Utrecht University

Master Thesis – MSc Sustainable Development

Stakeholder Frames of Carbon Farming in the German Agricultural Sector

Analysing Cooperative and Conflictual Dynamics

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Track: Earth System Governance

Scope: 45 EC

Word count: 31,641

Date: 25 October 2023

Acknowledgments

First and foremost, I would like to express my gratitude to my supervisor, Prof. Hens Runhaar, for his support. Your critical feedback and patience were invaluable in guiding me through this process. I would also like to extend my appreciation to my interview partners, who generously dedicated their time and expertise to this research. Your insights not only provided essential data but also served as a welcome distraction from the often tedious task of coding documents for content analysis. Recognising my limitations in the technical aspects of the topic, I am particularly grateful to all my interview partners for their additional content contributions. Your guidance enabled me to focus on the frame and governance aspects without disregarding the scientific background, which greatly enriched the overall quality of my work. Lastly, I want to express my heartfelt thanks to my professors and friends at Utrecht University. Your collective efforts transformed this masters' programme into an engaging and thought-provoking experience, filled with challenges and rewards. I am truly grateful to each and every one of you for being part of this incredible journey.

Abstract

Soil carbon sequestration is claimed to offer a potential solution to climate change and unsustainable agricultural practices by transferring CO_2 from the atmosphere into the soil. This process, in recent years referred to as “carbon farming”, has the capacity to enhance resilience, improve soil health, increase productivity, and reduce the need for fertilisers and pesticides. Yet, its effectiveness in mitigating climate change remains a subject of debate.

This study delves into the complex world of carbon farming and its adoption in the German agricultural sector, using frame theory to explore the diverse perspectives of stakeholders. While previous research has focused on barriers and business models, the role of shared stakeholder understanding in shaping the development and adoption of carbon farming practices has received limited attention.

This research identifies three main frames that influence stakeholder positions. The techno-economic frame centres on economic, innovative, and technical aspects, sparking a long-standing scientific debate and emphasising outcome-based financing schemes. The social and political acceptability frame gains prominence with the introduction of the European Commission’s proposal for a harmonised certification framework, highlighting social and governance considerations. It also addresses the widely debated concern of potential mitigation deterrence. The responsible development frame underscores environmental, equity, and justice aspects while steering private sector business models towards promoting ecosystem services over sequestered carbon.

Implications are drawn from the prevalence of conflicting frames and unresolved issues in stakeholder dynamics. The ongoing yet nascent nature of the debate, coupled with the perception of carbon farming as a niche topic, results in limited stakeholder contention. However, this research emphasises the importance of shared understanding and collaboration between stakeholders in addressing the challenges and opportunities of carbon farming.

This mixed methods study integrates stakeholder analysis, content analysis, and semi-structured interviews, offering valuable insights into the multifaceted landscape of carbon farming in the German agricultural sector. The findings contribute to a more comprehensive understanding of the issues at hand and pave the way for more informed and effective decision-making.

Key concepts: Carbon farming, frame analysis, stakeholder dynamics, Germany.

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List of Abbreviations

Abbreviation	Description
CDR	Carbon dioxide removal
CO_2	Carbon dioxide
EC	European Commission
EU	European Union
GHG	Greenhouse gas
IPCC	The Intergovernmental Panel on Climate Change
MRV	Measurement, Reporting and Verification
$MtCO_2eq$	Million tonnes carbon dioxide equivalent
NET	Negative emissions technologies
SCS	Soil carbon sequestration

1. Introduction

This introduction sets the stage by addressing the problems associated with unsustainable agricultural practices and the urgent need to store carbon to combat climate change. It introduces carbon farming as a solution that has been proposed by some as a potential contributor with numerous perceived benefits, yet it also faces criticism of its capabilities, as well as various barriers to adoption and scaling. The introduction emphasises the significance of stakeholder frames in shaping the debate on carbon farming, highlighting the potential for both cooperation and conflict among stakeholders. Germany is selected as the case study. The research objectives are outlined, focusing on the exploration of stakeholder frames and their implications, addressing a knowledge gap in the field, and underscoring the social relevance of carbon farming in achieving sustainability goals. Finally, this chapter presents the research questions that guide the study and outlines how these will be addressed in the research framework.

1.1 Problem description: Unsustainable agricultural practices and the need to store carbon

Historical developments in agriculture, aimed at enhancing productivity and profitability have led to resource-intensive practices. While higher yields and lower food prices initially led to favourable impacts such as increased calorie consumption, enhanced well-being, and longer life expectancy (Evenson & Gollin, 2003; Rust et al., 2021), the intensification of agricultural processes has also resulted in several environmental, social, and economic issues. Environmental and soil degradation, loss of biodiversity, unsustainable water management, and greenhouse gas emissions are some of the critical challenges that have emerged (Benton & Bailey, 2019). These issues not only amplify climate change but also contribute to exceeding planetary boundaries for biosphere integrity and biogeochemical flows (Campbell et al., 2017). Carbon dioxide, nitrous oxide, and methane are the main greenhouse gas emissions from agricultural processes that drive climate change (Chataut et al., 2023). Beyond this, methane emissions in particular can also lead to a reduction in crop yields, which in turn may require further expansion of agricultural activities (Shindell, 2016). The above-mentioned challenges not only threaten sustainable food security but also carry significant costs in terms of yield losses and societal impacts, such as those tied to the aftermath of increased flooding (Florini & Pauli, 2018; Nyssens, 2021). These challenges highlight the pressing need to transition towards more sustainable and environmentally friendly agricultural practices.

At the same time, emissions-intensive industries face mounting pressure from various stakeholders, including governments and environmental groups, to further increase their efforts to curb emissions (Littlewood et al., 2018). However, given the urgency of the climate crisis, the pace of emissions reductions often falls short of global commitment targets, such as those agreed on in the Paris Agreement of 2015 to limit temperature rise. Consequently, this has led to a growing consensus among scientists and policymakers that certain carbon removal technologies play a crucial role in achieving successful emissions reduction pathways

(Minx et al., 2018; Peters, 2016). As interest in such technologies grows globally, proponents of negative emissions technologies are gaining increased support in their endeavours to mitigate climate change and advance emissions reduction efforts. Notably, among emissions-intensive sectors, agriculture stands out both as a major emitter of CO_2 and other greenhouse gases, and as a potential provider of carbon removals (BMEL, 2021; EEA, 2013).

1.2 Carbon farming as solution

As outlined above, research indicates that the transition to sustainable agricultural practices is imperative. In this context, proponents argue that the sector could play a role in reducing atmospheric carbon concentrations through "farm management practices that aim to deliver climate mitigation in agriculture" (McDonald et al., 2021, p. 7), such as the adoption of carbon farming, which is further defined by the European Commission (2021):

> Carbon farming can be defined as a green business model that rewards land managers for taking up improved land management practices, resulting in the increase of carbon sequestration in living biomass, dead organic matter and soils by enhancing carbon capture and/or reducing the release of carbon to the atmosphere, in respect of ecological principles favourable to biodiversity and the natural capital overall. (p. 4)

Soil carbon sequestration can be defined as "the process of transferring CO_2 from the atmosphere into the soil through plants, plant residues, and other organic solids, which are stored or retained as part of the soil organic matter (humus)" (Olsen, 2010, p. 566). Carbon farming on arable land encompasses a variety of agricultural practices, often associated with agroecological or regenerative farming (EEB, 2021). These practices include improved crop rotations, the cultivation of cover crops, catch crops or crop residues management, as well as organic farming and the conversion of cropland to grassland (BMWK, 2022; Don, 2023; Mattila et al., 2022; Wiesmeier et al., 2020). Rodrigues et al. (2021) highlight a consensus in the scientific community regarding the potential of certain practices to enhance soil organic matter, which not only benefits soil fertility but also contributes to various ecosystem services. These encompass reduced erosion, improved water infiltration and storage capacity, provision of food, increased ecological resilience, nutrient binding, and reduced need for fertilisers and pesticides (Nyssens, 2021; Rodrigues et al., 2021; Wiesmeier et al., 2020).

The realm of carbon farming, limited in this study to carbon sequestration in agricultural soils, is characterised by manifold debates. These include the pivotal question of its potential to sequester carbon in quantities that significantly mitigate climate change. Proponents highlight the potential capacity to offset emissions on a large scale, estimating up to 26% of current annual greenhouse gas emissions from EU agriculture (McDonald et al., 2021). While soil carbon sequestration was historically disregarded in greenhouse gas emission reduction pathways due to a lack of scientific support (Dooley & Kartha, 2018), it has gained recognition through inclusion in the latest report by the Intergovernmental Panel on Climate Change (IPCC) and growing attention in policy (European Commission, 2022a; IPCC, 2023). However, scientific estimates on this matter show considerable variability, often influenced by

geographical differences and distinct characteristics of different soils (Fuss et al., 2018; Rodrigues et al., 2021; Wiesmeier et al., 2020). Further, uncertainties in the calculations are emphasised (McDonald et al., 2021), as well as the lack of knowledge and data gaps existing in many countries (Rodrigues et al., 2021). Critics estimate, based on their calculations, that the offset potential of carbon farming could be more modest, accounting for about 10% of agricultural greenhouse gas emissions from agricultural soils and biomass in the EU. This viewpoint can lead to the conclusion that the primary focus should be on reducing emissions, as articulated by Don (2023). The debate around carbon farming also delves into the generation of carbon credits and their subsequent trade with other industries to offset emissions (Food and Water Watch, 2021). Terms like 'greenwashing' and concerns about permanence frequently surface in the public discourse and position papers (Appunn, 2022; Scherger, 2022).

The consensus among stakeholders on the socio-economic benefits linked to a functioning carbon cycle, including the preservation of a significant amount of soil organic matter (Rodrigues et al., 2021), contrasts with the ongoing debate on the potential to mitigate climate change. This debate encompasses a range of opinions, including both sceptics and proponents. Carbon farming, with its focus on soil organic carbon sequestering, while simultaneously addressing the crucial challenge of maintaining and accumulating soil organic matter on European agricultural land (Chenu et al., 2019; Rodrigues et al., 2021), is proving to be a contentious solution. Various private actors have emerged in this debate, offering a spectrum of renumeration options for farmers such as platforms that issue CO_2 certificates for soil organic carbon accumulation, also particularly in agricultural soils (Wiesmeier et al., 2020). However, their efforts also face hurdles, as research indicates numerous obstacles and challenges in implementing and scaling up these practices.

Some scholars emphasise the support farmers need to adopt carbon farming, citing primarily technical and economic aspects such as the lack of robust monitoring, reporting and verification systems, the financial burden of the costs of these practices and issues of liability as barriers (Demeyer et al., 2021; European Commission, 2021; Nyssens, 2021). Other research addresses social aspects such as uncertainty about the reliability of standards and lack of trust in policies due to conflicting policy objectives or complex bureaucracy, as well as insufficient farmer knowledge about these practices (Baumber et al., 2021; Demeyer et al., 2021). A direct survey of farmers supports this, with them citing, in the order given, insufficient knowledge, restrictive policies, economic reasons, personal habits and preference, and lack of awareness as the main reasons that prevent them from taking action to improve soil carbon (Paulsen et al., 2022).

Overcoming these barriers in the early stages is crucial for scaling up climate-friendly practices, according to Demeyer et al. (2021), and as a large number of farmers surveyed indicated that they would consider adopting more carbon farming practices if they were financially supported by other partners in the chain (Paulsen et al., 2022), incentivising farmers becomes a key element (Wiesmeier et al., 2020). The European Commission (2021)

elaborates that currently “financial incentives can come from public or private sources and reward land managers either for their management practices increasing the storage of atmospheric carbon or the actual amount of carbon sequestered” (p. 4). To incentivise carbon farming through market-based approaches, stakeholders are interested in cross-sectoral collaboration where, for example, companies that are required to achieve net-zero targets in line with the European Green Deal and the Farm to Fork Strategy seek to achieve their emissions reduction targets through carbon offsets (Bumbiere et al., 2022; EEB, 2021). Overcoming perceived barriers and challenges in the realm of carbon farming requires a variety of actors to provide knowledge development and transfer, subsidies or other financial incentives, regulations, and access to tools and practices, and the processes therefore often involve actors such as government entities, certification programmes, companies, and farmers (Demeyer et al., 2021; Florini & Pauli, 2018). Other actors are needed to create the conditions for interest in carbon farming and scientific knowledge, such as academia, information and communication centres, and farmers’ associations (Horschig et al., 2020).

1.3 Frames matter for stakeholder interactions and carbon farming debate

Typically, for stakeholders to agree on and achieve common goals and visions when collaborating, a shared understanding and aligned values between stakeholders are crucial (Ansell & Gash, 2007; Buuren, 2009; Dewulf, 2013). This agreement can cover several aspects, including defining the problem and determining the necessary steps and capacities (Bentrup, 2001). Research suggests that stakeholders’ understandings, interpretations, and engagement are not only shaped by factual information but also structured by underlying frames (Schön & Rein, 1994). This has been established by Goffman (1974), who argues that ‘frames’ represent a particular perspective on a problem and defines them as ‘cognitive frameworks’ through which individuals understand situations by selectively enhancing certain elements of reality.

While stakeholders agree on the potential social and ecological benefits of soil carbon sequestration (Rodrigues et al., 2021), the ongoing debate on business models for carbon farming to incentivise its use reveals divergent viewpoints and complicated challenges. A key point of contention is the scientific feasibility of carbon sequestration itself (Demeyer et al., 2021; Don, 2023), considering uncertainties about the actual capacities of these processes to sequester carbon from the atmosphere. In addition, there are debates about the scope of what should be included in a carbon farming certification framework (European Commission, 2022b) and the nature of financial incentives for soil carbon sequestration processes (Demeyer et al., 2021). This complexity highlights the depth of the debate and the multiple challenges involved in carbon farming initiatives.

