questions.

A synthesis of the assessment of the ten crediting methodologies is presented in the following sections.

Beyond the methodologies covered in this analysis, we considered a number of other crediting methodologies that exist for implementing projects to promote climate-friendly soil management.[52] To select the ten mechanisms we evaluated, we considered the following criteria:

- Methodologies should be well-documented and transparent, with sufficient information to enable an assessment to what extent robust methodologies for addressing challenges are available at all;[53]
- “Good” and “bad” examples – we included both well-regarded and poorly regarded methodologies, to illustrate the range in the quality of approaches;
- Coverage of different climate-friendly soil management measures, e.g. including peatland rewetting, agroforestry, soil carbon-focused approaches, and grasslands;
- EU and international examples, including those from the largest voluntary carbon market mechanisms (e.g. Verra VCS, Gold Standard, ACR, CAR) and government-driven mechanisms (e.g. Australian ERF, Alberta, Label bas Carbone).

[50] The detailed assessment of the ten methodologies is published separately as an Annex to this report, see https://www.umweltbundesamt.de/publikationen/annex-analysis-ten-crediting-methodologies-soil-management.

[51] https://carboncreditquality.org/methodology.html.

[52] E.g. UK Peatland Code, CO_2-Plus-Zertifikate by Biomassehof Allgäu e.V., Peatland Code, MoorFutures, Max.Moor; Ebenrain Humusprojekt, Carbon Future, Valuta voor veen, Himmelserde, Stiftung Lebensraum Humusinitiative, HeckenScheck, aESTI, Bayer Carbon Intiative, Nutrien, TruCarbon, Spain’s Carbon Footprint Registration, Offsetting and Carbon Dioxide Absorption Projects.

[53] This effectively excluded a number of smaller, locally focused methodologies, which often lack the public documentation of the larger, international methodologies.

In this chapter, we synthesise the results of the assessment to present how the methodologies manage the challenges of quantification, additionality, non-permanence, double-counting, environmental and social safeguards, and governance. We identify key issues related to each challenge, summarise the methodologies' approaches to their management, and make conclusions to what extent the approaches can be considered appropriate for addressing the risks related to offsetting mechanisms. On the basis of the synthesis presented here, Chapter 6 will draw conclusions on whether offsetting mechanisms are a suitable instrument for promoting climate-friendly soil management at all.

Throughout the following sections, we refer to the methodologies using the following acronyms:

- Care Peat (*Care peat*);
- Alberta Emission Offset System (*Alberta*);
- Australian Government Emissions Reduction Fund (*ERF*);
- Ökoregion Kaindorf (*Kaindorf*);
- Nori Carbon Removal (*Nori*);
- Label bas Carbone (LbC);
- American Carbon Registry (*ACR*);
- Climate Action Reserve (*CAR*);
- Gold Standard (*GS*);
- Verra – Verified Carbon Standard (*VCS*).

Table 4 provides an overview of key characteristics of the ten crediting methodologies we assessed.

5.1 Characteristics of selected crediting methodologies

In this section, we introduce the methodologies, focusing on key characteristics including governance and history of the methodology, descriptive statistics regarding size and market price, and some key methodological aspects, including which climate-friendly soil management measures are promoted, which gases and carbon reservoirs are considered, and the length of the crediting period. These characteristics provide information how the different methodologies deal with the challenges we assess in the subsequent sections and therefore provide important context for our assessment. A summary is provided in Table 4.

Climate-friendly soil management measures

Three of the ten methodologies exclusively reward activities that enhance **carbon removals**, and do not reward other **emissions reductions** (*ERF, Kaindorf, Nori)*. The remaining seven reward both enhanced carbon removals and emissions reductions from the agriculture and LULUCF sector, including CO_2, CH_4, and N_2O reductions (e.g. GHG emissions from drained organic soils) (*Care peat, Alberta, LbC, ACR, CAR, GS, VCS*). Six of the ten methodologies only consider carbon stored in soils, while the remaining four also consider above- and belowground carbon reservoirs (e.g. carbon stored in aboveground biomass such as orchards or agroforestry systems) (Care peat, LbC, ACR, VCS).

14 of the 15 climate-friendly soil management **measures** we identified in Chapter 2 are covered by at least one of the methodologies. The only exceptions are the measures mixed crop/livestock and contour farming, which are not explicitly covered by any mechanism.[54] Seven methodologies recognise multiple measures (*Alberta, ERF, Kaindorf, Nori, CAR, GS, VCS)*, while the other three methodologies focus on specific measures (*Care peat:* peatland rewetting*; LbC:* agroforestry*; ACR:* permanent grassland management).

Governance and scope

The selected methodologies range in **geographic scope and location**. Five are operative in Europe, with *LbC* applicable only in France, *Care peat* in four EU countries (plus the UK), *Kaindorf* applicable only in the eponymous region in Austria, and two methodologies are global (*GS, VCS)*. The remaining five are international, with three applying only in the USA (*Nori, ACR, CAR)*, one in Australia (*ERF),* and one only in the state of Alberta, Canada (*Alberta)*. All methods are project-based (e.g. in contrast to pursuing jurisdictional approaches), that is, the reward of mitigation carried out on a specific location with a limited geographical scale (Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

Three of the mechanisms were established and are **publicly operated** (*ERF, LbC, Alberta)*. *Care peat* methodology is run by a mix of public and private entities, with the other methods **privately run** by non-profit organisations (*GS, VCS, ACR, CAR)* and one for-profit company (*Nori)*. Eight of the methods are still in operation, with the majority of methods developed or updated since 2018 (*CAR, ERF, GS, Nori, LbC, VCS);* the *ACR* method was developed in 2013, the *Kaindorf* method in 2007. The *Care peat* method is still under development, while the *Alberta* methodology was operational 2012-2021.

Of the seven methods who reported **mitigation and project data**, seven have resulted in mitigation and generated credits (*ACR, CAR, ERF, Kaindorf, Nori, LbC, VCS),* though other methods report projects in development - given that many of the methodologies have only been approved since 2020, and the slow soil carbon sequestration rates, more verified mitigation may be reported in the coming years. None of the methodologies yet has a huge uptake, e.g. *Nori, LbC,* and *VCS* report the most projects, each at around 20. *Kaindorf* reports that about 300 farmers have participated in their programme, but the individual projects are implemented at local, small scales. The climate impact is accordingly limited to date: *ACR* reports 0.16 Mt CO_2e of mitigation, *Nori* 0.12 Mt, and the rest significantly less or zero. For those methods who have reported mitigation and project data, information is available on the projects and the methodology but there is no explicit tagging of credits associated with the assessed methodologies as “carbon removals” or “emissions reductions”.

Three of the methodologies are standalone ones, that is, the mechanisms only have the one methodology that we assess (*Care peat, Kaindorf, Nori)*. Conversely, seven of the methodologies come from larger programmes or regulatory mechanisms that each feature multiple methodologies (*ACR, Alberta, CAR, ERF, GS, LbC, VCS)*, e.g. the *ERF* methodology we assess is one of eighteen land sector and a total of 35 methodologies now run as the Australian Carbon Credit Unit Scheme.[55]

Funding instrument and prices of credits

Nine of the crediting methodologies we assess are designed for offsetting use (*ACR, Alberta, CAR, Care Peat, GS, Kaindorf, Nori, LbC, VCS,* of which *Alberta* and *VCS* also feed into compliance

[54] However, seven of the methodologies recognise any measure that delivers a change in soil organic carbon, meaning they would also capture any SOC changes resulting from these measures (*Alberta, ERF, Kaindorf, Nori, CAR, GS, VCS*).

[55] https://www.cleanenergyregulator.gov.au/ERF/Pages/Method-development.aspx.

markets*)*, with one a publicly funded result-based payment scheme (*ERF)*. Prices paid by buyers of the offset credits and payments received by the farmer are not always clearly reported. *Nori* reports 2023 prices as €23 per unit (i.e. per t CO_2e),[56] in 2023 *ERF* units are ranging at €17-23[57], credits issued by *CAR* were available at $20 in 2020 and $40 in 2022[58], *Kaindorf* certificates are available at 45€ per tonne CO_2e[59], *Care Peat* sold units at 70€ per tonne CO_2ein 2019-2020[60]. The range of prices are suggestive that the methodologies operate in different, disconnected markets, though they could also reflect differences between the methodologies (e.g. in terms of implementation requirements and costs, as discussed in subsequent sections). There is sometimes a gap between the price paid by the buyer of a unit and the farmer implementing actions, e.g. *Nori* pays €18.50 of the €23 unit price to the farmer; Kaindorf €30 of the unit price of €45.

Method development and crediting period

Each of the methodologies is self-developed (or developed by contractors), with no standardisation across the methods. This is illustrated by differences in the length of the crediting period under each methodology, i.e. the duration of time over which mitigation is rewarded (see Table 4). As discussed in more detail in section 5.4, there is a wide range from 5-20 years (*GS)* to 10 years (*Nori, CAR)*, up to 25-100 years (*ERF)*, with some mechanisms also allowing renewals (i.e. extensions of the same period of crediting time again) up to five times (*VCS)*.

[56] https://www.cleanenergyregulator.gov.au/Infohub/Markets/Pages/qcmr/march-quarter-2023/Australian-Carbon-Credit-Units.aspx.

[57] https://nori.com/remove-carbon/checkout?tonnes=1&currency=USD.

[58] https://pressemitteilungen.sueddeutsche.de/indigo-agriculture-4734028; https://www.indigoag.com/pages/news/inaugural-carbon-by-indigo-credit-issuance?hsLang=en-us.

[59] https://www.oekoregion-kaindorf.at/index.php?route=common/download/file&download_id=191.

[60] https://vb.nweurope.eu/projects/project-search/care-peat-carbon-loss-reduction-from-peatlands-an-integrated-approach/news/netherlands-first-carbon-credit-sale-from-peatland-rewetting/.

Table 4: Funding instruments overview

Instru-ment name	Specific methodology (if applicable)	Governmen-tal/ non-governmen-tal	Method status	Geogra-phical scope	Measures promoted	GHGs covered	Carbon reservoirs	Certificates issued (t CO_2e), method	Funding instrument type	Length of crediting period
Care Peat – ***(Care peat)***	"Paying for Peat"	Non-governmental (non-profit)	Under development (since 2019)	Belgium, France, Ireland, Netherlands, UK	Land use change – Rewetting of organic soils	CO_2, CH_4 and N_2O (i.e. including non-SOC emissions)	SOC, above-/ below-ground biomass		To be determined, potentially offsetting	10–50 years
Alberta Emission Offset System – ***(Alberta)***	Quantification protocol for conservation cropping, v. 1.0	Governmental	Retired, active 2012-2021	Alberta, Canada	No tillage, reduced N_2O emissions under no till management, associated emission reductions from reduced fossil fuel use from fewer passes per field	CO_2, CH_4, N_2O (i.e. including non-SOC emissions)	SOC		Offsetting	10 years
Australian Government Emissions reduction fund – ***(ERF)***	Estimating soil organic carbon sequestration using measurement and models method	Governmental	Ongoing, since 2021 (previous method 2018)	Australia	Any measure delivering SOC increase, incl.: Land use change Grasslands and set-aside areas Crop rotation Residue, mulch, manure	CO_2	SOC	225	Publicly funded result-based payment	25 years or 100 years
Ökoregion Kaindorf – ***(Kaindorf)***	-	Non-governmental (non-profit)	Ongoing, founded 2007	Kaindorf, Austria	Various measures delivering SOC increase, incl.: use of compost, reduced tillage, cover crops, improved crop rotations, including forage or grain legumes in crop rotation, reduced use of fertiliser	CO_2 (unclear)	SOC		Offsetting	
Nori Carbon	Nori pilot croplands	Non-governmental (for profit)	Ongoing, method since 2019	USA	Various measures delivering SOC increase, incl.: Grasslands and set-aside	CO_2	SOC	123,000 (in 18 projects)	Offsetting	10 years

Instru-ment name	Specific methodology (if applicable)	Governmen-tal/ non-governmen-tal	Method status	Geogra-phical scope	Measures promoted	GHGs covered	Carbon reservoirs	Certificates issued (t CO_2e), method	Funding instrument type	Length of crediting period
Removal – ***(Nori)***	methodology v1.3				areas Crop rotation Residue, mulch, manure Technical fixes					
Label bas Carbone – ***(LbC)***	Methode Plantation de Vergers (Orchard plantation method)	Governmental	Ongoing, method since 2020	France	Land use change – Silvoarable and silvopastoral agroforestry	CO_2 and N_2O (i.e. including non-SOC emissions)	SOC, above-/ below-ground biomass	14,000 (in 21 projects)	Offsetting	20 years
American Carbon Registry – ***(ACR)***	Avoided Conversion of Grasslands and Shrublands to Crop Production (Version 2.0)	Non-governmental (non-profit)	Ongoing, method since 2013	USA	Land use change – permanent grassland management	CO_2, CH_4, N_2O (i.e. including non-SOC emissions)	SOC, above-/below-ground biomass	166,197 (in 1 project)	Offsetting	5-40 years
Climate Action Reserve – ***(CAR)***	Soil Enrichment Protocol v.1.1	Non-governmental (non-profit)	Ongoing, method since 2020	USA	Various measures delivering SOC increase, incl.: Improved crop selection and rotation, use of cover crops, reduced tillage, improved fertiliser management, improved irrigation management and improved livestock management	CO_2, CH_4, N_2O (i.e. including non-SOC emissions)	SOC	22,257 (in 2 projects)	Offsetting	10 years, renewable 2 times (total: max. 30 years)
Gold Standard – ***(GS)***	Soil organic carbon framework methodology Version 1.0	Non-governmental (non-profit)	Ongoing, method since 2020	Global	Any measure delivering SOC increase (specific measures to be defined by specific methodologies under development)	CO_2. Optionally also CH_4 and N_2O	SOC	0	Offsetting	5-20 years

Instru-ment name	Specific methodology (if applicable)	Governmen-tal/ non-governmen-tal	Method status	Geogra-phical scope	Measures promoted	GHGs covered	Carbon reservoirs	Certificates issued (t CO_2e), method	Funding instrument type	Length of crediting period
Verra – Verified Carbon Standard – ***(VCS)***	VM0042 Methodology for Improved Agricultural Land Management. Version 1.0	Non-governmental (non-profit)	Ongoing, method since 2020	Global	Various measures delivering SOC increase, incl.: silvoarable agroforestry, use of cover crops, crop rotations with forage legumes, crop rotation with grain legumes, permanent grassland management, residue management, applying manure/compost, improved crop rotation, buffer strips, nitrification inhibitors (urease inhibitor), precision farming, low-input grasslands, organic farming, critical external inputs	CO_2, CH_4, N_20 (i.e. including non-SOC emissions)	SOC, above-/below-ground biomass	0 (20 projects under development)	Offsetting	20 years, renewable up to 5 times (max 100 years)

Source: Authors' own compilation

5.2 Approaches for quantifying emission reductions or removals

5.2.1 What are key issues that should be included in programme methodologies?

Determining the SOC content of soils is inherently challenging (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). This is because of relatively small changes in SOC over time (compared to baseline stocks) or high soil heterogeneity across areas that may result in a high variance of carbon stock measurements, making it difficult to distinguish measure impact from other factors (i.e., a low signal-to-noise ratio) (West and Six 2007). Additionally, SOC stocks are affected by climate change and extreme weather events and sensitive to small management changes, which can lead to variations over time as well as to quick releases of accumulated carbon stocks. Furthermore, high soil heterogeneity across areas and lack of standardised sampling techniques (e.g. different sampling depths) can result in a high variance of carbon stocks measured.

Measuring and quantifying SOC stocks commonly occurs either through direct sampling of soil, or through modelling. The more heterogenous the soil in a specific area is, the more soil samples are required in order to robustly quantify the change in soil carbon stocks in response to changing management practices; yet heterogeneity also makes modelling more inaccurate. Other field conditions like stony or dry soils may pose further technical obstacles to sampling (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Direct measurements imply high costs, even more so if sampling in deeper soil layers is required (Smith et al. 2020). Subsoils sequester only a fraction of what is measured in topsoils (around 10-30cm), while the huge volume in combination with the long-term storage make them an important store for carbon. Modelling can incur relatively low ongoing costs, while the cost and time of establishing accurate models and gathering robust data are likely to be significant, given the challenges identified (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Additionally, for accounting for indirect land use changes as a result of mitigation measures that reduce agricultural yields, reliable models are still lacking (Paul et al. 2023). Modelling and remote sensing will presumably gain more importance in the future as better, ground-based data will become available.

For soil carbon stock changes, the distinction between carbon removals and CO_2 emission reduction is not obvious. The term C sequestration is often used misleadingly including a reduction in C losses rather (Don et al. 2023). Therefore, a clear distinction between emission reductions and carbon removals is crucial for transparent and robust quantification methodologies. In order not to overestimate soil carbon removals or reduced emissions from soils,[61] crediting mechanisms must have robust quantification methodologies in place. This is particularly relevant if credits issued under a result-based payment scheme are usable for offsetting (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). To avoid overestimating mitigation results, based on our research and our expert opinion quantification methodologies need to fulfil the following requirements (see CCQI 2022):

- Clearly define the scope of the methodology as well as eligibility criteria for projects to register under the programme;
- Clearly define project boundaries in terms of GHG, carbon pools covered and the geographic scope of the project which should remain unchanged over the course of the project duration. Specify how additional emissions or emission reductions at farm level resulting from specific carbon farming activities (i.e. direct leakage) are taken into account (e.g. increase in total

[61] The methodologies we assess reward both emissions reductions and removals.

nitrogen input to soils causing N_2O emissions or increase in diesel consumption) (Paul et al. 2023);

- Clearly define a monitoring period (i.e. the duration of monitoring in accordance with the type of action) and requirements (e.g. frequency of sampling, technical sampling requirements). For carbon removals: multiple sampling points are required to measure the SOC content of a larger area and sampling depth should at least be equal to tillage depth.[62] For calculating SOC stocks, SOC content, bulk density and rock fragment content need to be taken into account. For measuring changes over time, re-sampling in intervals of at least 3-5 years is required (Paul et al. 2023). For emission reductions from soils, the monitoring of carbon pools and fluxes of GHG emissions are important. The mapping of vegetation and water table can support indirect monitoring. Specific sampling requirements vary between different climate-friendly soil management measures (see section 2.2.3) and need to be considered as part of quantification methodologies;

- Clearly define rules and requirements for the use of models, whose precision depends on the quality of input data, the complexity of the model as well as its calibration. Ideally, models described in peer-reviewed scientific literature should be used (Paul et al. 2023) and the models used should be transparently described;

- Establish rules for submitting monitoring reports;

- Set clear rules and calculation approaches for quantifying emission reductions or removals resulting from project activities, including rules to account for assessing and accounting for uncertainty and indirect leakage;

- Clearly define rules for establishing the baseline scenario which should be re-assessed in case of renewal of the crediting period or new scientific insights but not in case of reversals; “sound science” should be applied regarding the choice of approaches, assumptions, parameters, data sources (e.g. by requiring a combination of sampling and modelling); safeguards must be in place to prevent perverse incentives to farmers to inflate the baseline scenario (by degrading land before entering crediting schemes), e.g. by relating baselines to multiple years of historical data;

- Clearly define applicable crediting periods and rules for their renewal. The length of the crediting period should account for the time required for a soil reservoir to reach saturation under a specific type of management practice though and may thus differ for different types of activities (e.g. longer crediting periods for rewetting of peatlands). If saturation levels are reached, no new credits would be issued.

Quantification methodologies or general programme provisions should also require that emission reductions are determined in a conservative manner (rather than using the most accurate estimate). This way, uncertainties in the quantification are acknowledged. Furthermore, the methodologies should define that a carbon credit unit represents one metric tonne of CO_2 equivalents of GHG emission reductions or removals.

[62] Even though subsoils sequester only a fraction of what is measured in topsoil, the huge volume of the subsoil (in combination with a lower turnover time, i.e. longer term storage) can be an important store for carbon, especially when deep rooting crops or trees are introduced (Skadell et al. 2023); (Button et al. 2022). Determining the subsoil SOC stock and sequestration, however, makes measurement, reporting and verification even more labour- and cost-intensive.

5.2.2 Summary of approaches by programmes including key challenges

Our assessment of the ten selected crediting methodologies revealed a number of red flags in terms of robust quantification of mitigation outcomes.

One methodology does not set specific eligibility criteria for projects to register under the programme (*Kaindorf*). Furthermore, for three methodologies, **no clear rules could be identified for defining project boundaries, GHGs and carbon pools covered** (*ERF, Kaindorf, Nori*). This leaves room for ambiguity in quantifying mitigation outcomes.

In terms of **monitoring requirements**, two methodologies do not require sampling at all (*Alberta, Nori*), one does not include any clear rules on how sampling is to be implemented (*Kaindorf*) and for other methodologies, sampling is one option among different monitoring approaches but not required (*ACR, CAR, ERF, GS, LbC, VCS*). Some of these methodologies lay down clear rules on how sampling is to be implemented though (*ACR, CAR, GS*). However, without sampling, effects of agricultural activities on soil carbon content remain uncertain. If measurement is only based on the use of models, stringent eligibility requirements for these models must be in place regarding the granularity and high requirements regarding quality of input data. Models must also accurately account for local conditions. Some methodologies do not lay down clear criteria regarding the requirements models must fulfilwhile for other methodologies, the requirements remain unclear (*Care Peat, ERF, LbC, VCS*); for other methodologies, the requirements are clear.

In the rules and calculation approaches for quantifying emission reductions or removals resulting from project activities, uncertainty of measuring or modelling should be assessed and accounted for to avoid overestimating mitigation results. **Most methodologies specify that quantification must be done in a conservative manner** in order not to overestimate mitigation results. However, this is not mentioned by *LbC* and not specified by *Care Peat*. **Uncertainty** is not (clearly) accounted for by six methodologies (*Alberta, Care Peat, LbC, Nori, VCS*[63]). Methodologies that account for uncertainty do so by discounting the credits issued (*ACR, CAR, ERF, GS, VCS, LbC*). **Leakage risks** are not addressed by three methodologies (*Alberta, Nori*[64]*, LbC*) and insufficiently accounted for (by not addressing different types of leakage (see section 2.2.4) or not accounting for effects outside of national boundaries) by another two methodologies (*Care Peat, ERF*). No information regarding the conservativeness principle or treatment of uncertainty or leakage could be found for *Kaindorf*.

Regarding **rules for establishing baseline scenarios** against which project activities can then be compared, safeguards must be in place to avoid perverse incentives for farmers to inflate their baseline scenario by first depleting their soils and then earning credits for implementing conservation measures. For four methodologies, no safeguards could be identified to prevent **perverse incentives for farmers to inflate the baseline scenario** (*GS, Kaindorf, Nori, VCS*). Nori for example allows farmers to exclude fields from their project ex post (e.g. those that are underperforming). The majority of the methodologies assessed use project-specific baselines, mostly based on historic land use parameters (*ACR, CAR, ERF, GS, LbC, Nori, VCS*). Three methodologies use standardised baselines (*ACR as one out of two options, Alberta, Care Peat*). While standardised baselines reduce transaction costs and increase transparency, they can lead to adverse selection and may be inappropriate for the complexity and high variability of soils (cf. Schneider et al. 2012; Oeko-Institut; Ecologic Institut; Universität Gießen 2023). Under five

[63] VCS accounts for uncertainty but since the requirements for models and sampling methods are not clearly defined, it is difficult to evaluate this approach.

[64] Nori allows farmers to register just some of their fields but claim that changes within the project boundaries are unlikely to lead to SOC losses outside the project (although no specific evidence is provided) (Nori 2021, p. 15).

methodologies, the baselines are regularly updated or valid for only very short time periods (*ACR, CAR, Care Peat, GS (update is non-mandatory though), VCS*). Four methodologies do not foresee any update or adjustment of baselines during the crediting period (*Alberta, ERF, LbC, Nori*[65]). Upon a reversal, six methodologies have rules in place to prevent an adjustment of the baseline (*ACR, Alberta, ERF, GS, LbC, Nori*). It is unclear whether *VCS* requires baselines to be adjusted in the case of a reversal. *CAR* does not have any provisions in place since baselines are only established for one cultivation cycle. No information on this issue could be found for *Care Peat*. For *Kaindorf*, no information could be found on establishing baselines at all.

Under five methodologies, the **crediting period** can exceed 10 years (*ACR, Care Peat, ERF, GS, LbC*); under another two methodologies, the crediting period can be renewed so that the sum of crediting periods exceeds 10 years in total (*CAR, VCS*).

5.2.3 Conclusions

Overall, the crediting methodologies imply a number of weaknesses that risk to undermine robust and conservative quantification of mitigation outcomes. **Overestimating mitigation results and not accounting for leakage risks undermine the environmental integrity of crediting mechanisms particularly if they are used for offsetting emissions, since this could ultimately entail higher levels of emissions in the atmosphere than would have occurred without the activity.**

The methodologies assessed show weaknesses in terms of their requirements regarding monitoring methods and sampling, which remains the basis for obtaining reliable information on SOC stocks. Measuring SOC stocks is the most robust approach to quantify mitigation impacts due to the heterogeneity of soils. Furthermore, the quantitative relationship between applying specific carbon farming measures and increasing SOC quantity is site-specific. This is because depleted soils can store more additional carbon than soils which are already carbon-rich (Paul et al. 2023). Sampling should therefore be required by crediting methodologies to obtain project-specific data on SOC stocks. **Uncertainty in quantification resulting from current challenges related to data collection and monitoring is not sufficiently accounted for by some of the methodologies assessed.**

Some methodologies fail to adequately update baselines, which poses particular risks in light of the high vulnerability of SOC stocks to warmer temperatures or other effects of climate change (Wiesmeier et al. 2020)**.** If models are used, it is important that they adequately account for external influences such as climate change (Paul et al. 2023).

Generally, the crediting methodologies evaluated focus on crediting additional sequestration while lacking incentives to uphold the soil balance and account for past sustainable practices. The approach by ACR to only account for the maintenance of SOC stocks in projects that avoid the conversion of grasslands and shrublands into croplands instead of also crediting potential increases of SOC stocks is a good practice example of a conservative approach in that regard.[66]

[65] *Nori* updates the baseline only to reflect deviations in weather from expected weather, with no other baseline adjustment.

[66] See section 1.2.3.2. of Annex A for description.

5.3 Approaches for assessing additionality

5.3.1 What are key issues that should be included in programme methodologies?

Additionality is a necessary condition if the mitigation results are used to offset emissions in other sectors or locations (Infras 2014). It is not absolutely necessary for other uses (e.g. government procurement or contribution claims) but remains 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. 2022). Mitigation is considered additional "if it would not have occurred in absence of the incentive created by carbon credit revenues" (ICVCM 2023). That is, additionality implies causality: without the incentive, the mitigation would not have occurred.

Assessing additionality is inherently challenging, as it depends on the construction of an unobservable counterfactual, i.e. what would have happened without the incentive (UBA 2022; Greenhouse Gas Management Institute 2012; Schneider 2009). Additionality is particularly challenging to identify in the land/agriculture sector, which is subject to many complex private and public drivers (e.g. CAP), and involves interconnected actions, making it hard to isolate causality (UBA 2022). Given the widespread participation of farmers in the Common Agricultural Policy, the cross-compliance requirements (the Good Agricultural and Environmental Conditions, GAECs) act as proto minimum standards – all farms must meet these conditions to receive basic payments under CAP.[67] Indeed, previous assessments of soil carbon offsets found that no methodologies effectively ensure additionality (Zelikova et al. 2021).

Methodologies must determine whether mitigation is additional or not. As it cannot be directly observed, methodologies must assess the likelihood that mitigation is additional. Based on our research and our expert opinion, the crediting mechanisms must address the following issues at a minimum:

- **A regulatory surplus test** to ensure that actions go beyond EU and national statutory requirements, as well as those established by cross-compliance conditions in the CAP. The regulatory surplus assessment must be updated regularly (e.g. five-yearly) and after significant CAP alterations.
- **Financial additionality tests** to assess whether mitigation actions require carbon payments to become financially attractive. If credits are used for offsetting, financial additionality should occur at the project/participant scale; for other uses, expected financial additionality could be assessed at the methodology level. Public subsidies (e.g. CAP) must be considered in the test.[68]
- **Barrier tests** and **penetration rates** assess whether there are (non-financial) barriers that would block the implementation of the activity in the absence of carbon payments, e.g. institutional barriers, lack of knowledge etc. Barrier tests can be assessed at methodology-level to identify positive lists of rewardable actions. Measures financed by CAP must be taken into consideration when determining whether a land use is to be considered common practice. However, barrier tests alone are not sufficient for assessing additionality if mitigation is going to be used as offsets.

[67] The GAECs are established at the European level and establish general requirements (e.g. GAEC 4: Minimum soil cover). Member States then define how this applies in their country, setting minimum standards.

[68] While these will be potentially captured as part of the financial additionality assessments, there is an argument for including them in regulatory additionality assessments, which can be more transparent and straightforward.

- **Timing**: The methodology should require measures to be newly implemented, excluding measures that were implemented before consideration of carbon payments. Methodologies must also protect against perverse incentives for participants to degrade their land before enrolling in a certification scheme (Paul et al. 2023).

Some mechanisms assess additionality against **standardised baselines,** with any mitigation beyond the baseline assumed to be additional, however, this is insufficient due to the high variability and variation of soils. Baselines are, however, important for quantifying the additional mitigation impact (as discussed in section 5.4.1). Standardised baselines may be a cost-effective method for quantifying mitigation if used alongside additionality assessments, though they may be more uncertain than individual baselines.

Additionality also requires that mitigation is only recognised once; issues related to double-counting are discussed in section 5.5.

5.3.2 Summary of approaches by programmes including key challenges

Our assessment of methodologies identifies a number of red flags in terms of ensuring additionality. Only three mechanisms offer relatively sophisticated additionality requirements (*ACR*, *CAR* and *GS*), though even here there are weaknesses and concerns. The remaining seven methodologies are clearly lacking in additionality requirements: four methodologies require no systematic assessment of additionality or have no established procedure to assess it (*Nori*, *ERF*, *Kaindorf*, *Care peat*). The remaining three methods claim to require additionality but have established only very weak additionality tests or requirements (*Alberta*, *LbC*, *VCS*). One methodology (*GS*) explicitly relies on additionality tests developed for other programmes (e.g. CDM), the rest have their own additionality tests.

General additionality requirements are often established at the mechanism level, with context-specific rules for assessing projects established in the methodologies. Not all methodologies require individual projects' additionality to be assessed, with some only evaluating additionality at the level of the method (i.e. assessing whether the incentivised action is likely to be additional).[69] A number of methodologies provide some evidence on the likely additionality of the funded activity but also have some individual project additionality assessments (e.g. *LbC*). Additionality assessment at the methodology level alone is likely insufficient to ensure additionality, given the variety and variability of farms and farmers.

While some methodologies require actions to be "new" (e.g. LbC), others pay little attention to whether projects considered carbon credits when deciding whether to implement the climate mitigation actions. *ACR* and *CAR* allow projects, even when they have already been implemented: projects implemented up to 12 months previously are acceptable for *ACR*, projects registered up to 24 months after implementation are acceptable for *CAR*. Some methodologies even credit actions taken prior to registration with the mechanism ("grandparenting"), even though these are clearly not additional (as they have already occurred) (*GS, Nori*).

Five of the ten methodologies evaluated either do not require project-level regulatory additionality, or do not assess it. In some cases, this appeared justified by the focus of the methodology, e.g. the *LbC* methodology rewards new orchard plantations, and provides evidence that orchard planting is generally decreasing across Europe, receives only limited public funding, and is not mandatory. *CarePeat* makes a similar claim for peatland rewetting in the

[69] For example, the *Alberta* emissions offset system assesses additionality when developing the protocol: this includes a strong regulatory assessment but otherwise the assessment is only on the incentivised action's penetration rate, with no assessment of individual projects.

Netherlands; neither *Care Peat* nor *LbC* have processes to revise the additionality assessment if policies change in the future. Other cases are more glaring: Nori carries out no regulatory additionality assessment, assuming that all increased storage relative to the baseline is additional. *Kaindorf* and the *ERF* make no assessment of regulatory additionality.