What is particularly noteworthy about this situation is that, despite a common recognition of the risks associated with carbon farming certification, stakeholders often reach different conclusions. For example, the European Commission (2021) cites the risks and uncertainties of certification that others consider critical, such as the lack of permanence, measurement

uncertainties, lack of standardisation of additionality and determination of additional biodiversity benefits, yet concludes that carbon credits provide a good incentive for the adoption of these practices by highlighting the "clear benefits" (p. 6) and emphasising that the land sector is "crucial for achieving sustainable carbon cycles" (p. 22). The different viewpoints range from the position that overcoming technical difficulties is sufficient to establish carbon credits as an integral part of business models to the view that soil carbon sequestration should not rely on carbon credits and should be spared from private sector involvement, as their potential impact is seen as limited and there is the potential for unintended social consequences, such as delaying necessary emission reductions (Appunn, 2022). Therefore, exploring the frames is useful to clarify which aspects stakeholders focus on.

Frames have been identified to matter in the uptake of carbon farming strategies. For instance, Kusmanoff et al. (2016) found that positive framing of specific land conservation benefits by organisations and government agencies could increase landholder engagement. The choice of frames appears to be crucial, as presenting carbon farming solely as a financial opportunity may lead to a negative perception and discourage farmers from adopting the concept (Fleming et al., 2019). Similarly, Buck and Palumbo-Compton (2022) argue that focusing solely on carbon rather than holistic soil quality could lead to the neglect of important co-benefits because farmers see soil only as a carbon store. Similar considerations apply to carbon farming strategies in sectors other than agriculture. For instance, Ojha et al. (2019) note that the inclusion of forests in carbon-centric policies as part of climate change mitigation strategies globally leads to a severe undervaluation of the multiple ecological and social contributions of forest ecosystems.

At a more general level, common frames can promote shared understanding and thus cooperation, but conversely, they can also lead to conflict. Frames of specific issues often emphasise multiple goals and values, such as in the realm of carbon farming, that may contradict each other or simply coexist, leading to competition between frames (Wise & Brewer, 2010). Frames that receive support can wield substantial influence over stakeholder discussions and the formulation of policy agendas (Adger et al., 2011; Schön & Rein, 1994). Divergent frames can prevent consensus on objectives such as policy design and implementation (Buuren, 2009; Dewulf, 2013) and can thus hinder mutual understanding, drag out debates and have a negative impact on decision-making and policy outcomes (Agramont Akiyama et al., 2022). However, research also indicates that this diversity carries the potential to foster innovation, with different frames providing new perspectives and solutions (Levänen & Hukkinen, 2019). Furthermore, aligning these various frames into a shared understanding through a frame alignment process can encourage engagement in collective action and promote collaboration (Dewulf, 2013; Dewulf et al., 2011). Given the slow uptake of carbon farming, the proliferation of voluntary and private carbon farming schemes, and the ongoing policy process for regulation, exploring the different viewpoints

using the concepts of stakeholder frames can help to better understand the underlying difficulties and explore a possible link to this development.

1.4 Research objectives and questions

While previous research has addressed the barriers and complexities surrounding the expansion of carbon farming in Europe (Demeyer et al., 2021; ENRD, 2022b; McDonald et al., 2021; Nyssens, 2021; Wiesmeier et al., 2020) and has examined the assessment of different carbon farming solutions (Bumbiere et al., 2022; ENRD, 2022a; Paul et al., 2023), there remains a critical gap in comprehensive research exploring the prevailing stakeholder frames of carbon farming. However, it is important to understand these to avoid further contestation of carbon farming. Bellamy and Raimy (2013) argue:

> with this great power of persuasion comes great responsibility; communicators must consider how their attempts to inform may be biased by their own opinion, as well as how other communicators may be building the case for alternative frames of carbon removal. Public support for carbon removal will hinge on responsible explanations by communicators who are aware of and attend to different framings. (p. 4)

Carbon farming has gained paramount significance within the European Union (EU) due to recent policy developments, including the European Commission's (EC) active engagement in regulating carbon farming schemes through the development of a certification framework for carbon removal initiatives (European Commission, 2022a). This study focuses on Germany as a case study, given its challenges in significantly reducing agricultural emissions. Despite ambitious policies aimed at unlocking the carbon sink potential (BMEL, 2021; BMUV, 2023b), and various private start-ups and schemes dedicated to carbon farming (Wiesmeier et al., 2020), the practical implementation has fallen short of achieving the intended targets. Germany highlights the pivotal role of the agricultural sector in combating and mitigating climate change, setting national targets that even surpass the European benchmarks for land-based carbon sinks[1]. However, it is noteworthy that the adoption of carbon farming schemes in the country remains limited, underscoring the need to explore the social dynamics and considerations that influence the engagement and interests of stakeholders in these strategies.

The aim of this research is to explore the prevailing frames of stakeholders engaged in the debate on carbon farming on arable land and to understand the potential impacts of these frames on stakeholder cooperation and conflict. The central research question is: "What defines the prevailing frames held by stakeholders concerning carbon farming on arable land in Germany, and what are the potential implications for stakeholder interactions?". This central question is divided into two interconnected sub-questions:

[1] (Federal Climate Change Act of 12 December 2019 (Federal Law Gazette I, p. 2513), as Last Amended by Article 1 of the Act of 18 August 2021 (Federal Law Gazette I, p. 3905), 2019).

1. How have historical events in variation among stakeholder groups contributed to forming and evolving the predominant frames held by stakeholders engaged in carbon farming on arable land in Germany?
2. How do the frames held by stakeholders influence their positions in the context of carbon farming on arable land in Germany, and what are the potential implications for stakeholder interactions?

The first sub-question aims to identify the stakeholders actively participating in the public debate on carbon farming on arable land in Germany. The specific frames held by these stakeholders are explored, shedding light and insights into their positions and interests regarding carbon farming. Additionally, it is aimed at investigating how historical events have contributed to the emergence and development of these frames over time, which is essential for comprehending the dynamic nature of frames (Hassenforder et al., 2016). The second sub-question delves into the potential implications of these stakeholder frames on their positions within the context of carbon farming on arable land in Germany. It is specifically aimed at exploring how these frames can either foster cooperation or lead to stakeholder conflict and influence policy agenda setting and stakeholder discussions.

1.5 Knowledge gap and relevance

While the importance of shared understandings and the influence of frames on stakeholder engagement and policy development are recognised, there remains a notable research gap concerning the role of these frames in shaping perspectives and debates related to sustainable agricultural practices and natural carbon removal technologies. This study aims to address this knowledge gap by conducting a comprehensive analysis of the frames held by stakeholders regarding carbon farming in the German agricultural sector. It seeks to contribute to an understanding of how these frames shape positions and impact stakeholder dynamics.

A substantial body of research on carbon farming primarily originates from Australia and the United States, where these practices and business models have received considerable political attention for several years (Kragt et al., 2016; Marks, 2020; Paul et al., 2023; Wiesmeier et al., 2020). This body of research has focused on general influences and barriers to adopting and expanding of carbon farming. There are a few studies on frame influences that examined the role of frames in adoption by farmers (Buck & Palumbo-Compton, 2022; Fleming et al., 2019; Kusmanoff et al., 2016). However, these studies focused on the role of certain frames in boosting individual adoption, rather than providing insight into the prevailing frames among the diverse array of stakeholders involved in carbon farming and their potential impact on contestation.

Furthermore, research has explored general frames in related contexts, such as carbon removal and geoengineering. Findings from these studies suggest that CO_2 frames tend to be negative, leading to path dependencies that negatively affect the acceptance of innovations and engagement with carbon reduction and removal options (Levänen & Hukkinen, 2019).

Jaschke and Biermann (2022) found that frames concerning soil carbon sequestration tend to be slightly more positive compared to other negative emissions technologies. Finally, studies have been conducted on specific issue frames in the discussions on climate change mitigation technologies (Dewulf, 2013; Guenther et al., 2023; Nisbet, 2009), geoengineering (Corner & Pidgeon, 2015; Porter & Hulme, 2013), and other carbon removal technologies (Bellamy & Raimi, 2023; Cox et al., 2018, 2020; Waller et al., 2020).

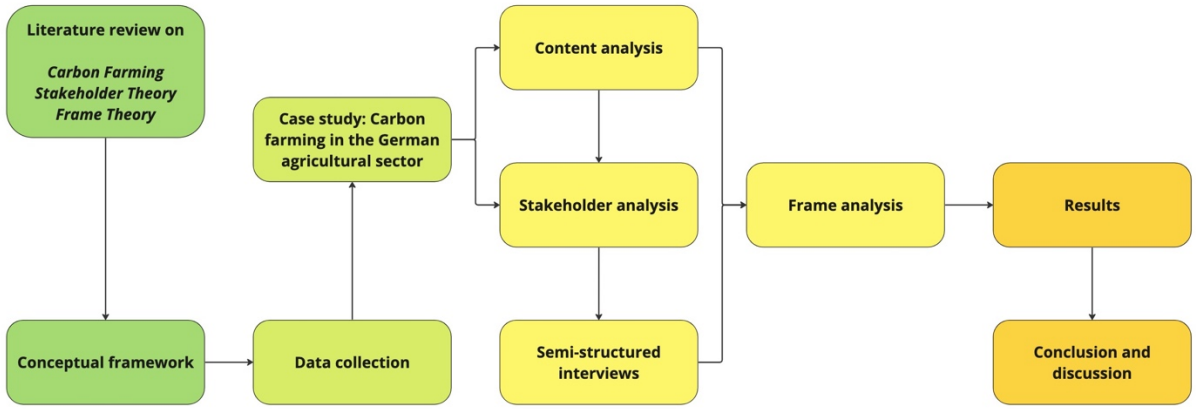
However, while studies have delved into frames related to carbon removal and geoengineering technologies, they have not specifically addressed carbon farming. Due to differences in various aspects, these studies do not provide directly transferable insights into the specific frames relevant for carbon farming. The multifaceted benefits of carbon farming, including biodiversity enhancement, climate change mitigation, and soil health improvement (Nyssens, 2021), underscore its pivotal role in sustainable agriculture. Furthermore, geographical differences also lead to cultural distinctions that encompass a diversity of values and beliefs (Anderson, 2015), influencing the frames. This underlines the necessity of exploring the frames held by different stakeholders in Germany concerning carbon farming, encompassing its potential benefits, associated challenges, and the resulting difficulties and facilitators in understanding possible solutions for carbon farming, deployment, and its widespread adoption. Understanding the frames that shape stakeholder perspectives is academically significant and holds social relevance. By shedding light on the frames held by stakeholders and their consequential impact on perspectives, this study contributes to informed decision-making and policy development, not only within Germany but also on a broader scale, ultimately advancing the adoption of environmentally friendly practices.

1.6 Research framework

This research adopted a mixed-methods approach, with Germany serving as a single-case study. The key steps undertaken are illustrated in Figure 1. The research started with a literature review on the essential concepts and theories, specifically focusing on carbon farming, stakeholder theory, and frame theory. This resulted in the development of a conceptual framework that addressed the diverse stakeholder frames deducted from literature. The data collection process encompassed gathering materials from multiple sources. This included the collection of newspaper articles and feedback documents obtained through stakeholder feedback processes conducted by the European Commission on carbon farming. Based on the outputs of this content analysis and stakeholder analysis, interviews were conducted. These interviews provided in-depth insights into the frames held by stakeholders as well as into the development of the frames and stakeholder dynamics. This resulted in an overarching frame analysis that facilitated answering the sub-questions posed in the research. Lastly, the study applied aspects of frame theory to shed light on the potential tensions between different frames and to gain a deeper understanding of the implications of these frames.

Figure 1

Research Framework (own depiction)



2. Theoretical background

This chapter provides a comprehensive overview of the key theoretical concepts employed in this thesis. Before going into the theoretical foundations, an understanding of carbon removal technologies is created and the current scientific status for assessing the potential of carbon farming as part of carbon removal is presented. Subsequently, stakeholder theory is introduced as the basis for the stakeholder analysis, which was instrumental in addressing the first sub-question. Following this, frame theory is presented as the primary theoretical foundation for this research. To this end, the fundamental assumptions of frame theory are outlined, and a brief historical overview of its development and various areas of application is provided. Lastly, relevant frames are derived from relevant literature. This leads to a presentation of the conceptual framework of this research.

2.1 Carbon farming as part of carbon removal technologies

The debate on how to limit further emissions growth and meet the Paris Agreement targets has led to the development of various emissions reduction pathways (Riahi et al., 2017). These include numerous mitigation measures and technologies, with research primarily addressing decarbonisation (Bataille et al., 2018; Capros et al., 2014; Meckling et al., 2017; Newell, 2019; Tvinnereim & Mehling, 2018) or carbon dioxide removal (Peters & Geden, 2017; Smith et al., 2016) to achieve net-zero emissions.

Negative emissions technologies, used and widely discussed for carbon dioxide removal, that is "anthropogenic activities removing carbon dioxide (CO_2) from the atmosphere and durably storing it in geological, terrestrial or ocean reservoirs, or in products" (IPCC, 2023, p. 2901), have become an integral part of most strategies and pathways due to the urgent need to meet targets in a timely manner and the difficulties of global decarbonisation (Minx et al., 2018; Peters, 2016). Negative emissions technologies as mitigation technologies are frequently deployed in various emissions-intensive industries to support the decarbonisation

process. The mitigation potential of negative emissions technologies is presented by some as substantial, albeit to varying degrees (Fuhrman et al., 2020; Minx et al., 2018; Rogelj et al., 2018), and the recent report by the IPCC even states that carbon dioxide removal is included in all successful pathway scenarios and is necessary to meet the ambitious temperature target of limiting warming to 1.5°C (IPCC, 2023, p. 2771; Rogelj et al., 2018). However, other researchers question their reliability and ethical implications, such as the risk of compromising social and environmental goals, overestimating the feasibility and ability to mitigate climate change, and deferring mitigation (Dooley & Kartha, 2018; Lenzi, 2018; van Vuuren et al., 2018).