Five of the ten methodologies assessed apply some form of regulatory additionality assessment. Unlike the others, Alberta assesses regulatory additionality at the level of the method: method developers are required to demonstrate that the incentivised activity is not required by law, regulation, by-law or directive. Any time there are legal changes that may affect the activities, the regulator carries out a new regulatory surplus assessment; project developers are also expected to inform the regulator if they identify relevant legal changes that the regulator has not yet assessed. The remaining four methodologies require project-level additionality assessments, though of differing stringency. GS give projects three options to demonstrate additionality, ultimately not strictly requiring demonstration of regulatory additionality in all cases.70 VCS requires projects to demonstrate that their actions are not required by law before the first implementation of the project but does not demand reassessment at project renewal. The strictest regulatory additionality standards are established by CAR and ACR. ACR requires projects to evaluate whether a regulation is in place mandating the action and stipulates that if regulatory requirements mandating the practice arise during the crediting period, the project will no longer be eligible for crediting (though does not specify how this reappraisal should occur). CAR requires all projects to be supplementary to legal requirements, and reassesses this before each verification. **A weakness of regulatory additionality rules of almost all methodologies considered in the EU agricultural context is that none consider the Common Agricultural Policy.** Only *CarePeat* explicitly allows for revenues from crediting to be combined with agricultural nature management subsidies under the CAP.

The methodologies we assessed had generally weak financial additionality tests. Most of the methodologies do not assess financial additionality (*ACR, Verra, Kaindorf, CAR, Nori, Alberta, ERF). GS* requires larger projects in developed countries (greater than 6000t CO_2e) to demonstrate additionality using CDM tools, which assess financial additionality through an investment analysis; smaller projects and projects in least developed countries do not have to assess financial additionality. *LbC* has a weak financial additionality requirement that according to evidence shown in the methodology all projects would pass.[71] **Alongside the lack of financial additionality tests, a number of mechanisms explicitly allow additional sources of funding.** For example, *CAR* and *ACR* explicitly permit other funding, as long as it is not tied to mitigation measured in tonnes of CO_2e. *Care Peat* explicitly allows additional payments from other sources (e.g. CAP), so long as the action leading to the *Care-Peat* carbon payment goes beyond CAP minimum requirements (it proposes that the CAP minimum requirement could then serve as the baseline for crediting). *Kaindorf* identifies the carbon payment as additional to any other funding received by the farmer.

Many of the methodologies assess additionality using barrier assessments or market penetration/common practice assessments, often in place of financial additionality tests. *GS* requires additionality to be demonstrated using CDM tools, which include barrier assessment

[70] Projects smaller than 6000 tCO_2e must only pass a penetration rate test, while larger projects must pass CDM additionality tests (which include regulatory additionality components). This includes an exception for regulatory additionality: even where actions are legally mandatory, projects can be determined additional if they can demonstrate that the laws or regulations are systematically not enforced.

[71] They require only that any public aid for planting costs will be less than 50% of the pre-harvest investment costs (with evidence suggesting that average public subsidies are equivalent to less than 10%); the test does not assess the wider profitability of planting the orchard.

(in some cases instead of financial analysis). *Verra* requires a barrier assessment for each project (as well as regulatory and market penetration tests), but allows this to be demonstrated using literature that they provide in the methodology. *Alberta* applies a barrier assessment at the methodology level; individual projects are not required to demonstrate barriers.

A common approach across the methodologies is to evaluate additionality against market penetration rates, which aim to assess how common an action is in terms of what percentage of the reference area have implemented the action. This is sometimes referred to as a "common practice additionality assessment". *VCS* approves projects as additional if implemented in areas that have a penetration rate of less than 20% for a weighted average of the set of incentivised actions (as long as they also pass a regulatory additionality and barrier test). For small projects, *GS* requires only a market penetration assessment (a penetration rate of less than 5% in the reference area is considered additional). *Alberta* also applies a penetration rate test, but at the methodology level: in 2021, this led to the methodology being withdrawn as the actions incentivised were found to have become too common practice. *CAR* requires projects to pass a very loose common practice additionality test: activities must pass a penetration rate test (set at 50%), as long as they are not on a negative list of "common activities". *ACR* assesses additionality using a "practice-based performance standard". For counties for which it has sufficient data, it defines a standardised baseline; in all of these counties, projects are assumed to be additional if they go beyond the baseline, with carbon payments awarded relative to the standardised baseline.

5.3.3 Conclusions

Overall, the methodologies we assessed are unlikely to ensure that projects and their mitigation are additional. The likelihood of additionality is higher with some methods than others.

Stringent regulatory additionality tests must apply. Standard regulatory additionality assessment is insufficient for climate-friendly soil management in the EU context, with the central role played by the Common Agricultural Policy. At a minimum, if an action is mandated by CAP cross-compliance, it should be considered non-additional. CAP cross-compliance requirements apply across the EU, their definition and implementation is the responsibility of Member States, with a wide range in specifics across Member States. For this reason, and due to different national approaches to soil (including e.g. national soil laws), regulatory additionality assessments must be Member State-specific. Also, given the regular updating of CAP every seven years, it will be important to reassess regulatory additionality when CAP standards shift. "Co-payments" also decrease the likelihood that mitigation is additional: this issue is discussed in section 2.2.6. Generally, it is important to reassess regulatory additionality regularly, to reflect the dynamic nature of agricultural and environmental policy.

Generally, financial additionality assessments in the methodologies assessed are weak; while strong financial additionality tests should be mandatory for offsets. Given the driving role of CAP and other public funding for the agricultural sector, it is crucial to consider other public funding through financial additionality assessments. If robust financial additionality assessments are not carried out, there is a significant risk of non-additionality, and of double-counting (see section 5.5).

Barrier tests and penetration rate tests can be relatively low-cost but will be insufficient to ensure additionality, and therefore should not be relied upon alone if credits are to be used as offsets, though they may be appropriate for other uses. They are most appropriate for single measures, as they will be complex to calculate for suites of measures. If they are to be used, "penetration rates" must be set at levels that realistically identify common practice (e.g. *GS's* 5% rate for small projects), the reference area needs to be carefully defined (regional-scale seems as broad as would be reasonable), and they must be regularly updated. To lower participant transaction costs and ensure consistency, it may make sense to assess and approve penetration rates at the regional level when developing the methodology.

It is difficult to ascertain the likelihood of additionality from a cursory inspection of methodologies. Sometimes the lack of additionality tests is relatively transparent in the methodology, e.g. *Nori, Kaindorf,* and *ERF*. However, other methodologies give the appearance of assessing additionality but at closer inspection their tests are unlikely to discern between projects with higher or lower risks of non-additionality. For example, *LbC* establishes a financial additionality test that all orchards will pass; *CAR* has a quite complex additionality assessment including penetration rates, but these penetration rates are set so high (at 50%) they are unlikely to bite. This is misleading: additionality assessments should be set at such a level that some projects will fail, otherwise they are a transaction cost for farmers and buyers without improving the quality of carbon payments.

5.4 Approaches for addressing non-permanence

5.4.1 What are key issues that should be included in programme methodologies?

Addressing non-permanence is crucial for the environmental integrity of offsetting mechanisms 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. In this case, the mechanism will have effectively over-issued credits (Schneider and La Hoz Theuer 2019).

Ideally, emission reductions or removals should be preserved indefinitely, as the expected warming of the atmosphere and other effects of climate change depend 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, especially for nature-based solutions such as climate-friendly soil management measures. As identified in section 2.2.5, with the exception of land-use change measures, no climate-friendly soil management measure offers long-term carbon storage. 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 crediting mechanisms (UBA 2022). This duration also corresponds to the best practice in the voluntary carbon market. For the preservation of carbon stocks in soils, it is also crucial that climate-friendly soil management measures are constantly sustained in order to prevent the release of the mitigated carbon into the atmosphere (UBA 2022).

To manage reversals and reduce the risk of non-permanence for carbon stored in soils, some combination of the following approaches should be applied (Ecologic; Ramboll; Carbon Counts 2021; CCQI 2022):

- **Reducing non-permanence risks** by conducting non-permanence risk assessments based on a thorough methodology and either excluding mitigation activities with higher risks from eligibility or requiring measures to mitigate the risks. The application of risk assessments should be independently validated and verified. In case of reversals, the risk assessment should be updated.
- **Monitoring and compensating for reversals** by requiring monitoring of carbon stocks over long time periods and provisions for cancelling other credits in case a reversal occurs.

All types of reversals (intentional and unintentional ones like natural disasters) must be compensated for but the responsibility is often split:

- **Pooled buffers** are often used to compensate for unintentional reversals. Credits in the buffer should be cancelled at the end of the time period for which monitoring and compensation for reversals is required. Also, rules should be in place that make sure that buffer pools can continue to operate if the crediting programme ceased to exist. Buffer pools also need to be sufficiently capitalised from a diversity of sources in order to be effectively able to compensate for reversals. Rules should also be in place how compensation is ensured in case of insolvency of the crediting programme or the project owner.
- Project participants are usually liable for any intentional reversals. This avoids moral hazard risk posed by intentional reversals. Requiring insurance can additionally ensure that compensation of reversals will happen. These approaches may be accompanied by **contractual or legal approaches,** which use contracts, legal restrictions or land use or other existing legislation to minimise the risk of reversals. Project owners can also be required to have legal titles to the land or legally binding arrangements can be put in place that require a project owner's consent to undertake any activity that might lead to intentional reversals. In the case where project participants are unable to compensate for reversals (e.g. due to insolvency), a backstop should be available (e.g. using the pooled buffer reserve).

- **Issuing temporary carbon credits** that expire after a certain time period, which need to be replaced by other credits as they expire (or when monitoring expires);

- **Discounting 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.

5.4.2 Summary of approaches by programmes including key challenges

Our assessment of methodologies reveals a number of red flags in terms of addressing the risk of non-permanence. Five methodologies rely on monitoring and compensating for reversals as an approach to reduce non-permanence risks (*ACR, CAR, ERF, GS, VCS*). Two methodologies make some reference to compensating for reversals, but no clear approach to address non-permanence by monitoring and compensating for reversals is described (CarePeat, Nori). Three methodologies apply alternative mechanisms to compensating for reversals: *Kaindorf* addresses non-permanence by issuing only temporary credits that expire after 5 years; *Alberta* and *LbC* apply discount factors to address potential reversal risks to the credits issued.

Only one methodology has a mechanism in place to address reversals for a period of 100 years (*CAR*[72]). Under the ERF, projects can choose between a 100-year or 25-year "permanence period"; the amount of credits issued is discounted by 20% if the shorter period is chosen. *ACR* has mechanisms in place to address potential reversals for a period of 40 years. **Obligations for monitoring and compensating for reversals are in place for 10 years or less beyond the crediting period under four methodologies** *(GS, VCS, Nori, CarePeat)*.

To compensate for intentional reversals, project owners should primarily be held liable to avoid moral hazard (CCQI 2022). Six methodologies *(ACR, CAR, ERF, GS, Nori, VCS)* have

[72] CAR offers the possibility to shorten this period if other permanence mechanisms are applied, including the use of surety bonds or issuing less credits to a project on the basis of tonne-year accounting (credits are determined proportionally to the time for which stored CO_2 is kept out of the atmosphere).

corresponding rules in place, but for three of them, liability applies only during the crediting period *(GS, VCS)* or for 10 years after the end of the crediting period *(Nori)*. *CarePeat* does not have any rules on liability in place.

For **unintentional reversals such as fire, disease or drought, buffer pools** can be a tool to compensate for reversals. Six of the seven methodologies that do not apply other approaches than compensating for reversals, have some form of buffer pool in place *(ACR, CAR, ERF, GS, Nori, VCS)*, however for three methodologies, this mechanism only applies during *(GS and VCS)* or for 10 years after *(Nori)* the end of the crediting period. For *CarePeat*, the buffer pool only applies to ex-ante credits and contributions are paid out after five years. To be effective, buffer pools need to be sufficiently capitalised (i.e. hold sufficient credits) to cover potential reversals (CCQI 2022). However, **only two methodologies fill the buffer pools from projects with *and* without reversal risks** *(CAR, GS)*, while for four methodologies only projects with reversal risks contribute to the buffer pool *(ACR, CarePeat, Nori, VCS)*. For *ERF*, no information on these aspects could be found. Contributions to the buffer pool are determined on the basis of a risk assessment under three methodologies *(ACR, CAR, VCS)*. **Under one methodology, the contribution to the buffer is too low to cover larger scale reversals** (*ERF*, fixed at 5%). For *Nori*, the calculation of the contribution to the buffer is not explained. **After the end of the period for monitoring and compensating for reversals, credits should be retired or cancelled in order to cover potential future reversals** (CCQI 2022). This is **only explicitly required by 2 methodologies** *(ACR, VCS)*. Under the other four methodologies that have buffer pools in place, credits remain in the buffer after the end of the period for which monitoring and compensation of reversals is required *(CAR, GS)* or the information provided is unclear *(ERF, Nori)*.

Furthermore, arrangements should be in place to address reversals in case of insolvency of the project owner or if the crediting programme ceases to exist. **Such arrangements are not in place or information is lacking for all but three methodologies regarding insolvency of the project owner** *(ACR, GS, VCS)* **as well as regarding the dissolution of the standard** *(ACR, CAR, GS)*.

To mitigate reversal risks upon the initiation of a project, risk assessments can be employed. **Only four methodologies have risk assessments in place** *(ACR, CAR, GS, VCS)*, but only two of them exclude projects from eligibility where the risk is deemed too high *(GS, VCS)*. Nori requires a "credit quality score" to be calculated but the details are unclear. Furthermore, programmes may require project owners to have legal titles to the land or legal arrangements that require project owner's consent to undertake any measures that might lead to intentional reversals to mitigate reversal risks (Schneider et al. 2022). For four methodologies, no such provisions are in place or could be found *(CarePeat, Kaindorf, LbC, Nori)*.

5.4.3 Conclusions

Overall, the methodologies in place show severe gaps with regard to ensuring that mitigation outcomes are sustained for long time periods. Only three out of seven methodologies that rely on monitoring and compensating for reversals have rules in place for addressing non-permanence risks for at least 40 years. These three methodologies, however, show weaknesses in the operation of the pooled buffer reserve or in terms of lacking risk assessments making it questionable as to what extent they will guarantee long-term storage. **For the other four methodologies, no mechanism to ensure long-term carbon storage is in place.**

Where a buffer pool is applied (seven methodologies), this pool risks to be undercapitalised in five cases to cover large-scale reversals. Empirical studies found that in the case of forest carbon offsets California, the buffer pool applied by California's cap-and-trade system is severely undercapitalised to cover unintentional reversals over the coming decades; even though contributions to the pool are based on a set of project-specific risk factors (Badgley et al. 2022a). With the accelerating climate crisis, natural disturbances that lead to unintentional reversals are very likely to occur more frequently and limit the future removal potential of soils and other ecosystems (Gatti et al. 2021). This reinforces the risk of buffer pools to be undercapitalised to fully cover future reversal events.

Discounting credits issued to account for reversal risks (applied by two methodologies and available as an option under a third one) **does not provide a robust alternative to address reversal risks** because it provides only limited incentives to avoid reversals and creates moral hazard problems. Furthermore, if credited soil carbon removals were completely reversed after a certain period of time, e.g. due to a natural disaster, these reversals would not be compensated for. In the case that these credits were used for offsetting purposes, this would lead to higher overall GHGs in the atmosphere (CCQI 2022).

Temporary crediting as an alternative to compensating for reversals (applied by one methodology) by contrast, can be a viable option to address non-permanence risks. Such credits should not be usable for offsetting emissions in the long run and thus ensure that the overall amount of emissions in the atmosphere does not increase as a result of using offsetting mechanisms if the credited mitigation outcomes are reversed at a later point in time.

Non-permanence risks are particularly relevant for soil carbon activities since the stored carbon can be reversed rather quickly by natural disturbances or human interference (while the risk is lower for climate-friendly soil management measures that imply land use changes which are more complex to revert, see section 2.2.5). Additionally, climate-friendly soil management measures need to be continued on an ongoing basis to prevent a release of stored carbon (Paul et al. 2023). Ensuring permanence for a time horizon of 100 years – which is still too short to match the impact of GHG emissions in the atmosphere (Archer et al. 2009) – is therefore very challenging to implement for farmers who have much shorter planning horizons and/or tenure or land titles.

5.5 Approaches for avoiding double counting

5.5.1 What are key issues that should be included in programme methodologies?

Double counting occurs if the same mitigation outcome is counted more than once towards the achievement of a mitigation goal (NewClimate Institute; Schneider 2020; Schneider and La Hoz Theuer 2019). Double counting can occur as **double issuance** of credits (when credits are issued more than once for the same mitigation outcomes), **double use** (when the same credit is cancelled twice in a programme's registry to achieve a climate target), or **double claiming** (when two different actors use the same credit to achieve different climate targets) (Schneider et al. 2015; OECD 2013; NewClimate Institute; Schneider 2020; UBA 2022; CCQI 2022). Any of these types of double counting can undermine the environmental integrity of a crediting mechanism by leading to higher aggregate emissions in the atmosphere than without the use of such mechanism (Oeko-Institut; Ecologic Institut; Universität Gießen 2023).

Double counting can involve different types of actors, depending on how carbon credits are used. For credits that are internationally transferred and **used towards achieving NDCs**, double claiming by the host country and the buyer country must be avoided. To achieve this, countries need to apply so-called 'corresponding adjustments' to their emissions balances under Article 6 of the Paris Agreement (CCQI 2022).

Furthermore, **double claiming can occur between two private entities** claiming the same credits for offsetting purposes on the voluntary carbon market. If credits on the voluntary carbon market are used for compliance under CORSIA[73], credits need to be earmarked for such use under the scheme in the registry of the carbon crediting mechanism to avoid double claiming (UBA 2022).

Double counting can also occur between buyers on the voluntary carbon market and host countries of mitigation projects, e.g. if private actors purchase and claim credits from projects on the voluntary carbon market and the same mitigation outcome is accounted by a country towards meeting its NDC under the Paris Agreement (NewClimate Institute; Schneider 2020). To avoid this form of double counting, the host country of the mitigation activity would need to authorise the activity under Article 6 of the Paris Agreement for "other international mitigation purposes" (OIMP), including use on the voluntary carbon market. As a consequence, the country would need to apply 'corresponding adjustments' to its own emissions balance, i.e. by making additions to its reported emissions corresponding to the authorised credits (CCQI 2022).

Another double counting risk is that the same **mitigation outcomes are used by countries to fulfil domestic climate policies** (e.g. use in an emissions trading system or under the EU LULUCF Regulation) and by a private or public entity in form of a credit for offsetting purposes or for accounting towards national mitigation targets.

To avoid double counting, crediting methodologies should implement the following approaches (CCQI 2022):

- A **well-functioning registry system needs to be in place** (including information on a project's serial number/unique identifier, transparently documenting issuances, transfers and cancellations, including information on the owners of credits, status of credits, and vintage of credits, and providing additional information on the project in terms of the host country, geographical location, project owners, description of project activities, emission sources, sinks, GHGs covered, mitigation technologies).
- **The purpose for which credits are used must be clearly documented** (beneficiaries, goal that is achieved through credits, calendar years) an**d transparently reported by the programme**. If credits are to be used towards an NDC or under CORSIA, programmes should require that the authorisation for such use be documented and make the earmarking for such use visible in the registry.
- **Provisions to avoid double registration of projects under different programmes and for the transition of projects between programmes** must be in place**.**

5.5.2 Summary of approaches by programmes including key challenges

Seven of the ten crediting methodologies that we analysed have a well-advanced registry system in place (*ACR, Alberta, CAR, ERF, GS, LbC, VCS*). Most of these registries provide comprehensive project information; however in the registry of *LbC*, only brief information is provided; the *VCS* registry lacks information on the GHGs covered by a programme and for *GS*, information on the location, emission sources, sinks, GHG covered and mitigation technologies is only available via links to external websites. *Nori* has a registry under development and states that comprehensive information will be available therein. For *CarePeat* and *Kaindorf* no information is available.

[73] Carbon Offsetting and Reduction Scheme for International Aviation, see https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.

A clear documentation of purposes for which credits have been used is in place for three methodologies (*Alberta, GS, VCS*). For *ACR*, only a general reason for retiring credits must be provided, but no information on a beneficiary year or the calendar years in which the credits are used towards a voluntary goal is available. For *CAR*, this information is sometimes given but not mandatory. No documentation is available for five methodologies (*CarePeat, ERF, LbC, Kaindorf, Nori*).

Provisions to avoid double registration under different programmes are in place under six methodologies (*ACR, Alberta, CAR, GS, Nori, VCS*). No information on such provisions is available for *CarePeat, ERF, Kaindorf* and *LbC*.

Three methodologies have rules in place to avoid double claiming of credits under Article 6 (*ACR, GS, VCS*). In addition to these three, CAR has rules in place to avoid double counting of credits used towards voluntary mitigation targets and under CORSIA. For two methodologies, such provisions are not relevant because credits are not permitted for use under CORSIA or Article 6 (*LbC*) or the methodology was withdrawn in 2020 (*Alberta*). **To avoid overlaps with domestic mitigation schemes, four methodologies have provisions in place** (*Alberta, CAR, GS, VCS*). For four methodologies, no information on such provisions is available.

5.5.3 Conclusions

In the land use sector, double counting is a particular risk because land ownership, land use and land management often lie in the hands of different stakeholders with overlapping rights. As a result, mitigation outcomes may be claimed by multiple entities (Schneider et al. 2018; UBA 2022). The risk must be addressed at the level of the crediting programme though; no specific regulation for activities related to soil carbon is required at the level of the specific crediting methodology.

Overall, the methodologies show significant weaknesses in terms of provisions to avoid double counting of mitigation outcomes. For the majority of methodologies, available project information and information on the use of credits is insufficient to track which purposes credits are used for and detect potential double counting.

Double counting is a risk to environmental integrity. If the same mitigation outcomes are counted towards two mitigation goals, this could lead to more carbon in the atmosphere than if the emission reductions or removals were only counted once. **The specific effect of double counting depends on how different actors respond to a reduction in net emissions resulting from the purchase of carbon credits though** (e.g. whether a private actor lowers its climate actions or whether a country decreases the level of ambition of its climate policy as a result of using carbon credits) (NewClimate Institute; Schneider 2020).

5.6 Environmental and social safeguards

5.6.1 What are key issues that should be included in programme methodologies?

Implementing mitigation projects under all types of funding mechanisms can have both positive and negative environmental and social impacts. Clear guidance, tools and compliance procedures need to be in place to ensure environmental and social safeguards and delivering positive sustainable development impacts (ICVCM 2023). To this end, it is important that methodologies support nature-based solutions, which deliver mitigation at the same time as improving well-being and enhancing biodiversity. Climate-friendly 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 ground (mammals, bird, amphibians, vascular plants) and below ground (bacteria, fungi, macrofauna) (Oeko-Institut; Ecologic Institut; Universität Gießen 2023). However, they can also involve risks such as applying off-farm organic compost bearing the risk of organic and heavy metal contaminants,the risk of high leakage effects regarding climate change mitigation due to excessive import of organic materials from elsewhere (Ecologic Institut; Universität Gießen; Oeko-Institut 2022). Considering the social aspect, implementing mitigation projects under result-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. However, it is difficult to identify and manage environmental and social impacts of funding mechanisms, understand their trade-offs and consolidate these impacts into indicators that enable comparison, mainly due to their subjective and highly contextual nature (UBA 2020) (CCQI 2022).

In order to manage these challenges, crediting mechanisms need to establish a methodology that considers environmental and social impacts, puts safeguards in place to do no harm and provides standards to deliver net-positive impacts. The following issues need to be implemented by crediting mechanisms, based on the CCQI (2022); Ecologic Institut; IEEP (2023) and Oeko-Institut (2022):

- Putting in place **robust environmental and social safeguards**. The Carbon Credit Quality Initiative (2022) comes up with a list of indicators to assess the social and environmental safeguards that a carbon crediting programme and any complementary certification standard requires a project to have in place, assuming that effective safeguards generally reduce the likelihood of harm. However, it needs to be noted that while these safeguards are essential, they cannot be assumed to anticipate all potential environmental and social issues, nor guarantee compliance with the programme's requirements (UBA 2020). It may be useful to integrate the concept of nature-based solutions, that is requiring measures to be "appropriate, adaptive actions to protect, sustainably manage or restore natural or modified ecosystems in order to address targeted societal challenge(s) - such as climate change mitigation -, while simultaneously enhancing human well-being and providing biodiversity benefits" (Oeko-Institut; Ecologic Institut 2022).[74]
- Establish guidelines on the **achievement of each of the Sustainable Development Goals** (SDGs)[75] on an individual project level if data and resources are available. However, this is considered as a very general sustainability criterion designed to safeguard that no significant negative impact occurs and that lacks for example specific protection for biodiversity. In addition, they often require additional approaches to be implemented (Ecologic Institut; IEEP 2023).
- Set clear guidelines to assess the extent to which the project supports or hinders **adaptation and resilience in the host country** across three dimensions: building adaptive capacity, reducing identified risks/vulnerabilities and successful development in spite of climate change (i.e., sustainable development)[76].

[74] This working definition of nature-based solutions has been developed for the purposes of this research project. A multilaterally agreed definition of NbS that resembles this definition was adopted by the United Nations Environment Assembly in 2022, see https://wedocs.unep.org/bitstream/handle/20.500.11822/39864/NATURE-BASED%20SOLUTIONS%20FOR%20SUPPORTING%20SUSTAINABLE%20DEVELOPMENT.%20English.pdf?sequence=1&isAllowed=y.

[75] With the exception of Goal 13 on climate action, which is the primary goal of climate mitigation projects.

[76] According to the Carbon Credit Quality Initiative (CCQI 2022), this criterion is assessed at the individual project level and is therefore optional.

- Implement an **ongoing monitoring system of environmental and social impacts** throughout the project period to verify whether the carbon crediting methodology avoids significant harm and delivers positive sustainable development impacts where possible. Monitoring also focuses attention on the broader sustainable impact and provides additional information that can allow for adaptation and progress towards a certain, positive impact on sustainability that goes beyond climate change mitigation (Scheid et al. 2023). Qualitative approaches can have low accuracy while quantitative approaches potentially have high monitoring, reporting, and verification (MRV) costs.
- Setting robust **transparency requirements and mandatory stakeholder consultation and grievance mechanisms.** Transparency requirements include the public disclosure of project documents, including verification and validation reports. Stakeholder consultation prior to project implementation and the implementation of easily accessible grievance mechanisms throughout the project lifetime needs to be required[77].
- Put overarching and dedicated **gender policies** in place. The promotion and equal and fair treatment of women and all genders has a huge potential to progress sustainable development in many aspects (IPCC 2018).
- Include **multiple payments** or other incentives for delivering both climate mitigation and environmental and social outcomes. Such additional payments are strong and clear incentives for land users but may increase the complexity of the methodology.

5.6.2 Summary of approaches by programmes including key challenges

Our assessment of methodologies identifies a number of red flags in terms of ensuring environmental and social safeguards. Most of the crediting programmes offer no or limited information on the criteria assessed. Only three out of ten programmes offer full information on some of the criteria assessed (*ACR, GS, VCS).*

Six out of ten crediting programmes offer no requirements or information to identify and mitigate negative social and environmental impacts *(Care Peat, ERF, Kaindorf, Nori, Lbc, CAR)*. Three programmes offer general but limited requirements that are not sufficient, e.g. only require projects to identify harm and take steps to mitigate or require compliance with the law *(GS, VCS, Alberta)*. Only one programme requires projects under its methodology to adhere to environmental and community safeguard best practices to ensure that projects “do not harm”, to identify environmental and community risks and impacts and contributions to sustainable development, and to detail how negative impacts will be avoided, mitigated, or compensated *(ACR)*.

Six out of ten crediting programmes have no requirements to put social and environmental safeguards in place (*Care Peat, Kaindorf, Nori, LbC, CAR, Alberta*). Three programmes require either general safeguarding mechanisms with specific safeguards for activities missing (*GS*) or involve only some social and environmental aspects such as “guidelines to consider native title holder interests” or negative lists[78] (*ERF, VCS*). *ACR* requires environmental and social safeguards implemented by identifying and mitigating risks and engaging stakeholders.

[77] Stakeholder involvement is considered as part of the first aspect “robustness of the carbon crediting programme's environmental and social safeguards”.

[78] Crediting mechanisms can exclude actions that pose social or environmental risks using negative lists, which exclude actions, areas, or actors from funding if they are seen to carry risks (Scheid et al. 2023).

Seven out of ten crediting programmes do not require impact assessment for social or environmental effects to be conducted or do not give any information *(Care Peat, ERF, Kaindorf, Nori, Lbc, CAR, Alberta)*. Only three programmes require such an impact assessment *(ACR, GS, VCS)*. *ACR* requires an environmental and community impact assessment as part of the project plan. Basic requirements and aspects to be covered in the assessment are defined in *ACR's* standard, including how negative impacts identified shall be assessed and mitigated. Land rights and tenure must be considered as part of the impact assessment. *ACR* also requires the net environmental and community impacts to be positive. *GS* requires an Environmental Impact Assessment to demonstrate compliance with the safeguarding principles. However, there is no clear guidance on what needs to be covered by an impact assessment. *VCS* only requires an impact assessment on social effects, mainly to identify local stakeholders likely impacted and understand legal or customary tenure or access rights, including potential conflicts, as well as stakeholders outside the project area that may be affected.

Eight out of ten crediting programmes require no monitoring of social and/or environmental impacts or give no information *(VCS, Kaindorf, CAR, Nori, Care Peat, Alberta, ERF, LbC)*. Only *ACR* and *GS* require monitoring. *ACR* requires that negative environmental or community impacts must be monitored throughout the crediting period and impacts or claims of such impacts as well as the appropriate mitigation measure applied must be disclosed in monitoring reports. The assessment of impacts should define who will monitor the impacts while roles and responsibilities for managing environmental and social impacts are not defined. Projects under *GS* have to provide an annual report for each monitoring year. These reports include a summary, feedback given by stakeholders, list of grievances received, events that impact the outcomes and legal contest/dispute.

Seven out of ten crediting programmes have no grievance mechanisms in place or give no information on how a complaint can be handled (*Care Peat, ERF, Kaindorf, Nori, LbC, CAR, Alberta*). One programme (*ACR)* has a grievance mechanism where stakeholders can appeal against ACR decisions (it is not mentioned whether project operators must consider grievance claims). Two programmes have clear grievance mechanisms in place (*GS, VCS).* Under the *GS* methodology, projects must establish a grievance mechanism to record concerns/grievance during the entire project lifetime, with the grievance mechanism agreed to with stakeholders and described in the Stakeholder Consultation Report.

Seven out of ten crediting programmes have no requirements for stakeholder consultation before implementing a project *(Care Peat, Kaindorf, Nori, LbC, CAR, VCS, Alberta)*. Two programmes have limited stakeholder definitions in place *(ERF, ACR)*. The *ERF* does consider native titles (i.e. land and waters that Aboriginal and Torres Strait Islander people can hold under traditional laws and customs), but does not consider other stakeholders, such as adjacent landowners or environmental organisations. The *ACR* only requires a stakeholder consultation, before validation of the project, if community-based stakeholders of the project are identified. However. there are no guidelines on how a consultation should be carried out. Only *GS* requires a clear stakeholder engagement process. Stakeholders have to be identified, invited and their feedback taken into consideration including ongoing reporting. Information provided to the stakeholders must be culturally appropriate and include among others a non-technical summary, the duration and an implementation plan.

Nine out of ten crediting programmes have no gender policy in place *(Care Peat, ERF, Kaindorf, Nori, LbC, ACR, CAR, VCS, Alberta)*. Only *GS* formulates in their principles gender equality and woman rights, however, without specifying the monitoring. *GS* will not recognise projects that contribute to discrimination against women or reinforce gender-based discrimination or inequalities. They further specify that projects have to contribute to SDG 5:

Gender Equality. Projects must not include sexual harassment and/or violence against women, sexual exploitation, human trafficking, slavery, imprisonment, etc.; equal pay for equal work should be respected. They also call for considering any national gender strategy and drawing on expert stakeholders.

5.6.3 Conclusions

Overall, the methodologies we assessed are unlikely to ensure environmental and social safeguards and delivering positive sustainable development impacts. The methodologies differ considerably in how they ensure environmental and social safeguards and assess positive and negative sustainable development impacts. Some methodologies do not provide any information on environmental and social safeguards.