Negative emissions technologies include both natural (land-based) and chemical (technological, engineered) solutions, with the various solutions facing different scientific uncertainties, such as technology and implementation costs, actual mitigation potential, potential emissions shifts, or readiness for uptake, with the former currently more common and more likely to be part of pathways (Dooley & Kartha, 2018; Fuhrman et al., 2020; Kriegler et al., 2013). Chemical negative emissions technologies involve geochemical processes with minerals and solvents either in terrestrial processes or in the direct carbon dioxide capture from ambient air (DAC) (Kriegler et al., 2013), while examples for land-based solutions are bioenergy carbon capture and storage (BECCS), soil carbon sequestration (SCS), afforestation, reforestation, and wetland construction and restoration (IPCC, 2023, p. 1109).

To create a soil carbon sink, practices that enhance carbon sequestration are increasingly being used, with potential carbon sequestration varying greatly by the type of land area (Nyssens, 2021). This research focused on carbon farming on arable land, including several agricultural practices such as the use of crop rotations, the cultivation of catch crops and annual crops or leaving crop residues on the field (BMWK, 2022). While agroforestry and the use of biochar are also counted as carbon farming in the agricultural sector according to some definitions, both practices were not included in this study, as agroforestry is considered an overarching concept for afforestation and reforestation practices, and biochar is a highly contested area involving a range of other stakeholders, with this breakdown following the example of Minx et al. (2018).

Certain techniques for carbon sequestration in soil have several positive co-benefits for ecosystems and biodiversity beyond carbon storage, providing an incentive for farmers to use appropriate practices. In addition to reducing erosion and improving water management, which increases resilience, agricultural carbon farming also frequently increases crop nutrients and soil fertility, and improves crop resistance to pests and diseases, leading to a reduced need for fertilisers and pesticides (Nyssens, 2021). However, the financial burdens on farmers, including costs of expenditure and revenue forgone (Poláková et al., 2022), insufficient knowledge, and lack of access to relevant technologies (Baumber et al., 2021; Demeyer et al., 2021) pose challenges to large-scale implementation and adoption of relevant practices. This results in the need for knowledge transfer and financial incentives as a pivotal tool for promoting carbon farming (Demeyer et al., 2021).

Subsequently, the term carbon farming refers not only, as the European Environmental Bureau puts it, to the category of sustainable agricultural practices that consists of “land management practices which reduce GHG emissions and increase the sequestration and storage of carbon in soils and vegetation” (Nyssens, 2021, p. 3), but also to emerging business models. These are part of the very policies where those business models can include the creation of carbon credits for soils (Baumber et al., 2019; Bumbiere et al., 2022; McDonald et al., 2021). Advocates emphasise, among other things, that investments in carbon management and inclusion in carbon trading markets promote the growth of low-carbon businesses and industries (Chu et al., 2019; Yin et al., 2023). These co-benefits show how ecosystem carbon sequestration (ECSS) contributes to the Sustainable Development Goals (SDGs) for water conservation, food security, and climate change mitigation (Yin et al., 2023).

However, soil carbon sequestration in the realm of carbon farming is highly contested. The potential for carbon reduction is challenging to precisely estimate and is highly uncertain, as carbon storage can easily be reversed if activities are not sustained (Regan et al., 2020; Rochecouste et al., 2017). Additionally, the accumulation of soil organic carbon is constrained by equilibrium states and saturation limits (BMWK, 2022). Furthermore, uncertainties stemming from temperature and precipitation changes due to climate change and their impact on plant growth can also influence soil carbon fluxes (EEB, 2021; Rodrigues et al., 2021). In this complex landscape, concerns surrounding key factors such as additionality, leakage effects, trade-offs with other targets, nitrogen emissions, permanence, and fairness have raised limitations in the generation of carbon certificates (Wiesmeier et al., 2020). This leads to opposition to carbon farming initiatives on the basis that these schemes might allow polluters to continue emitting fossil fuel emissions as long as concerns such as storage permanence and leakage are not effectively regulated and there is a lack of high-quality measurement, reporting and verification (MRV) systems, resulting in a potential for disproportionate benefits, as highlighted by Food and Water Watch (2021). Another perspective argues that market-based approaches may risk undermining farmers' access to land and create economic insecurities, particularly for already vulnerable farmers (Agroecology Europe, 2022).

2.2 Stakeholder landscape in the realm of carbon farming

To comprehensively analyse the frames held by stakeholders in the field of carbon farming in the German agricultural sector, it is first necessary to identify the relevant stakeholders. This multitude of farmers and production systems in the agricultural sector poses a challenge due to the numerous interests and actors involved (Soto Golcher et al., 2018). Furthermore, stakeholder collaboration and engagement largely require a shared understanding of the issue at hand and potential solutions, which are significantly influenced by stakeholders’ perceptions and frames, among other factors (Ansell & Gash, 2007; Buuren, 2009; Lejano & Ingram, 2009; Termeer, 2009). The identification of the stakeholders is not only necessary to explore the frames and shed light on their evolution within the broader debate but also

provides insights into tensions and fosters stakeholder cooperation in the governance processes related to the adoption and expansion of carbon farming.

The diversity of stakeholders becomes apparent when examining how partnerships are formed in the land use sector for more environmentally friendly production. Given its significant contribution to air emissions (EEA, 2013), the sector bears a responsibility to reduce carbon emissions. In light of overarching, albeit controversial, assessments suggesting that agricultural soils have the potential to increase soil carbon sequestration and thus make an important contribution to compensating for greenhouse gas emissions (BMEL, 2021; IPCC, 2023; McDonalds et al., 2021), a wide variety of market-driven partnerships focusing on sustainable agricultural investments have emerged (Florini & Pauli, 2018; Scherger, 2022; Wiesmeier et al., 2020). Engaging in and adopting such new initiatives in the agricultural sector typically requires collaboration among diverse actors, including researchers, policymakers, funders, and farmers, to ensure scientific credibility, information exchange, and large-scale implementation (Rumpel et al., 2020).

Hence, beyond stakeholders actively participating in carbon farming initiatives, such as farmers, agribusinesses, carbon farming platforms, and businesses leading initiatives, additional broad categories of actors have been derived from relevant research on stakeholder analyses and perspectives within the agricultural sector. Drawing from insights in research on the agricultural and forest sector by Soto Golcher et al. (2018), the primary stakeholder groups include research institutes, government and policymakers, farmer' associations, the private sector, NGOs, and financial organisations. This is complemented by actors who provide knowledge transfer (Demeyer et al., 2021; Florini & Pauli, 2018), such as information and communication centres and carbon farming platforms. Finally, the certification process of carbon credits further includes validation and verification businesses, certificate purchasers, funders, and controllers who monitor the success of the CO_2-removal measures (Federal Press, 2022).

This study emphasised the significance of stakeholders in addressing barriers to the adoption and scaling of carbon farming in Germany, encompassing issues such as implementation, financial constraints, access to technology and knowledge, and governance structures and processes. In summary, this research served as a basis for comprehending the range of stakeholders involved in discussions concerning carbon farming within the German agricultural sector. Recognising the diverse perspectives and frames they bring to the table is critical for designing effective governance strategies and informing policy formulation.

2.3 Frame Theory

This study investigated carbon farming, a complex issue with a wide range of stakeholders and positions. To explore stakeholder positions and their implications for cooperation and conflict, frame theory was employed as the central theoretical framework. This choice provided tools to uncover cognitive structures that shape positions and to analyse their

implications. Frame theory served as a guide for the research and allowed for a coherent and insightful analysis of the complex dynamics in carbon farming and stakeholder views.

2.3.1 Understanding frames and frame functions

The term 'frame' has been (and continues to be) used rather loosely in different fields of research and everyday life, with a wide range of definitions (Entman, 1993; Gray, 2003). This thesis follows Goffman, who describes frames as cognitive "frameworks" or "schemata of interpretation" that allow individuals to extract salient aspects of situations through organising principles and thereby give them meaning (Goffman, 1974, p. 21). He is considered a pioneer in this field (Borah, 2011; Entman, 1993), and his refined and influential definition is still used and adopted by many scholars today. More simply put, frames are described as "strong and generic storylines that guide both analysis and action in practical situations" (Dewulf, 2013, p. 322). Frames provide a lens through which to perceive situations by selectively enhancing certain elements of reality (Goffman, 1974). In doing so, they can emphasise certain issues, causes, moral judgements and potential treatment recommendations to a given problem or situation (Entman, 1993, p. 52), thus presenting a particular perspective on an issue. By emphasising certain aspects and omitting others, frames act as cognitive tools that help make sense of a large amount of information (Gitlin, 1980), resulting in different perceptions and interpretations depending on personal preferences and values (Borah, 2011; Edelman, 1988; Itkonen, 2009).

Goffman (1974) further states that frames can be identified and examined through textual analyses. This involves a systematic examination of frames to uncover how they are structured and shape interpretations and behaviours. This has led to an upsurge in publications using frame analysis to explore facets of frame theory. Notably, frame analysis encompasses diverse perspectives and thematic contexts. The concept has its roots in sociology and communication studies, but frame research has also been carried out in a variety of approaches based on literature from psychology, economics, political science and media studies, among others (Borah, 2011; Chong & Druckman, 2007; de Vreese, 2005; Dewulf, 2013). For instance, frame analysis considers frames established or adopted by the media (de Vreese, 2005; Rust et al., 2021), and those embedded in policy documents by various organisations (Jaschke & Biermann, 2022). Moreover, researchers have identified frames promoted by the government and other organisations (Kusmanoff et al., 2016) and even frames held by individuals or interest groups themselves presenting issues in specific ways that align with the interests of their creators (Chang & Park, 2022; Graversgaard et al., 2021; Klüver & Mahoney, 2015).

Issue-specific frames pertain to specific events or topics (de Vreese, 2005; Guenther et al., 2023), compared to generic frames that are cross-topic and often appear rather abstract (Brüggemann, 2014; Semetko & Valkenburg, 2000). With the specific topic of carbon farming in the stakeholder landscape of Germany being the focus of this research, the concept of issue-specific frames is used. Furthermore, in the realm of frame research, the framing cycle,

consisting of frame-building, frame-setting, and frame effects, is seen as a dynamic process that explores how frames are developed, adopted, and interpreted in discussions and decision-making processes (de Vreese, 2005; Scheufele, 1999). Most scholars do not usually discuss the entire framing cycle of their research object, but rather focus in-depth on specific parts of it (Guenther et al., 2023). With this research focusing on identifying issue-specific frames and their implications, based on the central premise that divergent frames of stakeholder groups can influence discourse and governance processes (Adger et al., 2011; Dewulf, 2013; Schön & Rein, 1994), the consideration of active framing is beyond the scope.

While the previous sections have discussed the fundamental aspects of frame theory and the diverse approaches to frame analysis in various disciplines, Entman's framework (1993) offers a valuable tool to delve deeper into the analysis of frame implications. This framework provides a structured approach to understand how frames define problems, diagnose causes, make moral judgements, and suggest treatment recommendations. Moreover, it takes into account broader contextual aspects, including communicators, texts, receivers, and cultural influences. In the context of this research, the focus is on exploring stakeholders' frames while considering their alignment with cultural and contextual aspects. This multifaceted framework allows for a richer exploration of the implications of frames, which are introduced and discussed further in the following chapter. It enhances the capacity to dissect and understand the roles of issue-specific frames in shaping stakeholder positions in the discourse on carbon farming.

2.3.2 Contextual factors and policy implications of stakeholder frames

Stakeholder frames play a vital role in shaping positions and discussions within the context of sustainable agricultural practices and natural carbon removal technologies. These frames are, in turn, influenced by contextual factors, such as historical events and the level of trust among stakeholders. This section outlines the intricate interplay of these influences on stakeholder frames, while also exploring the implications arising from these frames. Scholars have identified a variety of implications of frames held by stakeholders, particularly in political contexts, where frames are argued to play a pivotal role in shaping policy processes and decision-making (Triandafyllidou & Fotiou, 1998). These implications encompass a range of factors, including achieving common goals, collaborative efforts, policy development, and influence on stakeholder discussions. By understanding these dynamics, insights are gained into how stakeholders position themselves and communicate about carbon farming, as well as how these frames and dynamics can influence cooperative efforts, policymaking, and the adoption of climate-friendly practices within the agricultural sector.

Mistrust: Frames are not isolated entities; instead, they exist within a dynamic interplay of various contextual factors and dynamics that greatly shape their development and impact (Gamson, 1992). One such critical factor is the presence of mistrust among stakeholders, which can profoundly affect how frames are perceived and acted upon. In scenarios where stakeholders share responsibility, trust is paramount (Ansell & Gash, 2007). Past collaboration

matters, with successful partnership tending to favour collaboration (Margerum, 2008), whereas a conflictual past contributes to mistrust, disengagement or "stereotyping among stakeholders" (Dapilah et al., 2021, p. 3). The absence of trust can further hinder cooperation and lead stakeholders to place responsibility or blame on others (Cox et al., 2020; Waller et al., 2020), a factor that significantly influences the development of frames of issues (Gray, 2003; van Herten & Runhaar, 2013).

The dialectic between frames and events: The interplay of historical events, combined with the role of mistrust can significantly influence the prevalence of particular frames over time, with common assumptions at times transcending various frames (Gamson, 1992). This, in turn, results in various implications for stakeholder discourse and policy development. As discussed by Ellingson (1995), initial frames can play a fundamental role in shaping discourse and action, influencing the dynamics of stakeholder interactions. Consequently, the events that arise as a result of these initial frames can further impact their development and influence by altering the underlying beliefs and ideas of the involved actors. Ellingson refers to this process as the "dialectic between frames and events", which illustrates how the power dynamics of a specific frame are subject to reciprocal implications (Ellingson, 1995).

Achieving common goals and visions in collaborative efforts: Shared frames and aligned values among stakeholders are essential for achieving common goals and visions in collaborative efforts (Ansell & Gash, 2007; Buuren, 2009; Dewulf, 2013). This agreement encompasses several aspects, including defining the problem and outlining necessary steps and capacities (Bentrup, 2001).

Discourse and policy agenda setting: It is widely argued that frames act as tools for moving from identifying problems to developing solutions in policymaking (Adger et al., 2011; Dewulf, 2013; Schön & Rein, 1994). This is particularly significant in governance areas characterised by complex situations necessitating considerations of numerous aspects. Frames provide a structured approach to these complexities by "emphasising a subset of potentially relevant considerations" of an issue, thereby guiding individuals to concentrate on these aspects (Benford & Snow, 2000; Druckman, 2004, p. 672).

In the context of agricultural practices and carbon farming, research has explored the impact of frames on discourse and policy agenda setting. For instance, Puttkammer and Grethe (2015) identified the media and the way actors, lobby groups, and politicians portray themselves and their positions as key factors influencing discourse on land use practices and policy agenda setting. Kusmanoff et al. (2016) have explored the effects of frames in conservation messages by organisations and government departments on landholder engagement and conservation participation based on their value orientations that influence human behaviour. Thus, selected frames can influence the uptake of certain agricultural practices.

Influence on stakeholder discussions: Widely supported frames can prevail and become institutionalised (Gamson, 1992; Schön & Rein, 1994). In multi-stakeholder situations,

collective issue framing can significantly influence stakeholder discussions (Schön & Rein, 1994), which has also been recognised as crucial in the context of debates on CO2 reduction and removal solutions (Levänen & Hukkinen, 2019).

2.4 Deduction of frames from frame analyses

Although there is no unified framework for issue-specific frames, some researchers argue for a clearer alignment and consistent use of frames used in content and frame analyses for reasons of comparability, rather than creating a separate set of frames for each study, which could lead to researchers finding the evidence they are looking for more easily (Borah, 2011). This suggests limiting the number of frames to those that are mutually exclusive for analysing purposes (Van Gorp, 2009); some argue even limiting the number of frames to two for reliability (Tankard, 2001). This can be achieved either by inductively creating reconstructed frames that need to be sufficiently abstract to be applicable to other issues that go beyond the scope of the specific research topic (Van Gorp, 2009) or by using frames that have been reconstructed from similar topics. A large proportion of scholars appear to prefer the latter approach, meaning deductively pre-defined operationalisations of frames in content analyses (de Vreese, 2005; Van Gorp, 2009). This research follows this approach and examines frames that have been defined and operationalised in advance. However, during the content analysis these frames are redefined in an iterative process, testing for which frames are effectively held and adopted in the specific context of carbon farming.

To my knowledge, no frame or discourse analysis has been conducted specifically on carbon farming. The frames used for this study are therefore drawn from literature on frame and discourse analyses on climate change mitigation, geoengineering and other negative emissions technologies, as well as farming practices, based on a basic literature review. These topics were chosen because of the way the idea of and debate about carbon farming emerged.

Carbon farming is presented as a solution to two problems, hence the literature used encompasses both perspectives. First, from an emissions reduction and removal perspective, studies were identified on negative emissions technologies, geoengineering and other carbon removal technologies, all of which aim to mitigate climate change and include carbon farming in a broader sense. These frames were chosen to address the technical and social concerns and discussion points of the emission removal aspect. From the second perspective of sustainable agricultural practices, frames found in the context of agricultural practices are relevant given that this study examines carbon farming in the context of agriculture. These studies consider farm-specific aspects that may pose barriers to the adoption of certain practices. It is important to note that unlike adopting more rigid frameworks such as Entman's (1993), which provides a structured template for frame analysis, these studies frequently encompass a diverse array of perspectives and develop unique approaches tailored to their specific research objectives that demonstrate the adaptability and flexibility of frame theory. Therefore, the specific frame functions, in this case with a focus on treatment

recommendations, were used in the analysis only after the frames had been identified to support exploring potential tensions among the prevailing frames and implications on stakeholder interactions.

2.4.1 Frames identified in related fields of research

This subsection delves into the existing body of literature to explore the various frames that have emerged in these research fields, which further serve as an essential backdrop against the following analysis of frames on carbon farming.

Rust et al. (2021) explored frames surrounding sustainable agricultural practices held by the farming press, identifying frames related to agronomy, economics, environment, policy, resilience, social, and technical aspects. These frames, which offer insights into how sustainable farming practices are portrayed in the media, provide a basis for understanding how farming practices are framed in discussions related to sustainability and environmental issues, which in turn can inform the analysis of carbon farming frames.

In studies related to climate change mitigation, several common frames have been identified, shedding light on the multifaceted discourse surrounding this critical issue. Nisbet (2009) identified various frames that seem to be highly present in public climate change discussions, including those related to social progress, economic development, morality, ethics, and scientific aspects. Severson and Coleman (2015) delved deeper into moral frames, categorizing them as deontological-moral, empirical-scientific, and economic. Understanding how morality is framed in climate change discussions provides insights into the ethical dimensions of environmental issues. These frames from climate change mitigation studies provide valuable insights into the dynamics of climate change discourse. They serve as a reference point for understanding how stakeholders might frame the issue of carbon farming within the broader context of climate action.

Studies on geoengineering, carbon removal, and negative emissions technologies have identified various frames that are highly relevant to the present research. Some scholars examined public discourse on geoengineering and greenhouse gas removal, identifying frames held among stakeholder groups or in the media. Porter and Hulme (2013), for instance, examined multiple issue frames in the emergence of the geoengineering debate in the UK print media, identifying issue frames such as innovation, risk, governance, accountability, economics, morality, security, and justice to be prevalent. These frames highlight the multifaceted nature of geoengineering discussions. Cox et al. (2018) further examined the ethics and policy of greenhouse gas removal, identifying concern frames related to treating symptoms, democracy, plurality, mitigation deterrence, risks, benefits, and scale. These frames offer ethical and policy perspectives on carbon removal technologies. Similar to this, Cox et al. (2020) analysed stakeholder discourses on greenhouse gas removal, identifying risk frames (physical/environmental, techno-economic, social) and responsibility frames (for emissions reduction, development and funding of removals, governance, equity, justice, democracy). These frames illuminate the potential risks and responsibilities associated with

large-scale carbon removal efforts. Dooley and Kartha (2018) also identified risk frames to successful deployment of land-based negative emissions technologies, specifically technical and biophysical infeasibility, unacceptable social and ecological impacts and ineffectiveness.

Finally, researcher have taken up the effort to sort common frames into main frames (or top-level/dominant frames). Huttunen and Hildén (2014) found three main frames in academic literature on geoengineering, namely 1) risk-benefit (focus on climate engineering potential, effects, risks, and costs), 2) governance (appropriate governance systems), and 3) natural balance frame (human should live in balance with nature). Waller et al. (2020) investigated dominant frames of greenhouse gas removals, which further include feasibility dimensions, included in brackets. They highlight the techno-economic frame (technical, carbon reduction, environmental, economic), acceptability frame (political support, carbon accounting, market incentives, public acceptance), and responsible development frame (relation between feasibility and questions of directionality, justice, responsibility). These frames provide insights into how geoengineering and carbon removal technologies are perceived, evaluated and accepted by different stakeholders.

Table 1 provides a foundational understanding of frames relevant to environmental and technological discussions. These frames are derived from existing literature, and they serve as a reference point for the analysis of frames in the context of carbon farming. The identified frames are categorised into three main frames: techno-economic, social and political acceptability, and responsible development. Each of these main frames is further broken down into sub-frames and provides a detailed exploration of each frame. Further, cross-references are provided, facilitating a comparison between the frames identified in this study and those explored in related research areas. This cross-referencing informs a detailed exploration in Table 2.

Table 1

Summary of Relevant Frames Identified in Literature on Related Research Areas

Main Frame	Sub-frame	References
Techno-economic frame	Economic	(Fuss et al., 2014, 2018; Huttunen & Hildén, 2014; Minx et al., 2018; Nisbet, 2009; Porter & Hulme, 2013; Rust et al., 2021; Severson & Coleman, 2015; Waller et al., 2020)
	Innovation	(Dooley & Kartha, 2018; Porter & Hulme, 2013)
	Technical	(Dooley & Kartha, 2018; Rust et al., 2021; Waller et al., 2020)
	Risk	(Cox et al., 2018, 2020; Dooley & Kartha, 2018; Porter & Hulme, 2013)
Social and political acceptability frame	Governance and Accountability	(Cox et al., 2020; Huttunen & Hildén, 2014; Porter & Hulme, 2013)

	Social	(Nisbet, 2009; Rust et al., 2021; Waller et al., 2020)
	Morality/Moral hazard	(Cox et al., 2018, 2020; Dooley & Kartha, 2018; Porter & Hulme, 2013; Severson & Coleman, 2015; Waller et al., 2020)
Responsible development frame	Environmental/Ecological	(Dooley & Kartha, 2018; Hansen et al., 2017; Rust et al., 2021; Waller et al., 2020)
	Equity	(Cox et al., 2020; Waller et al., 2020)
	Justice	(Porter & Hulme, 2013; Waller et al., 2020)

Note. Literature stems from research related to sustainable agricultural practices, climate change mitigation, geoengineering and greenhouse gas removal. The identified frames are sorted in three main frames, similar to Huttunen and Hildén (2014) and Waller et al. (2020)., and into the respective sub-frames identified in research.

2.4.2 Frames specified to carbon farming

The diverse findings in these studies highlight the flexibility of frame theory and applicability to a wide range of contexts. They further indicate the multifaceted nature of how stakeholders perceive and discuss complex issues related to climate change and carbon removal technologies. While the review revealed a spectrum of frames employed in various environmental and technological contexts, some frames may have limited relevance to the specific domain of carbon farming. Carbon farming shares common goals with other negative emissions technologies, such as the overarching aim of mitigating climate change (EEB, 2021). Yet, it also possesses distinct characteristics rooted in agricultural practices and land management and the emphasis on sustainability present in carbon farming may lead to the prominence of certain frames while minimising the significance of others. The frames identified in previous research provide a valuable starting point for understanding how carbon farming could be framed within public discourse, policy discussions, and stakeholder narratives.

A crucial aspect guiding the choice of frames was provided by the identification of key barriers and challenges in previous research concerning carbon farming, indicating a perceived risk of these factors, such as economic aspects, e.g., financial uncertainties and profit opportunities, the risk of carbon leakage, questions of equity and fairness, social acceptability, technical aspects, e.g., measurement and verification methods, permanence, ecological aspects, e.g., resilience, water management, plant nutrients, use of fertilisers and pesticides, and others (Baumber et al., 2021; Demeyer et al., 2021; European Commission, 2021; Jassim et al., 2022; Nyssens, 2021; Rodrigues et al., 2021).

While some frames may seamlessly apply, others may require adaptation to align with the intricacies of carbon farming. Frames such as security (Porter & Hulme, 2013) and risk (Cox et al., 2018; Huttunen & Hildén, 2014; Porter & Hulme, 2013), which are more commonly

associated with geoengineering and large-scale technological interventions, as well as frames such as symptoms, plurality, benefits, and scale, stemming from ethics and policy of greenhouse gas removals (Cox et al., 2018; Nisbet, 2009; Severson & Coleman, 2015), might have a relatively lesser impact on the public discussions surrounding carbon farming.

The subsequent analysis focused on the frames that were considered most relevant to carbon farming, considering the nuanced frame dynamics in this specific context. Establishing links between these frames and the unique characteristics of carbon farming facilitated gaining insights into stakeholder positions on this approach to carbon sequestration and potential impacts arising from them. This analysis made it possible to identify which frames were most prevalent in the public debate, contributing to a more comprehensive understanding of the suitability of carbon farming in relation to the sustainability of agricultural practices and climate change. The following sections explore the deduction and adaptation of frames for the analysis of carbon farming to illuminate the complex interplay of frames and facts that underpin this important climate change strategy.

To maximise reliability, this research focused on a limited number of main frames with a limited number of sub-frames. Following other scholars mentioned previously (Cox et al., 2020; Huttunen & Hildén, 2014; Waller et al., 2020), this research assumed three overarching main frames (also referred to as dominant or top-level in research). Table 2 delves deeper into the identified frames presented in Table 1. Each sub-frame is accompanied by a concise operationalisation and corresponding literature references and serves as a reference for the subsequent analysis in this study.

Notably, while the sub-frame 'risk' was originally included in Table 1, it has been omitted from Table 2. This decision aligns with the primary focus of this study on carbon farming, which differs from the original focus of 'risk' in the context of technical risks associated with geoengineering. Instead, the aspect of 'scientific uncertainty' has been integrated into the technical sub-frame, as it aligns with concerns related to unreliability and measurability. Table 2 presents sub-frames and references that are more directly relevant to the specific research objectives and the examination of implications associated with the identified frames.