This analysis reveals several areas in which carbon crediting methodologies and complementary standards can further improve their requirements on environmental and social safeguards. A key weakness of most of the evaluated methodologies is that they do not provide any information on how to identify and mitigate potential negative social or environmental impacts. However, understanding the potential trade-offs of funding climate-friendly soil management measures is essential for mobilising the synergies between climate change mitigation and other sustainable impacts. **We recommend that carbon crediting methodologies put mandatory requirements in place for project developers to, at a minimum, identify and mitigate potential negative social or environmental impacts.**

We recommend a thorough risk assessment to identify negative social and environmental impacts of crediting mechanisms while putting in place robust safeguards are key to minimise and exclude risky climate-friendly soil management practices. The application of the SDG framework (as *GS* does) and existing tools to assess SDG interactions, can help to analyse general impacts in a systematic and comparable manner. We recommend that carbon crediting methodologies use this widely accepted framework by drawing on the existing tools to assess SDG interactions and implementing complementary and more specific requirements where necessary.

Ongoing monitoring of environmental and social impacts throughout the project period is critical to verify whether the crediting methodology avoids significant harm and delivers positive sustainable development impacts where possible. Qualitative approaches can have low accuracy while quantitative approaches potentially have high monitoring, reporting, and verification (MRV) costs. **We therefore recommend that carbon crediting methodologies require ongoing monitoring of the project's impacts on environmental and social impacts.**

Positive sustainability development impacts are more than just a co-benefit. The increased well-being, biodiversity and other benefits of nature-based solutions can be a strong motivator for adoption, especially given minimal carbon policies and low carbon prices (Buck and Palumbo-Compton 2022). Therefore, we recommend to clearly report positive social and environmental impacts, to motivate land-users in their adoption of climate-friendly soil management practices and to influence buyers' purchase decisions.

Stakeholder consultation can increase trust among buyers of carbon credits and accordingly the willingness to pay for net-positive sustainable impacts (Ecologic Institut; IEEP 2023). Grievance mechanisms ensure that stakeholders can raise concerns and demand fair treatment during the project lifetime. **We recommend that carbon crediting methodologies require stakeholder consultations prior to project implementation and the implementation of easily accessible grievance mechanisms throughout the project lifetime.** Individual local stakeholder consultation is unlikely to be appropriate for small-scale climate-friendly soil management measures, e.g. implementation on individual farms. However, for large-scale projects (e.g. large-scale land-use change, such as large peatland rewetting or agroforestry projects) such consultation should be employed. Stakeholders should also be involved in the approval of new methodologies.

Only one out of ten crediting methodologies assessed has a gender policy in place. **We recommend that carbon crediting programmes have overarching dedicated gender policies in place.**

Buyers of carbon credits need to be aware of the limitations of carbon crediting methodologies related to environmental and social safeguards. According to Oeko-Institut (2022)**,** there are three options for buyers to address these limitations: 1) choose carbon credits issued, or combinations of crediting methodologies, that provide more rigorous requirements, 2) carry out own due diligence and assess key aspects for specific projects and 3) make use of various online tools that can help to obtain a rough understanding of potential sustainability impacts, taking into account the limitations of such tools with regard to the contextual nature of sustainability impacts and the fact that there is currently no tool available that compares the impacts of different projects. While buyers have some options to address these limitations, this should not hinder carbon crediting methodologies to implement rigorous requirements as described above.

5.7 Governance questions

5.7.1 What are key issues that should be included in programme methodologies?

Carbon crediting programmes are responsible for ensuring that credits issued under their methodologies meet robust quality criteria. Their capacity to do so depends on having in place strong institutional arrangements and processes. These comprise the following aspects (CCQI 2022):

- **Robust overall programme governance** regarding the organisation of the programme (professional Secretariat, a Board of Directors or Trustees with oversight over the programme's operations, and professional staff) and having in place provisions on conflict of interests and procedural violations as well as a code of conduct;
- **Transparency related to the operation of the programme:** information on projects, methodology documents, programme requirements and documentation of public consultation processes should be publicly disclosed;
- **Robust third-party auditing of projects:** Projects should be validated before crediting begins and rules for operations of validation and verification bodies (i.e. the third-party assessors who evaluate projects) should be in place;
- **Robust process for developing new quantification methodologies:** The programme should also require that in developing new quantification methodologies an expert review as well as a public stakeholder consultation should take place. Quantification methodologies should be reviewed and updated regularly and rules should be in place to suspend the use of a methodology in case where new scientific evidence indicates that emission reductions or removals are over-estimated by the methodology.

5.7.2 Summary of approaches by programmes including key challenges

Six programmes implementing the selected crediting methodologies have robust programme governance structures in place (*ACR, Alberta, CAR, GS, LbC, VCS*). According to publicly available information on *Nori*, governance responsibilities are not fully clear. The *ERF* is administered by a very small decision-making body. For *Kaindorf*, no information on programme governance is available; for *CarePeat* the programme's governance structures do not seem to be in place yet.

Related to the transparency on the operation of the programme, four programmes make comprehensive information on projects, methodologies and programme requirements publicly available (*ACR, CAR* (even though a code of conduct is not publicly available), *GS, VCS*) while **for six programmes, the transparency on the operation of the programme is limited**. For four programmes, limited information is publicly available (*Alberta, ERF, LbC, Nori*). For *CarePeat* and *Kaindorf*, only very little information on the operation is available, lacking detailed project information as well as programme requirements. For *CarePeat*, corresponding requirements might still be under development.

Available information on third-party auditing is robust for only six programmes (*ACR, Alberta, CAR, GS, LbC, VCS*). For *Nori*, the scope of third-party auditing is limited, under the *ERF* the process lacks transparency. For *CarePeat* and *Kaindorf*, no information on third-party auditing is available.

For developing new quantification methodologies, robust processes including public consultation are in place for eight programmes (*ACR, Alberta, CAR, ERF, GS, LbC, Nori, VCS*). The transparency on *ERF*'s and *Nori*'s provisions is limited though. For *CarePeat* and *Kaindorf*, no information on processes for developing new methodologies is available.

5.7.3 Conclusions

For the majority of the programmes considered, the available information on the governance of the programmes suggests that institutional arrangements and processes are strong or mostly comprehensive. However, for two programmes, no information on programme governance is available which makes it questionable to what extent these programmes are able to issue high-quality carbon credits.

6 Appropriate funding instruments to promote climate-friendly soil management

Funding can support farmers to implement climate-friendly soil management measures as nature-based solutions. In this chapter, we develop recommendations on which funding instruments should be used to enhance climate-friendly soil management in the EU. Our conclusions consider the risks and challenges of individual climate-friendly soil management measures (Chapter 2), the advantages and disadvantages of action-based vs. result-based payments (Chapter 3), the experiences with public funding instruments for climate-friendly soil management (Chapter 4), and our analysis of crediting methodologies under existing result-based payment schemes (Chapter 5).

The following sections discuss the analyses presented in the preceding chapters of this report to draw conclusions on appropriate funding instruments in the context of climate-friendly soil management. We first discuss the general advantages of action-based and result-based payment approaches and draw conclusions under which circumstances and for which type of climate-friendly soil management measures action-based or result-based approaches are more appropriate (section 6.1).[79] Subsequently, we analyse which type of result-based approaches is appropriate to promote climate-friendly soil management measures, including offsetting (section 6.2). Given the challenges we identify for offsetting approaches, we also briefly discuss alternative types of instruments to promote such measures (section 6.3).

6.1 Action-based versus result-based payments

Funding instruments for promoting climate-friendly soil management can be broadly divided into two overarching categories, action-based and result-based payments, which have different strengths and weaknesses. In theory, result-based payments offer advantages over action-based payments. In practice, however, they pose significant implementation challenges. Therefore, their suitability depends on the context. In this section, we summarise the advantages and disadvantages of the two categories of funding instruments, and then assess which ones are more appropriate for specific climate-friendly soil management measures.

6.1.1 Advantages and disadvantages

From a theoretical point of view, the literature suggests that result-based payments are preferable to action-based payments: If well-designed with accurate baselines, result-based payment mechanisms can provide incentives to farmers to enrol land that will deliver higher environmental results to the scheme and ensure much higher certainty about the envisaged environmental outcomes since mitigation outcomes are required to be monitored and quantified.[80] Studies that modelled the impacts of action-based vs. result-based payments found better results in terms of effectiveness in meeting the set targets for result-based payment approaches (Simpson et al. 2023; Sidemo-Holm et al. 2018). Additionally, result-based payment approaches may involve lower informational requirements for the regulator, are theoretically cost-effective and dynamically efficient as they provide incentives for innovations that improve the measurable result (e.g. mitigation), and reduce the costs to achieve the intended outcomes over time (Bartkowski et al. 2021). Also, they are often less prescriptive than action-based

[79] Given the focus of this report and research project on “market-based instruments”, in our consideration of other funding instruments we rely on the basis of theoretical considerations and findings in the literature.

[80] However, if poorly designed, inaccurate baselines can lead to adverse selection and the failure of result-based payment mechanisms to deliver mitigation, whilst still rewarding actors with credits, as illustrated by improved forest management methods in the USA California Air Resources Board offsetting scheme (see e.g. Badgley et al. 2022b).

approaches in what specific measures are eligible for funding, giving farmers greater flexibility and thereby better support transformational change of management practices and attitudes by farmers (Burton and Schwarz 2013). Like action-based payments, result-based payments can be either public or privately funded; result-based approaches are more common in voluntary carbon markets as they enable quantification of mitigation, which is more attractive to buyers.

However, from a practical point of view, result-based payments involve a number of disadvantages when compared to action-based payment approaches. A major disadvantage relates to high costs associated with monitoring and quantification of results that limits their efficiency. Particularly in the context of SOC, there is a strong trade-off between the robustness of results and MRV costs (COWI 2021; OECD 2022).[81] Furthermore, result-based payment approaches can be less attractive to farmers due to higher uncertainty for farmers, e.g. because they do not know in advance whether their actions will generate results sufficient for rewards (Hanley et al. 2012). Studies show that farmers' acceptance of crediting mechanisms for climate-friendly soil management measures has been limited in the past (Hammond et al. 2021). Additionally, unless managed, the focus on one result (e.g. additional mitigation) can come at the expense of other objectives (e.g. biodiversity).

The main advantage of action-based approaches is that they imply lower implementation and transaction costs for farmers, particularly because no monitoring and measuring of mitigation results take place or the associated efforts are considerably lower. This makes action-based approaches generally more attractive for farmers. The fact that payments are more predictable than under result-based approaches adds to this advantage. As action-based approaches fund specific actions (rather than results), they can be targeted to support nature-based solutions that deliver multiple benefits.

The downside of action-based approaches is that they are less environmentally effective because there is much higher uncertainty to what extent they will deliver the envisaged environmental outcomes. As outlined in section 3.1, this uncertainty concerns mitigation results, and few or no guarantees that environmental outcomes will be maintained after the payment has been disbursed. Empirical evidence from assessing environmental outcomes of the EU's CAP illustrates the risk of poorly designed action-based payments failing to maintain environmental outcomes (see Chapter 4). Furthermore, action-based approaches provide less flexibility to farmers to try out different (soil management) approaches, and thus provide fewer incentives for farmers to innovate. There is thus a trade-off between limiting costs of administering result-based payment approaches and achieving desired environmental outcomes in a cost-effective way.

Hybrid approaches, which include a mix of action-based and result-based payments, have been suggested in the literature to combine the advantages of both types of funding approaches. For example, such schemes could provide base payments that are not linked to results to cover up-front costs and increase acceptance by farmers and combine this with additional payments if results are achieved (Burton and Schwarz 2013).[82] As an alternative, payments could be linked to modelled, i.e. expected, results and thus be paid out before mitigation outcomes have been verified (cf. Bartkowski et al. 2021; Kreft et al. 2023). Similarly, some result-based crediting mechanisms (Woodland Carbon Code, Gold Standard) issue non-verified ex ante credits that represent a promise to deliver verified mitigation outcomes in the future. Once these mitigation

[81] As an approach to reduce high transaction costs, readiness funds can build necessary MRV capacity or provide support to cover incremental costs of MRV of outcomes (as implemented in the context of REDD+ for example) (Oeko-Institut 2015).

[82] This has also been implemented by REDD+ funding mechanisms as a solution to cover investment gaps, see Oeko-Institut; CIFOR (2023).

outcomes have been achieved and verified, verified credits are issued which are allowed to be used for offsetting purposes.

Table 5 summarises the advantages and disadvantages of action-based and result-based payment approaches.

Table 5: Comparison of action-based and result-based payment approaches

Criteria	Sub-criteria	Action-based approaches	Result-based approaches
Environmental effectiveness	Achievement of mitigation results	Low Quantification and monitoring of results does not take place.	High Results are quantified and monitored; robust methodologies need to be in place.
	Additionality	Medium Additionality is difficult to assess n but can be addressed by eligibility criteria.	Medium Additionality is difficult to assess but can be addressed by eligibility criteria.
	Addressing non-permanence risks	Low Any reversal of environmental outcomes is not monitored.	Medium – High Appropriate mechanisms to mitigate reversal risk must be in place, but no guarantee possible.
	Perverse incentives	Medium Farmers may discontinue sustainable practices to be eligible for a scheme.	Low-Medium Robust baselines can reduce risk of perverse incentives.
Efficiency	Transaction costs	Low No costs occur for monitoring and quantification.	High Costs for measuring are high; alternative approaches are not robust enough yet.
	Cost-effectiveness (for climate mitigation)	Low Environmental outcomes are uncertain.	Medium High in theory, but limited due to high transaction costs and uncertainty in the quantification of outcomes.
	Innovation incentives	Low No incentive to innovate.	High Flexibility for farmers creates incentives to innovate to increase measured results.
Other considerations	Acceptance by land managers	High	Medium

Criteria	Sub-criteria	Action-based approaches	Result-based approaches
		High financial certainty of payment; relatively simple.	Uncertainty of payments limits acceptance and uptake; relatively complex.
	Social and environmental impacts	Medium Can be addressed by eligibility criteria but are not monitored	Medium Appropriate monitoring and complaints mechanisms could reduce risks i.

Source: Authors' own compilation

6.1.2 Appropriateness of different climate-friendly soil management measures for result-based funding approaches

As discussed in Chapter 2, climate-friendly soil management measures are diverse. The differences between the different measures affect their suitability for action-based or result-based funding. As identified in section 6.1, result-based approaches offer advantages over action-based payments but also pose additional practical challenges that mean they are not universally appropriate. Whether result-based funding instruments are suitable instruments to promote climate-friendly soil management measures depends on the specific characteristics of the implemented measures and the context in which they are pursued.

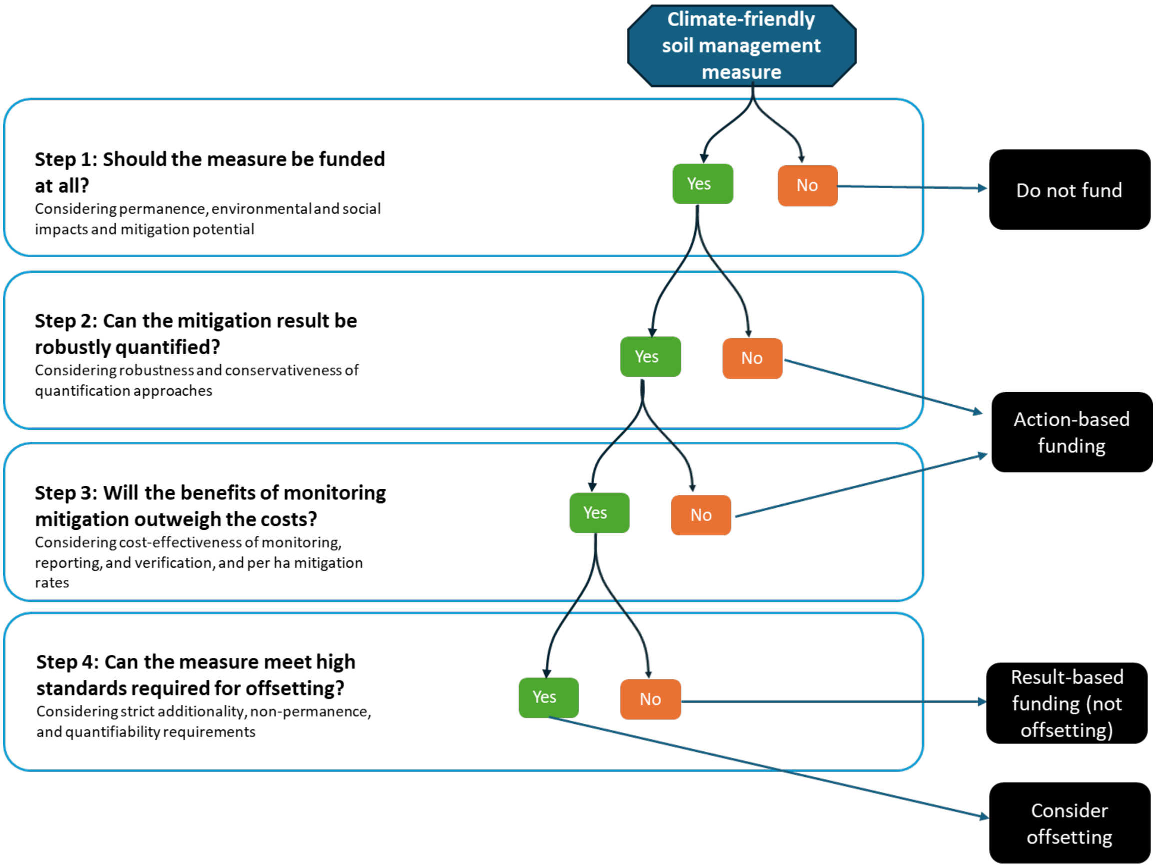
Our assessment of the suitability of different types of measures for result-based funding is stepwise, considering the different requirements of different funding approaches, as illustrated by Figure 2. Our evaluation draws on the findings from Chapter 2, in particular the evaluation summarised in Table 2. The results of our evaluation are presented in Table 6 (which also presents the findings from our evaluation of the suitability of offsetting approaches in section 6.2.1).

Some caveats apply to our evaluation. We assessed measures on an individual, measure-by-measure basis. However, as illustrated by Chapter 5, many existing crediting methodologies reward the effects of **multiple measures** combined (though these may be multiple individual measures implemented on different parcels of land).[83] It is difficult to conclude as to how results for combinations of measures would differ from our assessment of individual measures, or whether combinations of measures are more suitable for result-based than action-based payments (or vice-versa).[84] Further, given the diversity of farming contexts, it will be important to consider local context alongside our evaluation, which is at the European scale. Finally, the effectiveness of any funding approach will depend on its specific design, for example the robustness of rules regarding double-counting of mitigation.

[83] For example, the Verra VCS methodology rewards mitigation outcomes arising from measures including silvoarable agroforestry, use of cover crops, crop rotations with forage legumes, crop rotation with grain legumes, permanent grassland management, residue management, applying manure/compost, improved crop rotation, buffer strips, nitrification inhibitors (urease inhibitor), precision farming, low input grasslands, organic farming, critical external inputs, etc. (see Table 4 and Annex A).

[84] Relative to our assessment of individual measures, combining measures may increase or decrease quantification uncertainty or likelihood of additionality; our assessments of non-permanence risk would be the same as individual measures.

Figure 2: Decision tree: Selecting appropriate funding approach for climate friendly-soil management measures



Source: Authors' own illustration

Step 1 Should the measure be funded at all? Considering permanence, environmental and social impacts and mitigation potential: Irrespective of whether funding is result-based or action-based, funding should promote measures that deliver positive environmental and social benefits, such as nature-nature based solutions. Measures that pose significant environmental or social risks, such as a loss to biodiversity, should be excluded, as should those that do not have the ability to achieve long-term carbon storage, or that have a low mitigation potential. Policy-makers must also consider specific local context, including whether the measure is already common practice or being promoted by other instruments (additionality).[85]

- All climate-friendly soil management measures that we consider in this report are nature-based solutions, which by definition generate net social and environmental benefit, including biodiversity enhancements, in addition to mitigation. This is not true of all potential measures, some of which (e.g. biochar, nitrification inhibitors) can pose risks to soil health and biodiversity; measures that pose such risks should be excluded from widescale funding. All climate-friendly soil management measures we consider pose some risk of carbon

[85] We do not consider this issue of additionality in this first step of our EU-scale assessment, due to the wide range in farming practices across Europe, and the diversity of regulatory and funding situations in different Member States. This should be considered at local context.

reversal; we propose prioritising those measures with lower reversal risks, such as those related to land-used change (rewetting of organic soils, agroforestry, conversion of arable land to grassland, buffer strips, permanent grassland management). Four of the measures assessed offer only low or uncertain mitigation potential in the EU; these measures (low-input grasslands, mixed crop-livestock systems, mulching, and contour farming/terracing) should not be priorities for funding to achieve climate mitigation climate-friendly soil carbon management, even using action-based approaches. Their funding may be justified to meet other objectives.

Step 2 Can the mitigation result be robustly quantified? An essential prerequisite for result-based funding is that the mitigation impact can be robustly and conservatively quantified (i.e. a high signal-to-noise ratio can be found).[86]

- Quantifiability poses a significant challenge for climate-friendly soil management, given the complexity and cost of measuring or modelling mitigation impact (Environmental Defence Fund 2021a). Our assessment in section 2.2.3 shows that **four measures can only be quantified with high uncertainty** (agroforestry, mixed-crop livestock systems, contour farming, and reduced soil compaction), **which makes them inappropriate for result-based financing** given current quantification methods and technologies. Agroforestry and reduced soil compaction offer significant mitigation potential and are therefore appropriate for promotion through action-based payments. Further research may increase the quantification certainty over time to potentially enable result-based payments in the future. **We evaluate the remaining measures as being quantifiable with a medium level of uncertainty** and therefore as possible candidates for result-based payments, with those measures offering the highest mitigation potential being the most appropriate. However, given that none of the measures were assessed as being quantifiable with high certainty, ensuring conservativeness would be essential if result-based approaches were to be used (e.g. the use of conservative emission factors and modelling or measurement assumptions, to minimise the risk of overestimating mitigation impact). In the future, quantification challenges (uncertainty and cost) may partly be overcome through better modelling methodologies and technological improvements, e.g. soil spectroscopy or combined approaches (van der Voort et al. 2023; Environmental Defence Fund 2021a). Given that all three measures constitute land-use changes that may involve decreases in agricultural production, it will also be important to consider and control for leakage (i.e. discounting estimated mitigation based upon expected direct or indirect leakage, see section 5.2).

Step 3 Will the benefits of monitoring mitigation results outweigh the costs? Considering cost-effective monitoring, reporting, and verification (high per ha mitigation): As discussed in 5.2.1, monitoring, reporting, and verification (MRV) costs can be significant and feature a degree of fixed costs (e.g. sampling costs or model development costs). Accordingly, appropriateness for result-based funding also depends on the ratio of mitigation impact to MRV cost: if MRV is costly, then only measures that deliver a high per ha rate of mitigation will be economic to incentivise through

[86] Signal-to-noise ratio refers to the ability to distinguish a mitigation measure's impact from other factors that may influence emissions or removals, such as natural variations in SOC content and measurement error; only where this ratio is high can we be confident that any identified mitigation has occurred (and is not simply an artefact of other factors such as natural variation or inaccurate measurement).

a result-based mechanism. At the same time, the payment under the result-based funding scheme must be sufficiently high to cover the MRV costs.

- An indicator for the ratio of mitigation impact to MRV costs is mitigation potential per ha, with measures with high mitigation per ha more likely to generate sufficient mitigation and rewards to cover fixed MRV costs. **We identify three measures that have high mitigation per ha (in addition to medium quantification certainty) that therefore remain strong candidates for result-based payments: conversion of arable land to grassland, rewetting of organic soils, and buffer strips.** The use of cover crops, improved crop rotations, forage/grain legumes in crop rotations, residue management, and applying manure/compost may also be appropriate for result-based payments, but given their lower per ha mitigation, it may be more efficient to promote these measures using action-based payments. Due to low per ha mitigation scores (and only medium quantification uncertainty), permanent grassland management should be promoted using lower cost instruments such as action-based payments or regulation, not result-based payments. These assessments should be re-evaluated as scientific advances make quantification more certain and/or reduce the costs of MRV. For example, conservative models of mitigation impact of measures would make quantification reduce MRV costs, meaning additional measures would become appropriate for being promoted through result-based payments.

As shown in Table 6, the above assessment identifies three measures as most appropriate for promotion through result-based payments (conversion of arable land to grassland, rewetting of organic soils, and buffer strips).

Step 4 Can the measure meet high standards required for offsetting? Considering strict standards for additionality, non-permanence, and quantifiability: As discussed in section 6.2, to ensure environmental integrity and to be appropriate for offsetting, measures must meet particularly high standards of additionality, non-permanence and quantifiability.

- **We evaluate no climate-friendly soil management measures as appropriate for offsetting** (see section 6.2.1 for in-depth discussion of issues related to offsetting). Among the measures identified at least somewhat appropriate for result-based measures, we exclude any measures from offsetting if they are assessed as having a low likelihood of additionality at the EU-level (e.g. due to being common place or already often promoted through the CAP); this applies to buffer strips, cover crops, residue management, including forage and grain legumes in crop rotations, residue management, and mulching. For those measures with at least a medium additionality assessment,[87] no measures achieved both high quantifiability scores and high chance of long-term storage, and were accordingly assessed as being "risky" for offsetting approaches; this applies to conversion of arable land to grassland, rewetting of organic soils, permanent grassland management, low-input grasslands, improved crop rotation, and applying manure/compost. These measures should therefore be promoted by other types of funding measures (either action-based or result-based, as indicated by the previous steps of the assessment).

[87] Additionality assessment is at the EU level, given diversity of farming contexts and Member State-specific regulation and funding programmes, this should be further assessed at local level.

Table 6: Appropriateness of measures for different funding instruments

	Funding instrument appropriateness		
Measure	**Action-based***	**Result-based** (non-offset)**	**Offsets*****
Conversion of arable land to grassland	Mostly	Mostly	Risky
Rewetting of organic soils	Fully	Fully	Risky
Silvoarable and silvopastoral agroforestry	Fully	Inappropriate	Inappropriate
Mixed crop-livestock systems	Uncertain	Inappropriate	Inappropriate
Permanent grassland management	Mostly	Risky	Risky
Low-input grasslands / set-aside areas	Uncertain	Uncertain	Risky
Buffer strips	Mostly	Mostly	Inappropriate
Use of cover crops	Somewhat	Somewhat	Inappropriate
Improved crop rotation	Somewhat	Somewhat	Risky
Include forage and grain legumes in crop rotations	Somewhat	Somewhat	Inappropriate
Residue management	Somewhat	Somewhat	Inappropriate
Mulching	Uncertain	Uncertain	Inappropriate
Applying manure / compost	Somewhat	Somewhat	Risky
Contour farming / terracing	Uncertain	Inappropriate	Inappropriate
Reduced soil compaction	Somewhat	Inappropriate	Inappropriate

Source: Authors' own compilation

* **Action-based score: This considers social and environmental impacts, non-permanence, and mitigation potential.** Environmental and social impacts are marked light green if no significant risks, yellow if uncertain. Permanence: cell colour is upgraded to darker green if non-permanence score is medium or better (from Table 2); Mitigation potential: cell colour is made a shade darker if high potential in the EU, or downgrade to lightest green if low or uncertain potential.

** **Result-based score: Additionally considers quantifiability and cost-effective MRV.** Assessment builds on action-based column. Quantifiable: cell colour is downgraded to red if quantification score from Table 2 is low; Cost-effective MRV: for remaining green cells, cell colour is downgraded to lighter red if quantification certainty score is medium and per ha mitigation score is low in Table 2.

***__Offsets score: Additionally considers additionality, non-permanence and quantifiability__. Builds on result-based score. Additionality: cell colour downgraded to red if low likelihood of additionality (from Table 2); Non-permanence and quantifiability: cell colour downgraded to light red if anything other than good chance of longer term storage and green quantifiability.

6.2 Which types of result-based payment approaches are suitable to promote climate-friendly soil management?

Result-based payments can take three overarching forms: offsetting, contribution claims, or result-based public finance. All forms can be used to promote any climate project, with the key distinction being how the mitigation results are used. Most prominent and with greatest risk is offsetting, which is where we start this section. We reflect on our evaluation of ten carbon crediting methodologies (of which nine generate credits for offsetting) to assess the suitability of offsetting approaches to fund climate-friendly soil management. Given the challenges we identify, we then consider two alternative approaches: contribution claims and result-based public finance.

6.2.1 Offsetting approaches

Offsetting involves certifying the mitigation results of climate-friendly soil management as credits, which are then sold to a buyer who uses the carbon credits towards their own (voluntary) climate mitigation target. This is facilitated by voluntary carbon markets. These are advocated as a way to mobilise (private) funds for urgently needed protection and restoration of soils and transforming agricultural practices (The Nature Conservancy 2018).

However, given the quantification, non-permanence, and additionality challenges associated with funding climate-friendly soil management measures, offsetting poses significant risks to environmental integrity (see box in section 6.2.1.2). This arises because offsets may be used to achieve mitigation targets and related claims, such as "climate neutrality". If the associated soil management measure mitigation is not permanent, additional, or overestimated, then its use would ultimately lead to higher amounts of greenhouse gases in the atmosphere than would have been the case without the offset mechanism. In this context, some authors argue that it is generally inappropriate to offset emissions from fossil fuels by storing carbon in biomass, as any storage in biomass may only be temporary and that there is therefore no equivalence between avoiding fossil fuel emissions and storing carbon in biomass (Carton et al. 2021).

Generally, with offsetting arising from any type of climate projects, there is concern that the ability to use carbon credits for offsetting could delay emission reductions by the user of the carbon credits, which is also referred to as mitigation deterrence. This could lead to lock-in of more emissions intensive technologies and pathways which could make it more difficult to the deep emission cuts needed, potentially leading to negative earth feedbacks and accelerated climate change (IPCC 2021; Zickfeld et al. 2021). Accordingly, any use of offsetting today must ensure that it supports a transition to a net zero future, rather than reducing overall mitigation action.

Where offsetting is pursued, there is also a debate whether, or for how long, credits from emission reductions should continue to be used for offsetting. To achieve the goals of the Paris Agreement, emissions will need to be balanced out by an equivalent amount of removals by mid-century, with a significant scale of net removals needed in the second half of this century (i.e. where removals will need to exceed the remaining "hard to abate" emissions). This raises the question for how long emission reductions could still be used for offsetting. Some authors and stakeholders argue that only removals should be used for offsetting today, whereas others envisage this limitation only at a later point in time and see merit in continuing to use emission reductions for offsetting in the short term. Offsetting credits generated by reducing emissions should be allowed in the short term, as they can reward early movers and create incentives for innovation that will support overall reductions in emissions in the future, and lower transition costs for early movers.

6.2.1.1 Evaluation of ten existing offsetting approaches for climate friendly soil measures

To understand the appropriateness of offsetting for funding climate-friendly soil management measures, we analysed ten[88] selected crediting mechanisms that operate on the voluntary carbon market as well as on compliance markets and promote different climate-friendly soil management measures (see Chapter 5 and the detailed analysis published as an Annex to this report).[89] Table 7 summarises the identified shortcomings of the selected credited methodologies using a "red flag" analysis: red cells indicate a major issue, yellow cells a minor issue; with grey indicating that no significant problem was identified.[90] Overall, our assessment illustrates that the different methodologies generate credits with vastly different quality on the different aspects we assessed. **Our evaluation finds that no methodologies are sufficiently robust to generate credits appropriate for offsetting emissions reductions in other sectors.** Overall, the crediting programmes *ACR* and *CAR* have higher benchmarks in place for addressing key challenges related to non-permanence, quantification and additionality in the context of climate-friendly soil management measures than smaller programmes, while *Gold Standard* stands out in relation to its provisions for applying environmental and social safeguards; nevertheless, in our assessment none of the evaluated mechanisms meets the high standard necessary to justify the risk of using offsetting approaches to fund climate-friendly soil management measures.