Table 2

Main Frames with Sub-frames and References

Sub-frame	Operationalisation	References
	Techno-Economic frame	
Economic	Mentioning of crop yields, agricultural markets, farm profitability, costs of new technologies and funding streams, and their cost-effectiveness.	(Fuss et al., 2014, 2018; Huttunen & Hildén, 2014; Minx et al., 2018; Nisbet, 2009; Porter & Hulme, 2013; Rust et al., 2021; Severson &

		Coleman, 2015; Waller et al., 2020)
Innovation	Mentioning of the feasibility of these practices to influence climate change mitigation and issues of efficiency.	(Dooley & Kartha, 2018; Porter & Hulme, 2013)
Technical	Mentioning of the utilisation of new technologies and concerns about unreliability, measurability, and scientific uncertainties.	(Dooley & Kartha, 2018; Rust et al., 2021; Waller et al., 2020)
	Social and political acceptability frame	
Governance and Accountability	Mentioning of the institutions and policy mechanisms responsible for the governance, the role of states, corporations and governing bodies, and addressing concerns of power and democracy, political feasibility, legal frameworks and regulatory processes.	(Cox et al., 2020; Huttunen & Hildén, 2014; Porter & Hulme, 2013)
Social	Mentioning of aspects such as food security, health aspects, and resilience aspects, public acceptance or political support based on mistrust or scientific uncertainty, and the implications of market incentives.	(Nisbet, 2009; Rust et al., 2021; Waller et al., 2020)
Morality/ Moral hazard	Mentioning of a potential moral hazard related to policy instruments converting negative emissions intro tradable offsets and thereby risk postponing mitigation action, that is the risk of revising mitigation objectives based on projected future negative emissions.	(Cox et al., 2018, 2020; Dooley & Kartha, 2018; Porter & Hulme, 2013; Severson & Coleman, 2015; Waller et al., 2020)
	Responsible development frame	
Environmental/ Ecological	Mentioning of issues such as potential land use conflicts impacting food security and biodiversity conservation. Focus on the benefits of improved soil health with a functioning organic carbon cycle.	(Dooley & Kartha, 2018; Hansen et al., 2017; Rust et al., 2021; Waller et al., 2020)
Equity	Mentioning of aspects such as the risk of displacement of land use change or land grabbing.	(Cox et al., 2020; Waller et al., 2020)
Justice	Mentioning of issues such as the identification of beneficiaries and those adversely affected, compensation, and the suitability of distribution in alignment with the principles of fairness.	(Porter & Hulme, 2013; Waller et al., 2020)

The frames most frequently identified and that are seemingly most fitting to carbon farming and therefore adopted for the analysis of this research are firstly the techno-economic frame, secondly the social and political acceptability frame, and thirdly the responsible development frame. These are explored in more detail below, including their sub-frames and associated potential treatment recommendations.

2.4.2.1 Techno-economic frame

The first main frame adopted in this research is the techno-economic frame and is, in its overarching structure, mostly known from analyses of greenhouse gas removal strategies (Cox et al., 2020; Waller et al., 2020), however, sub-frames such as the technical and economic ones have also been identified in debates about farming practices (Rust et al., 2021). This main frame emphasises economic feasibility and technological advancements as crucial issues for successful carbon farming practices and initiatives, with stakeholders highlighting **economic**, **technical**, and **innovation**-related aspects. With focusing on uncertainties in the interactions between physical, technological, and economic aspects (Creutzig, 2016), such as the comparison of assumptions about crop yields between economic and ecological models (Waller et al., 2020), stakeholders holding this frame attribute the slow uptake of carbon farming to financial constraints and the lack of technological know-how as causal interpretation. Finally, this frame may advocate for financial incentives, market-based mechanisms, and research and development supported to promote carbon farming (Huttunen & Hildén, 2014). Several implications for conflict among stakeholders can emerge. These are for instance conflicts regarding resource allocation, since different stakeholders might have varying opinions on how resources should be invested in technological solutions for carbon farming, based on their perceived economic viability and potential returns on investments. Furthermore, stakeholders within this frame can have differing opinions about the potential risks associated with adopting certain technological solutions for carbon farming. In addition, policy recommendations can differ, which are explored in the frame analysis to identify tensions between stakeholders within the frame and with other frames. Understanding these potential conflict points can help policymakers and stakeholders navigate discussions and negotiations effectively, fostering collaboration and productive engagement.

2.4.2.2 Social and political acceptability frame

The second main frame identified is the social and political acceptability frame (Cox et al., 2020; Waller et al., 2020), which is related to Huttunen and Hildén's (2014) governance frame. This frame focuses on the social implications of carbon farming, such as impacts on rural communities, and highlights governance and accountability aspects. Crucial **social** problems in the realm of carbon farming are stated related to aspects such as food security and health aspects. Furthermore, public acceptance or political support based on mistrust or scientific uncertainty, and the implications of wrong or right market incentives, can hinder successful implementation and adoption (Rust et al., 2021; Waller et al., 2020). This links to the **moral hazard** sub-frame, which has been widely identified by stakeholders and researchers (Cox et

al., 2018, 2020; Dooley & Kartha, 2018; Porter & Hulme, 2013; Severson & Coleman, 2015; Waller et al., 2020) and centres on the potential moral hazard linked to policy instruments that convert soil carbon sequestration intro tradable offsets and thereby risk postponing mitigation action. Finally, **governance and accountability** aspects are highly relevant in this frame and involve discussions on the role of states, governance institutions, corporations, and regulatory procedures (Porter & Hulme, 2013). All these aspects are deeply intertwined and significant for social acceptance and community engagement and are considered as key drivers or barriers for successful implementation by stakeholders holding this frame. Finally, stakeholders holding this frame might recommend community engagement, participatory approaches, and capacity-building initiatives to foster stakeholder adoption and collaboration. This frame also implies the urgent need to shape governance (Huttunen & Hildén, 2014). Tensions in differing policy recommendations and solutions to overcoming barriers are identified in the frame analysis using Entman's (1993) framework.

2.4.2.3 Responsible development frame

The third main frame identified is the responsible development frame (Cox et al., 2020; Waller et al., 2020). This frame is closely related to the natural balance frame, identified by Huttunen and Hildén (2014) in their research on frames about geoengineering. Specified to carbon farming, this frame emphasises **environmental and ecological** aspects, as well as **equity** and **justice** concerns highly relevant for a successful uptake of carbon farming (Huttunen & Hildén, 2014; Porter & Hulme, 2013; Waller et al., 2020). It further underscores the need for sustainable and ethical approaches to carbon farming, emphasising environmental stewardship and climate responsibility (Dooley & Kartha, 2018; Hansen et al., 2017; Rust et al., 2021; Waller et al., 2020). This frame emphasises the significance of carbon farming as an essential tool for environmental conservation and climate change adaptation. Stakeholders adopting this frame tend to prioritize ecological sustainability and the protection of natural resources, biodiversity, and ecosystems. This frame also stresses the importance of carbon farming as part of climate adaptation strategies to build resilience in the face of climate change impacts. This frame further emphasises the need for policy and governance mechanisms that prioritise ethical approaches, sustainable land use, and environmental protection (Huttunen & Hildén, 2014). Finally, this frame could propose a comprehensive policy approach that integrates environmental protection, social equity, and climate change mitigation in carbon farming strategies as treatment recommendations. Implications of these differing treatment recommendations are analysed in the third sub-question.

Cross-frame implications

Conflicts between stakeholders holding divergent frames can manifest across various dimensions and have far-reaching implications. For example, stakeholders may clash over how resources, such as funding, land, or research investments, should be allocated within the context of carbon farming (Huttunen & Hildén, 2014). Conflicting frames can lead to disagreements regarding the long-term sustainability of carbon farming practices, including concerns about soil health, biodiversity, and ecosystem resilience. Differences in frames may

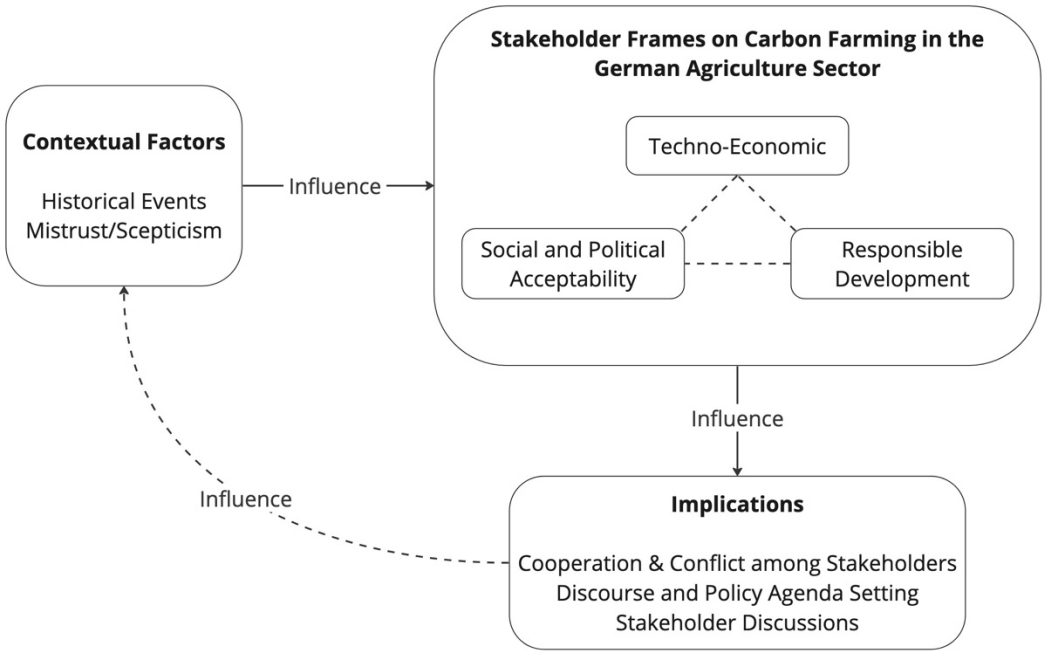
impact perceptions of transparency and accountability within carbon farming regulations and initiatives, potentially leading to disputes over governance and decision-making processes. Stakeholders may hold opposing views on the role of government regulation in overseeing and enforcing responsible and sustainable practices in carbon farming (Huttunen & Hildén, 2014). Conflict can also arise when stakeholders diverge in their assessment of the trade-offs between economic benefits derived from carbon farming and its potential environmental impacts (Waller et al., 2020).

2.5 Conceptual framework

This section presents the conceptual framework that captures the intricate interplay of contextual factors, stakeholder frames, and implications in the field of carbon farming in the German agricultural sector. The main stakeholder frames deductively identified are the techno-economic frame, the social and political acceptability frame, and the responsible development frame. The implications identified are cooperation and conflict between stakeholders, discourse and policy agenda setting, as well as an influence on stakeholder discussions. The framework also incorporates the dialectic between frames and contextual factors and recognises that the implications of frames can have feedback effects on contextual factors. These considerations result in the following conceptual framework in which the concepts and accounts of their relationships are visually depicted in Figure 2.

Figure 2

Conceptual Framework (own depiction)



Note. The dashed lines between the frames illustrate their internal relationships and connections. The arrows from the contextual factors to the frames and from the frames to the implications indicate the potential causal relationship surrounding the prevalence of frames. The dashed arrow from the implications to the contextual factors acknowledges the

dynamic interplay between frames and contextual factors, which can be triggered by the implications of the frames.

3. Technical research design

This chapter provides an overview of the research strategies and data collection methods used, as well as ethical considerations and data analysis procedures.

3.1 Research strategies

The research strategies considered in this research proposal represent a mixed methods approach employing both qualitative and quantitative methods (Clark et al., 2021). The German agricultural sector was utilised to explore the relationships between frames and policy implications in the governance field of carbon farming. A combination of research materials was used to answer the research questions. Prior to the analysis, secondary data from studies on frames, carbon removal strategies, and research on carbon farming were used for guidance. To gain an in-depth understanding of the phenomenon of this specific study of the German agricultural sector, a combination of sources was used (Verschuren & Doorewaard, 2010). Specifically, this involved two different types of data, firstly a combination of documents from different sources, focusing on the Nexis Uni newspaper database, supplemented by public consultation documents from the European Commission and industry publications. Secondly, this was complemented by semi-structured interviews with stakeholders to gain deeper insights into the stakeholder landscape, the frames, the development of the debate in the German agricultural sector, as well as the implications of the frames. By using quantitative and qualitative methods based on the data collected, the aim was to triangulate the results "to mutually corroborate them" (Clark et al., 2021, p. 557). While acknowledging the challenges and limitations of frame analysis, this method provides a deeper understanding of how stakeholders perceive and engage with the issue of carbon farming in agriculture.

3.1.1 Case study analysis

Stake (1995) describes a case study as "the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (p. xi). This research employed a single case design, with Germany serving as a representative case, to conduct a comprehensive analysis aiming to explore the relationship between frames and stakeholder implications in the realm of carbon farming on arable land, employing both quantitative and qualitative methods.

The selection of the German stakeholders for this case study resulted from the strong representation of a broad range of interests within agricultural policy. Notably, Germany's climate policy landscape is uniquely intertwined with environmental organisations (Jost & Jacob, 2004). Germany's agricultural sector stands out for its strong presence in organic

farming (Eurostat, 2020), a factor that has significantly influenced shifts in agricultural policies. Moreover, Germany's ambitious climate policy objectives, aimed at enhancing natural carbon sinks (BMEL, 2021; BMUV, 2023b), further underscore the relevance of this case study. Furthermore, German stakeholders seem to be strongly interested in shaping carbon farming policy, as they are the most represented country in the feedback documents received by the European Commission during the public consultation period on a carbon removal certification framework (European Commission, 2022a). Finally, the availability of German documents in German and English facilitated access to important research materials.

To enable "an intensive, detailed examination of a case", this case study included "both quantitative and qualitative research", following a mixed-methods approach (Clark et al., 2021, p. 59). This included a qualitative analysis of the frames and a quantitative overview of their development, and the stakeholders involved.

3.1.2 Stakeholder analysis

To analyse the frames held in the stakeholder landscape, stakeholders first had to be identified and categorised, following Reed et al. (2009). This analysis drew from Freeman's (1984) stakeholder theory, defining stakeholders as "any group or individual who can affect or is affected by" a situation or decision, while originally referring to the corporate context with "the achievement of the organization's objectives" (p. 46). This distinction is followed in in the stakeholder literature on natural resources and referred to as active or passive stakeholders (Grimble & Wellard, 1997).