Table 7: Overview of red flags resulting from analysis of selected crediting methodologies

	Quantifica-tion	Additionality	Non-permanence	Double-counting	Env./social impacts	Governance
ACR - Avoided Conversion of Grasslands and Shrublands to Crop Production, v2.0	Yellow	Yellow	Yellow	Yellow	Yellow	
Alberta - Quantification protocol for conservation cropping, v. 1.0	Red	Red	Yellow		Red	Yellow
CAR - Soil Enrichment Protocol v.1.1	Yellow	Yellow	Yellow	Yellow	Red	Yellow
Care Peat -"Paying for Peat"	Red	Red	Red	Yellow	Red	Yellow
ERF - Estimating soil organic carbon sequestration using measurement and models method	Red	Red	Yellow	Yellow	Red	Red
Gold Standard - Soil organic carbon framework methodology Version 1.0	Red	Yellow	Red			
Label bas Carbone - Methode Plantation de	Red	Red	Red	Red	Red	Yellow

[88] All but one (Australian ERF) of the ten crediting methodologies that we analysed generate credits that are usable for offsetting emissions or will do so in the future (see Table 4).

[89] See https://www.umweltbundesamt.de/publikationen/annex-analysis-ten-crediting-methodologies-soil-management.

[90] We do not use green, as our assessment methodology aims to identify major flaws. Our failure to identify any major flaws does not mean that we endorse or recommend the approach applied by the certification methodology.

	Quantification	Additionality	Non-permanence	Double-counting	Env./social impacts	Governance
Vergers (Orchard plantation method)						
Nori pilot croplands methodology v1.3	Red	Red	Red	Red	Red	Red
Ökoregion Kaindorf	Red	Red	Yellow	Red	Red	Red
VCS - VM0042 Methodology for Improved Agricultural Land Management, v1.0	Red	Red	Red		Red	

Notes: Red cells reflect highly insufficient rules to address the challenges (R); yellow cells reflect partially insufficient rules (Y). Grey cells reflect that no major shortcomings were identified. Source: Authors' own compilation.

More specifically, our evaluation of the selected crediting methodologies identified the following problems:

- **Non-permanence:** All measures assessed pose significant risks of being reversed in the future (see sections 6.1.2 and 2.2.5). All crediting methodologies we assessed show some shortcomings in addressing non-permanence risks, with six out of ten posing significant shortcomings; accordingly, we assess that they do not sufficiently address non-permanence risks (see section 5.4). The relatively high risk of non-permanence for soil management measures makes offsetting approaches generally not appropriate for promoting their implementation.
- **Uncertainties related to quantification:** Quantifying mitigation outcomes from soil management measures involves a significant degree of uncertainty (see sections 6.1.2 and 2.2.3). If mitigation outcomes are overestimated and resulting credits are used for offsetting, then the aggregate GHG emissions in the atmosphere ultimately increase. All of the crediting methodologies we analysed have shortcomings in their rules and methods for quantifying mitigation impacts, with eight raising red flags. Moreover, five out of ten methodologies do not account for uncertainties related to the quantifications. For these reasons most of the methodologies are unlikely to deliver robust and conservative estimates of the mitigation impacts of climate-friendly soil management measures (see section 5.2). Resulting credits should therefore be considered ineligible for offsetting.
- **Additionality:** Additionality is desirable for any funding instrument, as it also promotes cost-effectiveness. It is essential for offset mechanisms to ensure environmental integrity. Only two crediting methodologies that we analysed have relatively robust approaches in place for assessing the additionality of climate-friendly soil management measures, albeit with some limitations (see section 5.3).
- **Double counting:** Offsetting approaches imply risks of various forms of double counting. These risks are not unique to climate-friendly soil management measures though and they can be addressed by rules and requirements at programme level: Five methodologies that we analysed have relatively robust provisions in place to address the risk of double counting (see section 5.5).
- **Environmental and social impacts:** Considering environmental and social impacts is key for climate-friendly soil management measures, regardless of the funding approach by which they are promoted. Nevertheless, for all but two crediting methodologies we identified severe shortcomings in their approaches to ensure environmental and social safeguards and mitigate potential negative impacts (see section 5.6). These would urgently need to be

addressed in order to make the methodologies recommendable as result-based finance instruments.

Due to the challenges highlighted above, offsets from currently available methodologies cannot be considered an appropriate instrument to promote climate-friendly soil management measures. The resulting credits are unlikely to deliver the mitigation impact attributed to them, especially in the long run (cf. also Paul et al. 2023), and therefore should not be usable for compensating for CO_2 emissions that remain in the atmosphere for several centuries.[91]

6.2.1.2 Shortcomings of all offset approaches for climate-friendly soil measures

Next to the specific shortcomings identified in the evaluation of the ten methodologies, there are considerable general challenges when using offsetting approaches for climate-friendly soil management measures. To justify offsetting, we must be confident that the mitigation results of climate-friendly soil management measures are equivalent to emissions reductions in the other sectors they replace (e.g. reduced emissions from air travel). This requires a high degree of confidence regarding additionality, non-permanence, and quantification certainty. Any non-equivalence poses a risk to environmental integrity (see Environmental Integrity box in Chapter 3). For example, in the case where the air travel sector purchases climate-friendly soil management offsetting credits instead of reducing its own emissions, the offset credits must be backed by mitigation that is as permanent, additional, and robustly quantified as emissions reductions by air travel. If not, the offsetting would result in more GHGs in the atmosphere than if air travel reduced its own emissions (that is, it would fail to achieve environmental integrity).

As our evaluation in section 6.1.2 concludes, **none of the climate-friendly soil management measures analysed meets the high degree of confidence necessary to justify an offsetting approach**. As described in step 4 of our evaluation in section 6.1.2 and illustrated in Table 6, no climate-friendly soil management measure meets the high degree of confidence necessary to justifying their funding through offsetting due to additionality, non-permanence, and quantification uncertainty concerns. **We therefore conclude that offsetting should generally not be pursued for climate-friendly soil management measures.**

6.2.1.3 Fixing the shortcomings of offsetting approaches

Given our conclusion that offsetting is not appropriate for promoting carbon-friendly soil management measures, below we discuss four possible paths forward to “fix” the identified weaknesses of offsetting as a tool to promote climate-friendly soil management: increasing stringency of crediting methodologies, temporary crediting for offset use, accepting higher uncertainty, or alternative uses of credits.

1. Increasing stringency of crediting methodologies

An obvious approach to “fixing” offsets is to address the issues that undermine their claim to effective GHG mitigation, for example, making additionality requirements more stringent and effective. Indeed, carbon crediting programmes often try to do this already, iteratively updating their methodologies as they identify issues or receive feedback. As summarised in Table 7, our evaluation in Chapter 5 identified numerous problems with existing methodologies, with all methodologies showing “red flags” for different key methodological elements. It also showed that there was significant variance between methodologies, with some methodologies showing

[91] Other evaluations of methodologies for crediting soil carbon also come to the conclusion that robust crediting is challenging and that “none of the existing protocols is doing enough to guarantee good outcomes” (Carbon Plan 2021a).

fewer "red flags", and in some cases raising only minor concerns for some elements (e.g. rules and requirements for quantifying mitigation outcomes by ACR). This raises the question of whether methodologies could draw on best practice elements to address the identified issues, thus reducing risks to environmental integrity and making credits represent more robust and long-term mitigation outcomes. **While improvements to methodologies should be ongoing, in the near term it is questionable whether any improvements will sufficiently "fix" offset-based carbon crediting methodologies for climate-friendly soil management**, for the following reasons:

- As our evaluation in Chapter 5 demonstrates, all evaluated methodologies have issues, illustrating the fundamental challenges posed by additionality, permanence, and quantification for climate-friendly soil management measures. **While technological improvements may begin to address quantification, and methodological improvements may begin to address additionality challenges, the requirement of ensuring long-term storage is difficult to achieve within the context of soil carbon and may require different approaches, such as temporary crediting (see option 2 below).**
- **Further, increased stringency has a trade-off in the form of increased transaction costs and administration, and lower uptake.** This has been demonstrated in the context of REDD+, where more stringent MRV requirements decrease economic returns for foresters and therefore uptake (and overall mitigation) (Köhl et al. 2020). For example, tighter additionality requirements will exclude more actors and increase transaction costs of participating, and more accurate quantification of soil carbon (e.g. through more samples) is costly, reducing the net rewards available for implementing the measures. This limits the ability of methodologies to increase stringency, as it is likely to result in reduced incentives and uptake by farmers. Indeed, this tension - between stringency, transaction costs, and farmer uptake – may provide disincentives for carbon credit programmes to increase stringency. Ultimately, very stringent requirements could lead to a situation where the mitigation measures are not pursued under carbon crediting programmes, as transaction costs would be prohibitively high.
- **A further barrier for enhancing carbon credit quality is that carbon crediting programmes compete to a certain degree for market shares.** They may be reluctant to strengthen their requirements, as this could imply that project developers move to carbon crediting programmes that have less stringent rules.

2. Temporary crediting

There are arguments for accepting temporary carbon storage as a tool to promote climate-friendly soil management. Firstly, temporary carbon storage may slow the rate of global warming. This may give society more time to develop more permanent mitigation options (Herzog et al. 2003; Marshall and Kelly 2010; Murray and Kasibhatla 2013). Temporary nature-based carbon storage therefore can be considered as beneficial for climate mitigation, "but only if it is implemented as a complement (and not as an alternative) to ambitious fossil fuel CO_2 emissions reductions" (Matthews et al. 2022).[92] Moreover, climate-friendly soil management measures that are nature-based solutions involve a number of co-benefits which make them worth promoting even if their mitigation impact is temporarily limited (see section 2.2.2). Thus, while temporary carbon storage is not able to counterbalance GHG emissions that remain in the atmosphere for decades to millennia (no "physical equivalence", Zickfeld et al. 2021) there is economic value in keeping carbon stored for a certain period of time by avoiding or deferring

[92] This also applies to non-temporary (i.e. permanent) carbon storage, which should be a complement to emissions reductions.

negative climate impacts ("economic equivalence", see e.g. Chay et al. 2022; Marshall and Kelly 2010; Kalkuhl et al. 2022).

Following the logic of economic equivalence, temporary crediting is discussed as a way to appreciate the advantages of temporary carbon storage while acknowledging its limits for long-term climate mitigation in the context of carbon markets. Temporary crediting is an alternative approach to address non-permanence risks that was pursued under the Clean Development Mechanism (CDM) for afforestation and reforestation activities. Under temporary crediting, credits are issued that are based on temporarily limited carbon storage. Temporary credits differ from other carbon credits in that they are time-limited (e.g. only valid for ten years). Buyers of temporary credits, or other responsible entities such as states, would then be expected to replace temporary credits as they expire. Depending on the design of the temporary crediting scheme, the credits may be replaced by new temporary credits (if the carbon stocks are still in place, or from new temporary mitigation actions) or by carbon credits from mitigation activities that do not have reversal risks. In contrast to other crediting approaches that typically monitor and compensate for reversals only within a certain time frame, temporary crediting, in theory, is able to compensate for reversals in perpetuity.

Temporary crediting could also help to emphasise the difference between reversible mitigation outcomes, such as those from climate-friendly soil management, and permanent emission reductions from e.g. replacing fossil fuels.

However, temporary crediting poses significant governance and market demand challenges that make it an inappropriate solution to fix offsetting. To ensure the environmental integrity of crediting mechanisms, buyers need to be held liable for continuously renewing temporary credits or replacing them with permanent ones upon expiry and this liability must be effectively enforced (Kalkuhl et al. 2022; Marland et al. 2001; Roston et al. 2022). Such governance is challenging enough in the short term but even more so over the 300-1000+year timescales relevant for offsetting fossil fuel emissions. Further, the requirement for ongoing renewal of temporary credits would entail high costs for buyers. While these higher costs would reflect the true cost of maintaining or replacing temporary storage, in practice, temporary credits are likely to be less attractive to offset buyers as a result of these limitations. However, temporary credits could be used as part of other result-based finance approaches (see section 6.2.2).

3. Accept higher uncertainty

An alternative approach would be to accept that carbon credits generated through climate-friendly soil management may be associated with a higher degree of uncertainty of the mitigation impact. This could be justified if the acceptance of higher uncertainty levels mobilised significant increases in funding for climate-friendly soil management measures or sped up climate-friendly soil measure implementation, and the net benefits of this outweighs the risks. Accepting greater levels of uncertainty may be further justified if carbon crediting mechanisms incentivised measures that deliver significant biodiversity benefits. **However, this may raise significant signal-to-noise issues, as explained above, and would undermine environmental integrity.** Next to undermining integrity, this also raises questions of acceptability. Given recent media attention to the lack of quality of different types of carbon credits and unfounded offsetting claims (e.g. Berkeley Carbon Trading Project 2023; Greenfield 2023), it may be difficult for buyers and other market stakeholders to accept a higher degree of uncertainty. A higher uncertainty of the mitigation impact of individual climate-friendly soil management measures would be of less concern if it could be expected to be unbiased, e.g. the likelihood of any generated credits being an over-estimation is equal to the likelihood of underestimation. However, this may be difficult to achieve due to information asymmetries between project developer and regulators, in particular for additionality assessments and partially for quantification and due to adverse selection of projects that are overcredited as they are able to offer carbon credits at lower costs (see e.g. Badgley et al 2022). **Accordingly, accepting a higher level of uncertainty does not seem an appropriate approach for "fixing" offsetting.**

4. Alternative uses of credits

As an alternative to offsetting, public or private actors could use credits to make a non-compensatory claim which is supplemental to ambitious climate mitigation efforts to reduce their own emissions (cf. CMW 2023a; see next section). **This approach, however, is not a fix for offsetting approaches but rather the promotion of alternative result-based funding approaches** (as discussed below in section 6.2.2).

6.2.2 Result-based finance approaches other than offsetting

The challenges associated with crediting approaches are particularly severe if the credits are used for offsetting purposes to compensate emissions. As an alternative to offsetting, two different result-based finance approaches are available where achieved mitigation outcomes are used in different ways and thus lower the risks for environmental integrity:

- **Contribution claims**, whereby climate action by others is supported financially without accounting the mitigation outcome towards the mitigation target of the users of the carbon credits. The users would claim that they financially supported mitigation and may also state the expected mitigation outcomes but would not claim that such action counterbalances their own emissions. This implies that claims such as "climate neutrality" would not be eligible. Private actors can use such contribution claims in different ways: either the number of carbon credits purchased still corresponds to the remaining emissions of the organisation or the product, also referred to as "tonne-for-tonne method" (VCMI 2023) , or a climate budget is established by multiplying the remaining emissions with a carbon price and that budget is used to promote climate action, also referred to as "climate responsibility" approach (WWF 2022; WWF 2021; NewClimate Institute 2020b; New Climate Institute 2023). Temporary credits could be built into this approach. Such claims should be supplemental to mitigation efforts along the value chain by the buyer (CMW 2023a; SBTI 2023). Positively, Gold Standard is a notable exception to other crediting mechanisms by providing guidance on how the credits issued should be used. According to the Gold Standard´s guidance for impact claims, all carbon credits issued may be used towards "contribution claims" that reflect or describe the climate change mitigation impact represented by the credit. The users of carbon credits should transparently document the reasons for using the credits as well as underlying calculations, assumptions, limitations and caveats. Additionally, the guidelines include recommendations for avoiding the deferral of mitigation actions by countries to achieve their NDCs or companies in achieving Science-Based Targets as a response to voluntary carbon market action (Gold Standard 2022). This focus not just on the creation of credits but also on the buyers and their use of them should be commonplace across all crediting methodologies, as it helps to ensure that purchasing of contribution claims (or credits) is in support of a real transition and reduces the risk of greenwashing.[93]

[93] Additionally, regulatory approaches that determine rules for making green claims should be pursued, e.g. the Green Claims Directive.

- **Public result-based finance,** whereby a public authority makes a payment in accordance with achieving mitigation results. The payment can be provided in different forms, such as subsidies or tax reliefs. The resulting mitigation can then contribute towards national mitigation objectives; indeed, the aim of public result-based finance would be to efficiently fund mitigation. Public result-based finance does not involve offsetting, so does not pose environmental integrity risks. We explored previous examples of public result-based finance in Chapter 4, which include some examples from CAP and the UK Agriculture Act.