This chapter describes the process of stakeholder identification and categorisation, noting that this research focuses on the German context of carbon farming and yet recognising that the debate is also influenced by European and international actors. For example, foreign actors are engaged in the process in which the European Commission is trying to create a harmonised framework for carbon based on carbon farming (European Commission, 2022a), which has given the debate a significant boost, and there is also considerable demand from international companies that want to offset their emissions and make their value chain carbon neutral (Scherger, 2022). While European and international actors influence the broader discourse, the aim of this study was to provide specific insights into the German debate. Additionally, practical constraints such as language barriers and resource limitations contributed to this decision. However, it is important to acknowledge that these actors might have indirectly impacted the frames held by German stakeholders.

To systematically identify stakeholders who are directly affected by policy decisions or who are active in the field of carbon farming in German agriculture, a basic literature review and a comprehensive content analysis were conducted. This included Google Scholar, Nexis Uni, specialised press sources and EU Commission public consultations. The detailed data types used for this identification are presented in section '3.1.3 Content analysis'.

This approach also aimed at capturing the diverse landscape of stakeholders that play an important role in shaping the carbon farming regime in Germany. This includes categories of

various stakeholders, such as those actively implementing carbon farming, those relevant to the eventual introduction of carbon farming, as well as those contributing to shaping the landscape through critique and scientific contributions. Shaping carbon farming includes governance structures and processes, its adoption, managing financial constraints, and access to technology and knowledge. It is important to note that this selection includes a wide range of stakeholders who have varying perspectives on carbon farming.

Government and policymakers play a pivotal role in drafting legislation and regulations and, together with environmental NGOs, have a major influence on the governance process, while farmers and farmers' associations play a crucial role in implementing carbon farming practices (Horschig et al., 2020). Carbon farming platforms facilitate connections between farmers and buyers of certificates, who serve as funders, and provide farmers with tools, practices, and knowledge (Federal press, 2022). Behind these platforms one often finds agribusinesses or other companies. Academia and research institutes are indispensable in laying the scientific groundwork for these efforts, addressing scientific uncertainties and setting the context along with the media. Investors and the public are observers, according to Horschig et al. (2020), who further distinguished between organic and conventional farmers, recognising their distinct interests. This distinction is particularly relevant to carbon farming, given the significant presence of organic farming in Germany (Eurostat, 2020), and regenerative practices largely informing carbon farming approaches (EEB, 2021). However, within the following analysis, this overview is subject to iterative revision based on prominent stakeholders in the public debate and those identified during interviews.

Stakeholder were also identified based on their participation in the public debate, which was assessed through content analysis and further verified through stakeholder insights from semi-structured interviews. Stakeholders who either made a statement or were mentioned in the context of carbon farming types other than related to farming practices on arable land were excluded.

It is important to note that the list of stakeholders in section '4.1.2 Stakeholders involved in the carbon farming landscape' was compiled to the best of my knowledge and belief at the time of compilation. It does not claim to be exhaustive of all individuals who have ever spoken out in Germany, nor of all organisations and initiatives that were or are active in Germany. On the one hand, this is because e.g., actors involved in providing scientific advice or background reports were not mentioned in the analysed documents but have published elsewhere. On the other hand, some international actors were identified in the analysed documents, however, the focus of this study was on actors whose sphere of influence lies in Germany. Furthermore, actors who are only active at the local level were generally not mentioned, unless they are actors with superregional significance. For reasons of clarity, only those stakeholders are listed who were not only mentioned once in a newspaper article but who have commented extensively on the topic of carbon farming. Excluded individuals included mainly actors from the scientific community, environmental organisations and associations, agricultural businesses and traders, and foundations.

3.1.3 Content analysis

The content analysis had several purposes. First, it was used to identify stakeholders who have spoken on the issue in the public debate and engaged actively in shaping policy. Further, it was aimed at systematically investigating the frames of carbon farming in Germany held by the stakeholders. The goal was to gain both quantitative and qualitative insights into frames and frame functions, which is a commonly used operationalisation of textual frame analysis (de Vreese, 2005; Neuman et al., 1992). In this case, frames represent how carbon farming was presented and discussed, and the frame function focused on the proposed treatment recommendations within these frames, introduced by Entman (1993), which was used to analyse the implications of these frames. Quantitatively, the analysis also provided information to track the evolution of the dominant frames of carbon farming over time.

The content analysis included several sources. First, feedback documents received during public consultations on carbon removals were collected, which are particularly relevant in light of recent developments such as the EC proposal for a carbon removal certification framework in 2022 (European Commission, 2022a). This proposal has increased attention on the implementation and regulations of carbon farming programmes and incentives in Germany and is based on two successive consultation processes. The first EU consultation on Sustainable Carbon Cycles, which aimed "to support the development of sustainable carbon removals", had a feedback period from 09 September 2021 to 07 October 2021. In addition, the planned outcome was to "propose an action plan to promote carbon farming and develop a regulatory framework for the certification of carbon removals" (European Commission, 2021). This was followed by a proposal for a carbon removal certification framework, which in turn had a feedback period from 07 February 2022 to 02 May 2022 (European Commission, 2022a). A second feedback period was opened from 01 December 2022 to 23 March 2023 for stakeholders to respond to the published draft. These consultation processes involved a range of stakeholders who provided written comments on the Communication and the draft proposal, explaining their views. These documents offer deep insights into stakeholders' objectives and frames, as they usually consist of at least one page of opinion and reasoning. Following the reasoning of Huttunen (2014), the insights from these stakeholder comments offer a valuable insight into the frames of German stakeholders engaged in carbon farming and its legal anchoring. As the focus of this study was to gain insights into German stakeholder frames, the feedback was limited to submissions from Germany. However, after Indigo Agriculture Europe (feedback from Switzerland) and Arla Foods (feedback from Denmark) were identified in the stakeholder analysis as important companies leading carbon farming initiatives and being vocal stakeholders in Germany, they were included in the selection. Finally, anonymous feedback and feedback from citizens in Germany were removed, as they did not contain usable feedback.

The second data source involved querying the Nexis Uni database for newspaper articles, while adding specialised agricultural press. While this research recognises that the German media only partially covers the public discourse, it provides a valuable overview of ongoing

discussions, following Gamson (1992). The search terms for the Nexis Uni query were selected to cover key concepts associated with carbon farming in both English and German, as German stakeholders often consult news sources in both languages and issue-related press outlets such as agricultural magazines in Germany are published primarily in German. The chosen keywords are presented in Table 3. These were identified after conducting a preliminary literature review and an internet background search aimed at developing an understanding of the issue and were additionally cross-checked with the query results. Keywords such as carbon dioxide removal, negative emissions, carbon management and humus build-up were avoided in order not to distract from the focus of this study, which was carbon farming on arable land. Expanding the search would have resulted in a significant surplus of data, for example on technical carbon removal options, the review of which was not possible due to limited resources and time constraints.

Table 2

Keywords for the Carbon Farming Media Coverage in Germany

Carbon Farming	Soil Carbon Sequestration	CO_2-Senkenleistung (German for CO_2 sink performance)	Kohlenstoffanreicherung (German for carbon accumulation/build-up)

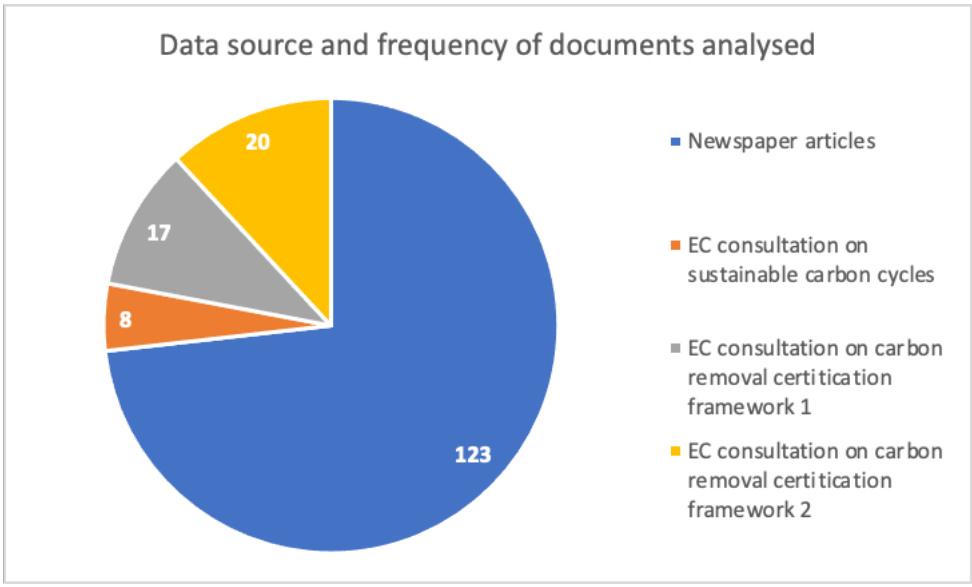
The search process in Nexis Uni for newspapers utilised the search string: "*Carbon Farming OR Soil Carbon Sequestration OR CO2-Senkenleistung OR Kohlenstoffanreicherung*". The Paris Agreement, adopted on 12 December 2015, kicked off the debate on carbon farming in Europe and was therefore chosen as the start date for the search for all eventual news. The end date, 15 June 2023, is only due to the timing of this research. After limiting the search to English and German news articles published in Germany by location, the source EurActiv.com was added, as it is a major pan-European media network that also covers agriculture and food industry news; despite being based in France, it has offices in Germany that cover German agricultural news. Additionally, a database search was conducted in significant German agricultural magazines not included in Nexis Uni, specifically TopAgrar and Agrarheute, following Horschig et al. (2020). Abstracts and full articles were screened to ensure that the selected articles were relevant to Germany, as well as included German stakeholders relevant for the upscaling of carbon farming and focused on carbon farming with farming practices on arable land, rather than covering carbon farming elsewhere globally or emphasising unrelated technical carbon capture and storage strategies or other carbon farming practices.

Once the articles and documents were located, a screening process was applied, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram outlined by Page et al. (2021). This process ensured transparency, completeness, and accuracy by documenting the number of articles identified, the reasons and number of articles and documents excluded during the screening process, and the new reports included, providing a comprehensive overview of the datasets from initial identification to inclusion in

the analysis (Clark et al., 2021). The reasons for excluding articles and documents were as follows. Documents were omitted if they comprised only an abstract or a brief rather than an actual article and therefore did not include relevant stakeholders, or if they had the same content as another article but were published in several newspapers or on different dates and were therefore not detected as duplicates by Nexis Uni. In addition, some articles focused mainly on the European or global situation and did not include relevant stakeholders for the German context or were found based on the keywords but did not include relevant content on carbon farming. In this context, articles and documents were also excluded that dealt with other carbon removal technologies or carbon farming practices unrelated to agriculture. The screening process of the individual documents from the different sources is elaborated and visually represented in the corresponding PRISMA diagram in Appendix A. Based on this, 329 articles from the various newspaper sources and 104 documents from the EC consultation processes were located. After the screening process was completed, 168 documents were included in the content analysis. Figure 3 illustrates the number of documents analysed from different sources.

Figure 3

Pie Chart of the Documents Analysed in the Content Analysis including Data Source and Frequency (own depiction)



3.1.4 Semi-structured Interviews

To dive deep into the frames and consider the dynamic nature of the frames throughout the process (Hassenforder et al., 2016), the frames were tracked over time in the document analysis and the development was deepened in semi-structured interviews. To gain comprehensive insights and a diverse range of perspectives, a wide spectrum of expertise was sought through semi-structured interviews. Interviews are considered a suitable approach to use for exploratory and qualitative research (Clark et al., 2021).

Participants were drawn from various sectors, reflecting the diverse stakeholders involved in carbon farming in Germany. During interview scheduling, it is important to recognise the factors that influenced the selection process. A broad spectrum of potential respondents was approached. However, several factors contributed to the composition of the final respondent pool. Some ecological farmers' associations, despite their interest, were unable to participate due to time constraints. Some large environmental organisations and NGOs generally refrain from participating in thesis research interviews due to their extensive commitments and limited capacities. Validation and verification businesses, key players in the context of carbon certification, cited capacity limitations and a lack of interest as reasons for declining interviews. Policy makers, a crucial group for understanding regulatory aspects, indicated constraints related to time and capacities as their reasons. Agribusinesses, although potentially relevant, often encountered difficulties in identifying an available responsible person for interviews. Businesses leading initiatives mentioned facing capacity constraints.

These refusals, while informing the selection process, ultimately led to the refined respondent pool shown in Table 4, consisting of following groups: academic experts, government and policymakers, farmers' associations, carbon farming platforms, agribusinesses and -trader representatives, environmental organisations and association, consultancies and advisors, as well as information and communication centres representatives. Respondent selection followed a purposive sampling approach, initially targeting people who possessed knowledge and opinions on carbon farming, either because they stood out in the document analysis or due to their professional roles. In cases where a response could not be obtained, the snowball sampling method was employed, wherein participants were asked to recommend other individuals with relevant insights. This combined approach of purposive and snowball sampling facilitated in-depth and nuanced understanding (Cox et al., 2020).

The semi-structured approach has the inherent advantage "that it allows the interviewer to shape the questions around the needs of the interviewee" (Clark et al., 2021, p. 433). This was particularly advantageous when considering the different positions and expertise of the respondents in this case study, ranging from policymakers to carbon farming platforms and farmers' associations, all with different knowledge of the debate, frames, and views of other stakeholders.

Each respondent was provided with an interview guide with a list of questions that allowed for comparability of respondents' answers but also left room for flexibility and follow-up questions (Clark et al., 2021). Ultimately, the interviews followed conversational flow, adapting questions to each participants' expertise, allowing for open-ended questions and statements. Although the aim of the interviews was to further explore the frames held by stakeholders and to identify contextual factors that triggered shifts in the prevailing frames within the stakeholder landscape, the term 'frame' and an excessive amount of theoretical background were avoided in order to cover the areas necessary to answer the research questions on the one hand and to preserve the respondents' perspective on the other (Clark et al., 2021). Rather, the thematic blocks covered in the interviews included an introduction

of the participant and their role in the debate, the respondents' perspective on agricultural carbon farming, their impressions of other actors in the debate, and finally their insights into the development of the debate. The interview guide is provided in Appendix B3.