Funding climate-friendly soil management through contribution claims or public result-based finance has the potential to benefit from the advantages of result-based approaches without the downsides of offsetting. Contribution claim approaches provide a framework for private/corporate actors to fund more sustainable agriculture, without reducing their own incentives to reduce emissions, or opening up environmental integrity risks. The sale of credits by farmers can diversify and support farm income, improve societal perception of farmers, and encourage farmers to adapt their management to improve environmental outcomes, enabling innovation. Given that increasing SOC stocks generally also improve soil structure and health and thus improve plant growth, water retention capacities and yield stability, farmers would also enjoy supplementary benefits (Paul et al. 2023).[94]

Credits that are used for contribution claims or result-based finance could require less stringent standards relating to non-permanence, quantification and additionality (compared to those used for offsetting)**.** Lower standards would reduce MRV costs and the need for stringent additionality requirements and may thus enable more soil management measures to be eligible for funding. Possible options also include that carbon credits could report ranges of removals or emission reductions (rather than absolute figures) or be time-limited temporary credits (rather than permanent) (CMW 2023b). Even if credits are used for contribution claims or result-based finance, in order to avoid greenwashing and providing misleading information about these contributions, rules on communicating claims will still be necessary (e.g. as proposed by the Voluntary Carbon Markets Integrity Initiative Claims Code of Practice and the proposed EU's Green Claims Directive). Climate-friendly soil management activities should be prioritised along the considerations outlined in section 2.2. In any case, stringent social and environmental safeguards should apply in order to make sure that such activities do not cause any social or environmental harm.

6.3 Instruments other than action-based or result-based funding

Other instruments beyond action-based or result-based finance can be used to promote climate-friendly soil management measures. While these have not been the focus of our study, we identify important alternative instruments here. Each of these instruments offer their own strengths and weaknesses, and their suitability will depend on the specific types of climate-friendly soil management measures and contexts. These must be weighed up against our evaluation of action- and result-based funding approaches discussed above. None of these measures are mutually exclusive, they can all be used, also in combination with one another.

- **Targeting subsidies towards greater soil health:** In addition to publicly-funded action-based and result-based payments, mitigation can be promoted by reducing subsidies for environmentally harmful activities, or reorienting existing subsidies to increase their effectiveness at delivering climate-friendly soil management. For example, the European Court of Auditors' (2023) evaluation of EU efforts for sustainable soil management found that poor targeting and a lack of ambition meant that CAP ineffectively supports soil health.

[94] These supplementary benefits would need to be considered as part of the additionality assessment.

Given the large budgets involved of about 53 billion EUR annually,[95] refocusing these subsidies could contribute substantially to transforming soil management. These could also be combined with other action-based or result-based funding. For example, CAP funding could support baseline data gathering and farmer training, enabling farmers to then implement climate-friendly soil management measures and have these rewarded by result-based funding measures.

- **Taxation:** Rather than rewarding farmers for mitigation, regulators could implement equivalent incentives by taxing carbon emissions from farmland. This would represent an implementation of the polluter pays principle, which is a key principle underlying EU environmental policy,[96] and require that the polluter bears the costs of preventing pollution and maintaining the environment (European Court of Auditors 2021a). Putting a price on carbon faces some of the same challenges as those identified for result-based payments in this report though, since it may not be straightforward to quantify the emissions or removals from soil management. In practice, there are presently no examples of policy instruments that tax emissions from soil management from around the world (Henderson et al. 2020).
- Other types of instruments to promote climate-friendly soil use include **command-and-control instruments** that address environmental issues by regulating certain practices. In the context of soil carbon sequestration, regulatory instruments would require land managers to adopt specific practices aimed at enhancing or preserving soil carbon. For example, regulations may mandate the maintenance of buffer strips or the adoption of no-till agriculture. The proposed EU Soil Monitoring Law (Commission Proposal 2023/416) will set a key legal framework to help achieve healthy soils by 2050, e.g. by requiring Member States to define which sustainable soil management practices should be implemented by soil managers and which ones should be banned.[97]
- **Facilitating instruments:** Instruments that do not directly promote the uptake of climate-friendly soil management measures but make their implementation easier (OECD 2022). This includes research and development (especially in MRV), farmer and farm consultant training and support, as well as financial support. Research and development should directly involve farmers implementing measures while being supported by researchers, farm advisors and peer-to-peer learning, with or without direct financial incentives or credit schemes as part of the measures implemented. Farm advisory services could include publicly or privately funded non-monetary advisory services, such as workshops, information material, etc. The living labs approach promoted by the European Soil Mission and the European Agroecology Partnership provides a promising way to support bottom-up and co-creation approaches to developing locally specific solutions for soil management.

[95] https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

[96] "Union policy on the environment (...) shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay," Article 191(2) of the Treaty on the Functioning of the European Union (TFEU).

[97] https://environment.ec.europa.eu/publications/proposal-directive-soil-monitoring-and-resilience_en

7 Conclusions and recommendations

The objective of this report was to assess how climate-friendly soil management can be funded to support the transition of the agriculture sector to a net zero climate future. Our evaluation of climate-friendly soil management measures identified the potential of but also significant challenges of using funding approaches to promote their upscaling - particularly related to the difficulty and cost of quantifying mitigation impact, ensuring additionality, and enabling long-term storage. We assessed the relative strengths and weaknesses of result-based and action-based funding approaches in light of the particular challenges posed by climate-friendly soil management measures. Given the interest in crediting approaches (a type of result-based funding approach) to increase uptake and available funding for climate-friendly soil management measures, we investigated ten existing carbon crediting mechanisms in depth. Our assessment identified many significant weaknesses with how mechanisms currently attempt to manage the challenges of quantification, additionality, and non-permanence, and also identified some weaknesses in approaches to avoiding double-counting and environmental and social safeguards. Based on our evaluations, how then should we move forward to promote climate-friendly soil management?

- **Nature-based climate-friendly soil management measures offer significant potential to mitigate climate change, while at the same time enhancing biodiversity and supporting attainment of other societal objectives.** They should therefore be promoted, whether through action-based or result-based funding approaches, or other instruments.
- **Climate-friendly soil management measures are diverse, and different measures should be funded using different instruments.**
- **Offsetting approaches are not an appropriate instrument for funding climate-friendly soil management measures** due to environmental integrity concerns arising from non-permanence, additionality, and quantification uncertainty. Our evaluation of crediting mechanisms demonstrated that existing approaches fail to sufficiently manage these risks. This has implications for the development of an **EU Carbon Removal Certification Framework (CRCF): "carbon farming" removals achieved through climate-friendly soil management should be excluded from any uses that would entail offsetting emissions in other sectors.**
- **Contribution claims and public result-based finance offer an attractive way forward for some climate-friendly soil management measures to deliver mitigation with environmental integrity.** Measures with a high mitigation potential in the EU, lower non-permanence risks, and relatively better quantifiability would be appropriate to be promoted through result-based payments. **We identify three measures fulfilling these criteria for result-based funding: rewetting of organic soils, arable land to grassland conversion, and buffer strips**. When considering whether to implement result-based finance methods, rather than requiring very high stringency levels, they should be compared to the results achieved through likely next best funding instruments (e.g. an action-based payment) and implemented if expected to deliver greater benefits. As quantification methods and models may, over time, improve in accuracy and decrease the cost of monitoring, reporting and verification, other soil management measures may also become appropriate for result-based funding. Progressing quantification approaches should remain a focus of research and innovation efforts.

- **Action-based payments (and other policy instruments) should be employed to promote other climate-friendly soil management measures.** The priority should be on measures that can deliver long-term and significant amounts of mitigation. Even though precise quantification of soil carbon dynamics currently remains challenging, Paustian et al. (2019, p. 568) note that "the basic controls on gross SOC stock changes are understood and it is reasonably well known which management practices can be used to increase SOC storage across a wide range of environments". Accordingly, action-based payments may be appropriate if the context and the spatial conditions in which measures are to be implemented are well-known. No funding should go to measures that pose risks to biodiversity or other environmental objectives (e.g. soil health, water quality): rather, the focus should be on nature-based solutions that deliver biodiversity and other benefits alongside mitigation.
- **To improve the effectiveness and efficiency of action-based payments, they should be better targeted.** By varying rewards depending on easily observable characteristics associated with the expected type of mitigation measures, action-based payments could better incentivise mitigation by actors or in areas that deliver the biggest "bang for buck". An option here would be to make payments higher for soil types or land uses expected to deliver higher GHG mitigation and biodiversity enhancement impacts. At a minimum, action-based payments should be monitored to evaluate the impact on mitigation and other environmental outcomes, and adapted in response to monitoring results (e.g. if monitoring shows higher than expected mitigation impacts, then action-based payments could be raised to support wider upscaling).

Other key considerations

- **Additional private funding instruments are only part of the puzzle – there is a need for a wider supportive EU and Member State regulatory environment.** Land use cannot only be addressed by individual incentives but requires a regulatory policy framework. Here, central is the CAP – refocusing its subsidies and implementing funding structures that better reflect sustainability challenges while supporting farmers and land managers will be essential to transition agriculture to sustainability (IEEP 2023) . The EU Soil Monitoring Law is also important, with its support to farmers and farm advisors, and MRV developers, to ensure skills and tools are available. To reduce land take for settlements and conversion of forests or grassland to agricultural land, legal restrictions, binding limits and strategic planning is necessary (Naumann et al. 2018).
- **Funding should focus on broad sustainability impacts, not just mitigation (e.g. biodiversity, water retention, soil health, etc.): nature-based solutions should be central here, as they deliver multiple benefits including biodiversity enhancement alongside mitigation.** A narrow focus on mitigation will miss the opportunity to shift to sustainability more generally. Also, while some of these measures may only offer limited climate mitigation benefits, they may support attainment of other societal objectives such as enhancing biodiversity, increasing water quality and quantity, promoting climate resilience and farmer welfare, and should therefore be promoted. Emphasising these broad benefits can make measures more attractive to farmers, supporting uptake. Such environmental and social benefits can, for example, be achieved by identifying geographical areas where measures will deliver the greatest ecosystem service benefits and offering increased payments in those areas. Further, the conditions upon which payments are made can be updated over time to reflect changes in knowledge of dynamic factors such as climate change (Reed et al. 2014).

- **Agricultural sustainability requires system-wide change. Alongside incentives for farmers, policy must promote change along the value chain and with consumers.** Regulation and taxes can ensure that the true costs of agricultural production are reflected by consumer prices, reducing demand for ecologically harmful products (Boerema et al. 2016; Sisnowski et al. 2017).
- **Consider dynamic effects and adjust funding approaches over time.** Funding should support innovation and the development of technologies, tools, and methodologies to increase knowledge and increase future options. At small scales, relatively risky funding approaches should be considered for piloting and research purposes where they will help to develop skills and experience that will lower future costs. Short-term costs should also be kept manageable for farmers to give them time to learn and adapt. Also, given increasing ambition of climate goals over time, actions that are currently eligible for funding may in the future be subject to regulatory requirements.

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A Annex 1

A full assessment of ten carbon crediting methodologies is published separately, see https://www.umweltbundesamt.de/publikationen/annex-analysis-ten-crediting-methodologies-soil-management.

B Prioritising climate-friendly soil management measures: detailed assessment

Table 8 (on the next page) provides a more detailed breakdown of expert assessment of each measure in accordance with criteria. A summarised version of this assessment is presented as Table 2.

Table 8: Prioritising climate-friendly soil management measures: detailed assessment

Measures	Mitigation potential				Co-benefits	Leakage		Long-term storage	Quantifiability		Additionality		
	Mitigation (EU total)		Mitigation (per ha)			Market leakage	Ecologic, up-/ downstream		Level of uncertainty	Standardised approach	Common practice	Financial add.	Regulatory add.
	Evaluation	Certainty	Evaluation	Certainty									
Conversion of arable land to grassland	Medium	*Low*	High	*High*	Green	Red	Red	Green	Orange	Orange	Green	Orange	Orange
Rewetting of organic soils	High	*High*	High	*High*	Green	Red	Red	Green	Orange	Green	Green	Green	Green
Silvoarable and silvopastoral agroforestry	High	*Medium*	High	*Medium*	Green	Orange	Orange	Green	Red	Red	Green	Green	Orange
Mixed crop-livestock systems	Low	*Very low*	Low	*Low*	Green	Orange	Orange	Orange	Red	Red	Orange	Orange	Orange
Permanent grassland management	Medium	*Medium*	Low	*High*	Green	Green	Green	Orange	Orange	Orange	Orange	Orange	Orange
Low input grasslands / set-aside areas	Low	*Low*	Low	*Low*	Green	Orange	Orange	Red	Orange	Orange	Orange	Orange	Orange
Buffer strips	Medium	*Low*	High	*Medium*	Green	Red	Green	Orange	Orange	Orange	Red	Orange	Red

Measures	Mitigation potential				Co-benefits	Leakage		Long-term storage	Quantifiability		Additionality		
Use of cover crops	Medium	*Medium*	Medium	*Medium*	Green	Green	Green	Red	Orange	Orange	Red	Red	Red
Improved crop rotation	Medium	*Medium*	Medium	*Medium*	Green	Orange	Green	Red	Orange	Orange	Orange-Green	Orange	Orange
Inclusion of forage and grain legumes in crop rotations	Medium	*Medium*	Medium	*High*	Green	Orange	Green	Red	Orange	Orange	Orange-Red	Red	Orange
Residue management	Medium	*Medium*	Medium	*Low*	Green	Green	Orange	Red	Orange	Orange	Orange	Red	Orange
Mulching	Low	*Very low*	Low	*Very low*	Orange	Green	Orange	Red	Orange	Orange	Green	Red-orange	Orange
Applying manure / compost	Medium	*Medium*	Medium	*Low*	Orange	Green	Orange	Red	Orange	Orange	Orange	Orange	Orange
Contour farming / terracing	Low	*Very low*	Low	*Very low*	Green	Green	Orange	Orange	Red	Orange	Green-orange	Green	Green-orange
Reduced soil compaction	Medium	*Low*	Medium	*Low*	Green	Green	Green	Red	Orange	Red	Orange	Green	Green

Mitigation EU total: Evaluation: best estimate of realistic 2030 potential based on available evidence - high (more than 20Mt/yr in Europe), medium (5-20 Mt/yr in Europe), low (less). **Certainty**: High (good evidence), medium (reasonable evidence for best guess), low (little evidence), very low (no good data)

Per ha mitigation potential (EU): Evaluation: best guess of realistic per ha mitigation potential in Europe based on available evidence - high (more than 4t CO_2e/ha/yr), medium (1-4 CO_2e/ha/yr in Europe), low (less than 1 tCO_2e/ha/yr). **Certainty**: High (good evidence), medium (reasonable evidence for best guess), low (little evidence), very low (no good data)

Co-benefits: Green (delivering co-benefits and posing no environmental risks, NbS-aligned); Orange (expected to deliver co-benefits but posing some environmental risks in some contexts, broadly aligned with NbS definition); Red (posing significant environmental risks, not aligned with NbS definition)

Additionality: **Common Practice** - Are practices similar to those implemented by the project typical in the region?: Green: Not common practice (less than 2.5% of farmers); Orange: relative uncommon practice (less than 20% of farmers); Red: Common practice (more than 20% of farmers)

Additionality: **Financial additionality** - Are project activities financially viable and attractive without carbon revenues? Green: economic costs outweigh benefits and/or significant barriers for all farmers; Orange: economic costs outweigh benefits and/or medium barriers for most farmers; Red: economic benefits outweigh costs and no significant barriers for most farmers

Additionality: Policy & Regulatory - Are there regulations or incentives that enforce or encourage the project activity? Green: No regulatory requirements or existing funding; Orange: Voluntary measures in CAP (e.g. rural development/eco-schemes) in some Member States; Red: Existing regulatory requirements or part of CAP GAECs

Quantification: Project team evaluation: Quantification depends on measurement uncertainty, leakage, and baselines. Leakage assessed elsewhere. Here, we assess whether mitigation impact estimates can be robustly reached, in general, considering measurement uncertainty and baselines (are there standardised methods with low uncertainty and is the impact large enough to be captured (high signal-to-noise ratio)? We assess separately for soil measurement and for modelling.

Leakage: Market leakage - Green: Measure does not reduce production; Orange: Uncertain impact on production and some risk of market leakage; Red: Measure reduces production, risk of market leakage

Leakage: Ecological, upstream/downstream leakage: Green: No risk of ecological leakage or inducement of increased upstream/downstream emissions; Orange: Some risk of ecological leakage or inducement of increased upstream/downstream emissions; Red: High risk of ecological leakage or inducement of increased upstream/downstream emissions

Long-term storage: Is it difficult to reverse carbon removals? Green: permanent storage (no measures); Orange: Relatively difficult or costly to reverse quickly (e.g. agroforestry, peatland); Red: Easy to reverse, and few incentives to maintain after funding ends.