Table 4 offers an overview of the interviews that were initially targeted and successfully conducted in June and July 2023.

Table 3

Respondents and their Respective Positions

Stakeholder category	Contacted (45)	Scheduled (22)	Respondent position
Academia	5	3	A1 – Officer for national climate protection strategies in agriculture
			A2 – Working Group: Impact Assessment of Land Use Change
			A3 – Expertise – Agricultural policy and land use
German government offices, ministries, and policymakers	6	2	G1 – Advisor for renewable raw materials, bioeconomy and climate-friendly agriculture
			G2 – Advisor for climate protection, world's food supply, international cooperation with a focus on agriculture and food
Farmers' Associations			
Conventional Farming Associations	4	3	F1 – Head of Agriculture and Advisory Services
			F2 – Climate Protection and Animal Welfare officer
			F3 – Department of Agricultural and Environmental Policy
Ecological/Organic Farming Associations	5	2	FE1 – Agricultural Policy Officer
			FE2 – Advisor sustainability and climate protection
Regenerative agriculture platforms	4	3	RF1 – Co-founder
			RF2 – Agricultural engineer
			RF3 – Advisory board
Business leading initiatives and carbon farming platforms			
Businesses leading initiatives (food industry)	2	0	/
Carbon farming platforms	4	3	C1 – Public relations
			C2 – Agro-environmental scientist
			C3 – Key-Account Manager (Sustainable Agriculture and Food Security)
Agribusinesses- and trader	3	1	AB1 – Advisor climate protection and sustainability
Validation and verification businesses	2	0	/

Environmental organisations and associations	5	2	E1 – Speaker working group agriculture
			E2 – Nature conservation and agricultural policy officer
Consultancies and advisors (Independent)	2	1	I1 – Agricultural expert and policy adviser
Information and communication centres	2	2	N1 – Contact for carbon farming projects
			N2 – Managing direction of an agri-social company
Foundations	0	0	/
Financiers and investors	0	0	/

3.2 Data processing

The collected data from the content analysis was analysed using the online software NVivo. This facilitated the systematic coding and categorisation of patterns within the data to obtain a qualitative and quantitative evaluation (Clark et al., 2021). The focus was on the predominant stakeholder frames of carbon farming on arable land in Germany and offered first insights into the stakeholder landscape and the development of the frames. The semi-structured interviews were conducted using the programme Microsoft Teams. After using the software's built-in transcription service and then checking for accuracy, the data obtained was also analysed using NVivo. This integrated approach allowed for a comprehensive examination of stakeholder frames and their development. Specifically, the data analysis was structured to address the following research questions:

1. How have historical events in variation among stakeholder groups contributed to forming and evolving the predominant frames held by stakeholders engaged in carbon farming on arable land in Germany?

To answer this sub-question, the data from content analysis and interviews were combined to identify the predominant frames held by stakeholders, with a particular focus on the influence of historical events, doing a quantitative frame analysis. The frames initially deduced from the relevant literature were iteratively refined and adapted to the available statements on carbon farming.

2. How do the frames held by stakeholders influence their positions in the context of carbon farming on arable land in Germany, and what are the potential implications for stakeholder interactions?

This question guided the analysis of stakeholder frames and their implications. The identified frames were examined for their potential to foster cooperation or lead to stakeholder conflict and influence policy agenda setting and stakeholder discussions using frame theory and literature from related research.

3.3 Ethical considerations

To comply with the principle of informed consent, all interview participants were informed about the purpose and process of this study before they participated in the data collection, following Clark et al. (2021). To this end, they were given an informed consent form explaining how their data would be used and they could also choose whether they wanted to be treated anonymously, with the name of the organisation or with their personal name. However, as some respondents had requested to be treated anonymously, it was decided to anonymise all participants in the final report for simplicity. To protect the privacy and confidentiality of the participants, all data were stored securely and deleted after the study was completed. Respondents were informed that their participation was voluntary and that they could end their participation at any time. The forms are included in Appendices B1 and B2.

4. Results

To address the first sub-question, which focuses on the dynamics of the prevailing stakeholder frames on carbon farming, section 4.1 is structured as follows. First, the carbon farming landscape in Germany is outlined, followed by an overview of the stakeholders involved. This forms the basis for identifying the prevailing stakeholder frames of carbon farming and finally this information is integrated with information on the historical development and dynamics to answer the first sub-question.

For the second sub-question, section 4.2 examines first the commonalities and conflicts between the frames and then identifies observed and expected implications. These include stakeholder cooperation, policy development, and the adoption of carbon farming practices.

4.1 The dynamics of the predominant stakeholder frames of carbon farming in Germany

4.1.1 Carbon farming in Germany

In this form, the concept of carbon farming is relatively new in Germany and other European countries, in contrast to Australia and the USA (Kragt et al., 2016; Marks, 2020; Paul et al., 2023). On the political agenda, however, the importance of carbon farming has risen sharply since its appearance in Europe around 2018 (Demeyer et al., 2021), which also influenced Germany. The EU is currently working on changing guiding documents and legislative proposals to incentivise the increase and protection of soil carbon sinks for farmers to achieve the aspirational target of 310 million tonnes of carbon dioxide equivalent ($MtCO_2eq$) annual net removals by 2030 and climate neutrality in the land sector by 2035, with the Communication on Sustainable Carbon Cycles presented in 2021 and the proposal for a Regulation on an EU certification for carbon removals in 2022 (European Commission, 2021, 2022a). The EU argues that due to the significant potential mitigation effect of carbon farming, although mainly referring to peatlands, scaled-up application is necessary to achieve

the planned net zero emissions of total GHG in 2050 included in its binding climate law, translated to a necessary 55% reduction in total GHG emissions in 2030 compared to 1990[2] (European Commission, 2021).

In addition, there are political funding programmes in Germany and across Europe for research into sustainable soil systems, some of which are also concerned with research into carbon farming programmes and carbon storage capacity. Table 5 list those that include German research institutes and farmers. Moreover, the European Common Agricultural Policy (CAP) provides financial support for farmers for sustainable and productive land management. Despite these efforts, the CAP indicator for agricultural and forest land contributing to carbon sequestration or conservation under management contracts has so far only been designed to indicate afforestation, woodland creation and agroforestry, and remains at just over 1% in Germany (DG AGRI, 2023).

Table 4

European Schemes, Scheme Objectives and Scale

Scheme	Project objective and scale
LIFE Carbon Farming Scheme (LIFE programme) – 2021-2027	Aim of promoting a voluntary carbon market. Focus is on result-based funding for carbon sequestration and the increase and maintenance of the organic carbon stock in soil and biomass in Europe. Actors: farmers, public bodies, industrial companies, banks (Tiusanen et al., 2022).
INTERREG Carbon Farming project (European Regional Development Fund) – 2018-2021	Aim of promoting Carbon Farming in the North Sea Region. Focus is on on-farm carbon sequestration and facilitating collaboration. Actors: farmers, agricultural advisors, knowledge institutes and other interested parties within and outside the food chain (Demeyer et al., 2021).

In Germany, the agricultural sector is responsible for a significant share of overall CO2 emissions (UBA, 2022). Germany has even more ambitious targets than the EU, aiming to reduce GHG emissions by at least 65% by 2030 and 88% by 2040 compared to 1990 levels, as well as reaching total net zero GHG emissions by 2045 and net negative emissions by 2050[3]. Furthermore, the federal climate change act includes an increased contribution of the land use, land-use change and forestry sector to climate change mitigation with at least a removal of 25 $MtCO_2eq$ by 2030, 35 $MtCO_2eq$ by 2040 and 40 $MtCO_2eq$ by 2045[3]. Individual sectors, including agriculture, receive emissions budgets that are set annually. In addition, smallholders in Germany are under considerable economic pressure, with the trade-off between higher environmental standards and economic factors having already led to a

[2] (Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), 2021).

[3] (Federal Climate Change Act of 12 December 2019 (Federal Law Gazette I, p. 2513), as Last Amended by Article 1 of the Act of 18 August 2021 (Federal Law Gazette I, p. 3905), 2019).

"consolidation of the German agricultural industry" (BMEL, 2019a; Schaub, 2021, p. 784). In response, even though there is currently no dedicated national policy for carbon farming, the government has undertaken multiple farming strategies and programmes to pursue a multifaceted approach to support farmers and facilitate a transformation of the sector towards sustainability (BMEL, 2021; BMUV, 2023b).

Table 6 lists the national schemes and programmes that are related to carbon farming, with the Federal Action Plan on Nature-based Solutions for climate and Biodiversity being the most recent and the only one directly targeting carbon storage enhancement, although it is still in its early stages with the first two funding programmes starting in July 2023 (BfN, 2023). In addition, this programme refers to a range of measures that serve to mitigate climate change while creating or strengthening diverse ecosystems, of which the promotion of carbon sinks in agricultural practices is only a small part (BMUV, 2023a). The other schemes and programmes have been identified by Van Hoof (2023) and focus on reducing agricultural emissions and mitigating climate change in the agricultural sector. They address carbon farming and soil carbon sequestration only indirectly, but it can be argued that schemes that encourage farmers to practice organic farming and improve soil quality and humus formation also indirectly contribute to increasing soil carbon levels (BMEL, 2019b).

Table 5

German National Schemes and Programmes Related to Carbon Farming

Scheme and year	Description
Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK) – 2023	Promotes climate protection services of ecosystems, including mitigation, adaptation and negative emissions (BMUV, 2023b).
Integrated National Energy and Climate Plan – 2019	Ten-year integrated document mandated by the EU to each of its member states to meet EU's overall GHG emissions targets (BMWK, 2020).
Future Strategy for Organic Farming – 2017	With organic farming being the guiding principle for ensuring a sustainable agricultural sector, the aim is to have 30% of agricultural land in Germany farmed organically by 2030 (BMEL, 2017).
Climate Action Plan 2050 – 2016	Agreement encompassing targets of greenhouse gas emissions reduction, including a variety of measures[3].

Not only state-organised projects have emerged, but also private national initiatives such as those of BonaRes and Bioland Foundation (Boden.Klima project), whose projects focus on research into carbon-based farming methods with an emphasis on sustainable agricultural soil (Respondents FE2, I1). In addition, several private sector humus building programmes and schemes have been launched at local, national and EU level. A common inventory on carbon farming schemes has been drafted and the resulting platform provided a first overview of schemes, including those in Germany (Carbon Schemes Inventories, n.d.). However, given the lack of information and due to rapid dynamics and poor data availability, drawing up a

complete and up-to-date list was challenging (Respondent A1). For example, carbon farming schemes have emeged that aimed at certification, but with no information available on the status of participating farmers or certificate buyers or the duration, such as the agricoin platform with its business model 'carbofarm' (agricoin, n.d.). In addition, private soil carbon certification schemes have emerged, often supported by model projects (BMEL, 2022), such as 'HumusKlimaNetz' (Humus Climate Network), that is a model and demonstration project and aims to test innovative and long-term measures for humus conservation and build-up and to establish them on a broad scale on arable soils, without aiming directly for result-based certificates. Various institutions are involved, such as the Federation of the Organic Food Industry (BÖLW) and the German Farmers' Association (DBV) with scientific support provided by the Thünen Institute and funding by the Federal Ministry of Agriculture and Food (BMEL) (HumusKlimaNetz, 2022).

In the area of private carbon farming programmes, several notable initiatives have been identified that specifically target carbon storage as part of a business model. The programmes take different approaches, some focusing on measure-based remuneration, others on outcome-based. Certificates or products are either sold primarily to food industry companies who want to compensate or reduce emissions from their own value chain (insetting), while other schemes offer certificates to any interested buyers who use them to work towards their climate protection goals and compensate for emissions (offsetting). Further, these programmes exhibit varying geographical focuses, with some exclusively limited to Germany and others, while actively involving German farmers in the process, extend their reach to encompass the broader European Union (Carbon Schemes Inventories, n.d.). One prominent participant is the German multinational company Bayer AG, whose efforts span across the entire European Union. In contrast, WASA, a Swedish company, is notable for its presence in both Sweden and Germany, reflecting a more regional focus. The US company Indigo has opened toward the European market under the brand Indigo Agriculture Europe GmbH and has emerged as a vocal and prominent actor in carbon farming endeavours, having also collaborated with the agricultural trade company Beiselen GmbH. ATR Landhandel, with its own German carbon farming programme CarboAgrar, has since merged with Beiselen to form BAT-Agrar. The Climate-Farmers Carbon+ Program operates on an EU-wide scale. In contrast, Klim directs its focus predominantly towards Germany, while CarboCert extends its activities to both Germany and Switzerland. Similarly, KlimaHumus and CO2-Land primarily centres its operations within Germany. It is important to emphasize that the field of private carbon farming is dynamic and ever evolving, and this list provides a snapshot of the notable programs as of the available data.

Proponents of carbon farming argued that carbon farming initiatives and programs are expanding too slowly. This is also evident in various reports and programmes funded primarily by the European Commission, aimed at incentivising and scaling up carbon farming across the EU and its member states (Bumbiere et al., 2022; Demeyer et al., 2021; EEB, 2021; ENRD, 2022b; McDonald et al., 2021; Nyssens, 2021). These assessments emphasised the need for a

diverse range of interventions, both political and from private farming initiatives, to encourage farmers to deploy carbon farming practices (ENRD, 2022a). While the slow uptake of soil organic carbon management practices is not unique to Germany (Merante et al., 2017), and carbon farming is "still in its infancy in many European regions and Member States" (Margaras et al., 2022, p. 11), the country stands out for its ambitious targets for carbon sequestration through land use, which envisaged an allowed annual emissions budget of 56 Mt CO2eq for agriculture in 2030[4], without adequate uptake of practices or incentives. The efforts and existing mitigation measures in the German land-use sector are further viewed as insufficient to counteract the historical trend of net emission, and, unlike most other European member states, potentially leading to an increase in projected emissions by 2030 (EEA, 2021). It is also argued that agriculture is the sector with the least ambitious sectoral targets for emission reductions by 2030 (Germanwatch, 2021). This is especially challenging, as emissions from the agricultural sector were responsible for 8% of total GHG emissions in Germany in 2021, with slow emissions decline compared to other sectors (UBA, 2022).

4.1.2 Stakeholders involved in the carbon farming landscape

The analysis identified a variety of different stakeholders that are involved in the carbon farming debate. Key stakeholders are listed in Table 7 and have been grouped into the in chapter '3.1.1 Stakeholder analysis' identified stakeholder groups relevant to carbon farming.

In addition to these stakeholders, several buyers of certificates were identified in the analysis, comprising a variety of German actors. However, they inherently have an observer role in the debate and as they are constantly changing, it is beyond the scope of this research to list them all. Examples included food industry companies, hotels, banks, municipalities, breweries, and other individual companies. Furthermore, companies were identified that are involved in carbon farming technologies other than soil carbon sequestration, mainly engineering solutions, biochar or biomass, which have commented on carbon farming to a small extent but are not immediate stakeholders.

Table 6

Stakeholders Involved in Carbon Farming in Germany's Agricultural Sector

Stakeholder category	Stakeholder
Academia: *Provide scientific knowledge and influential in advising governance processes.*	
Research Institutes and Think Tanks	• Ecologic Institute • Agora Energiewende • Research Institute of Organic Agriculture (FiBL) • Institute for Advanced Sustainability Studies (IASS/RIFS) • Bavarian State Research Centre for Agriculture (LfL) • Mercator Research Institute on Global Commons and Climate Change (MCC) • Institute for Applied Ecology (Öko-Institut)

[4] See (Federal Climate Change Act of 12 December 2019 (Federal Law Gazette I, p. 2513), as Last Amended by Article 1 of the Act of 18 August 2021 (Federal Law Gazette I, p. 3905), 2019).

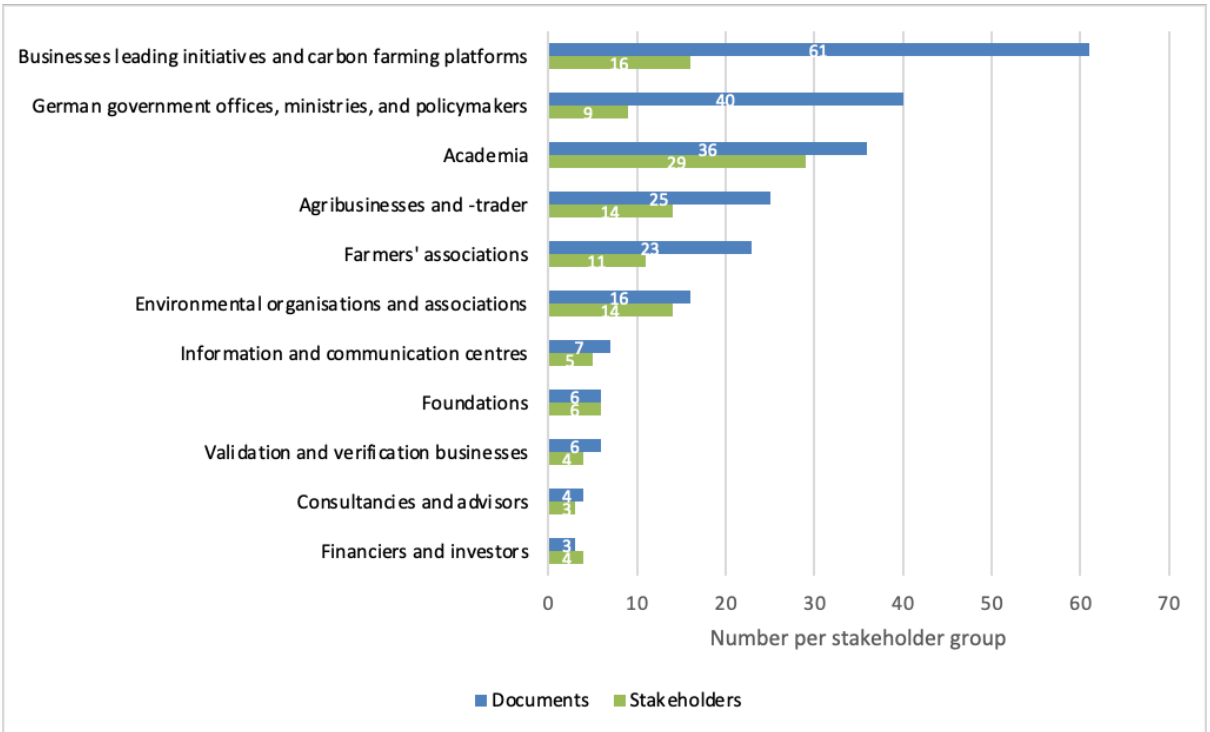
	• Potsdam Institute for Climate Impact Research (PIK) • Thünen Institute • Helmholtz Centre for Environmental Research (UFZ) • Leibniz Centre for Agricultural Landscape Research (ZALF) • Perspectives Climate Group (PCR)
Universities	• Individual researchers from various universities
German government offices, ministries, and policymakers: *Drafting legislations and regulations, as well as providing public funding.*	
Government (offices, ministries and agencies)	• Germany Federal Government • Federal Ministry of Food and Agriculture (BMEL) • Federal Agency for Nature Conservation (BfN) • Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) • Federal Press (BDg)
Policymaker	• Cem Özdemir (Minister of Food and Agriculture) • Martin Häusling (Member of the Alliance 90/The Greens and European Parliament)
Farming associations: *Advising farmers and networking with other stakeholders.*	
Conventional Farmers' Associations	• German Farmers' Association (DBV) • Working Group for Rural Agriculture (Arbeitsgemeinschaft bäuerliche Landwirtschaft – AbL) • Maschinenringe
Ecological/organic farmers' organisations	• Bioland • Demeter • BioBoden Genossenschaft e.V.
Regenerative/conservative farmers' organisations	• Gesellschaft für konservierende Bodenbearbeitung (GBK) • Interessengemeinschaft (IG) gesunder Boden • Klimapraxis • Aufbauende Landwirtschaft • Förderverband Humus (FVH)
Business leading initiatives and carbon farming projects: *Provide certificates and are the intermediary between the farmer as deployer of the practices and buyers of certificates, and provide farmers with tools, practices, and knowledge.*	
Businesses leading initiatives	German companies: • BASF Agricultural Solutions Seed • Bayer (Crop Science) • Bioland foundation (Boden.Klima project) • HIPP • AGRAVIS Raiffeisen European businesses engaging German farmers' and markets: • Indigo Agriculture Europe • Nestlé (Germany) • WASA • Arla Foods
Carbon farming platforms and initiatives	• Ackercrowd • CarboCert • Climate Farmers • CO2-Land • Klim (Carbon Farmed Solutions) • Klima-Milchfarm • Klimahumus • tgo (Carbofarm)

Agribusinesses- and trader: *Provide access to tools and practices.*	• Head offices of the Raiffeisen Confederation (Raiffeisenverband Zentralen) • Lemken • Beiselen GmbH / BAT-Agrar • Baywa AG • Agricultural Industry Association (IVA) • K + S AG • Novihum GmbH • KWS Saat
Validation and verification businesses: *Relevant for certification process.*	• German Agricultural Society (DLG) • First Climate AG • TÜV Association
Environmental organisations and associations: *Context setting and influencing governance processes.*	• Friends of the Earth Germany (BUND) • Environmental Action Germany (Deutsche Umwelthilfe – DUH) • Deutscher Naturschutzring (DNR) • World Wide Fund For Nature Germany (WWF) • Nature and Biodiversity Conservation Union (NABU) • Misereor e.V.
Consultancies and advisors: *Advising stakeholders such as policymakers and environmental organisations, as well as participating in debates.*	• Office for Soil Protection & Ecological Agriculture (Dr. Andrea Beste – Büro für Bodenschutz & Ökologische Agrarkultur) • AFC Management Consulting • C.A.R.M.E.N
Information and communication centres: *Knowledge transfer and building networks*	• 3N Kompetenzzentrum • Bundesinformationszentrum Landwirtschaft (BZL) • Food First Informations- und Aktionsnetzwerk (FIAN)
Foundations:	• Bodensee Stiftung • Stiftung Lebensraum
Financiers and investors: *Financing carbon farming.*	• Landwirtschaftliche Rentenbank

Figure 4 provides a comprehensive depiction of stakeholder participation in the carbon farming landscape in Germany. It illustrates the frequency of stakeholder mentions in documents and the composition of each stakeholder group, providing valuable insights into their public engagement. In the following, the information from Figure 4 was combined with insights from the interviews to map the perceived role with indications of the engagement of stakeholder groups in the public debate.

Figure 4

Number of Documents Coded and Organisations Across Stakeholder Types (own depiction)



Note. The number of documents corresponds to the documents coded in the analysis per stakeholder group and the stakeholders correspond to the number of organisations per stakeholder group identified in NVivo (which differs slightly from the enumerated ones in Table 7, as it includes all relevant ones according to the criteria, even if they only commented once).

Notably, **businesses leading initiatives and carbon farming platforms**, while not the most numerous stakeholder group, were prominently featured in a significant number of documents, as indicated by Figure 4. Their frequent occurrences underscored their perceived crucial role as drivers of the debate and their active outreach to other stakeholders (Respondents FE2, G1). Their commitment is reported as reflective of the growing recognition of carbon farming as a lucrative opportunity, driven by market incentives, the prospect of government funding, and increasing commitment among businesses to reduce their carbon footprint (Respondents A1, C1, C2, I1).

German government offices, ministries, and policymakers received frequent mentions in the documents analysed (Figure 4). However, some respondents perceived their engagement with carbon farming in Germany as relatively reserved (Respondents A2, C1, C2, C3, E2, N1, RF1). Despite infrequent mentions in documents, this group also includes Chambers of Agriculture (Respondents C3, FE2, N1, N2).

Academia emerged as another key stakeholder group, with a strong presence both in terms of mentions in the analysed documents and the number of stakeholder organisations listed in Figure 4. They were perceived as exerting substantial influence in the debate by issuing

warnings about the potential impacts and conducting scientific research (Respondents A1, A2, A3, AB1, C1, C2, C3, E2, F1, F2, FE1, FE2, G1, I1, N1, RF2, RF3).

Farmers' associations, except for the German Farmers' Association, which is the most influential advocacy organisation in the agricultural sector (Respondents F3, N2), were generally viewed as reserved yet influential (Respondents A2, F3). They are represented in a significant number of documents, indicating their active involvement in the public debate (Figure 4).

Agribusinesses and -traders, as indicated by the recurrent mentions in the document analysis (Figure 4), were identified as one of the driving forces for carbon farming, particularly due to the interest of agricultural machinery manufacturers (Respondents C3, E1, N2). Some perceived them as being actively interested but only moderately contributing to the discourse (Respondent C1).

Figure 4 illustrates a moderate level of mentions in the documents analysed for **environmental organisations and associations**, a highly heterogeneous group (Respondents C3, E1, F3, N2). They were perceived in various ways, with some viewed them as significant contributors to the discourse and active participants in the debate (Respondent A1), while others considered them critical (Respondents C2, E1, F2, I1), but somewhat reserved on a national level (Respondents A3, C3, E2, RF2).

Information centres and networks, as well as **consultancies and advisors**, while relatively fewer in numbers (Figure 4), play a significant role in shaping strategies and offering expert insights (Respondents E2, I1, RF2). Additionally, some of these centres were reported to be further engaged in collaborative projects, with some receiving (partial) funding from governmental ministries and offices (Respondent G1).

Foundations, apart from the active involvement of the Bioland foundation (Respondents FE1, I1), were not prominently featured in the interviews. They were mentioned in a small number of documents (Figure 4), reflecting some involvement of certain foundations in initiatives and position papers.

Validation and verification businesses were not mentioned in interviews and had only a few mentions in the documents analysed within the public debate (Figure 4).

The content analysis revealed only limited mentions of **financiers and investors** (Figure 4), and some stakeholders did not perceive any external pressure on this issue from these actors (Respondent A2). Others, however, argued that they were significant initiators and a driving force at EU level (Respondent I1).

4.1.3 Prevalence of frames

Table 8 provides an overview of the dominance of frames in the document analysis and whether they tend to represent positive or negative aspects of carbon farming.

Table 7

Frames Coded as Exemplifying Positive or Negative Aspects

Frame	Occurrences of frame in statements	Statements highlighting positives	Statements highlighting negatives
Techno-Economic	**46%**	**77%**	**23%**
Economic	15%	80%	20%
Innovation	15%	60%	40%
Technical	20%	53%	47%
Social and Political Acceptability	**37%**	**83%**	**17%**
Governance-Accountability	13%	56%	44%
Social	12%	67%	33%
Morality/Moral hazard	3%	0%	100%
Responsible Development	**17%**	**71%**	**29%**
Environmental-Ecological	9%	94%	6%
Equity	0%	0%	100%
Justice	3%	23%	77%

Note. The occurrence is the share of a particular frame in the total number of statements coded in NVivo in which a frame was detected. It is important to note that a statement can contain multiple frames. The share of examples of statements of frames with positive and negative connotations is based on these occurrences.

In the following, the frames are presented with the dominant stakeholder groups in each case, expressed by the share in the total statements of the respective frame and illustrated with exemplary quotations. In addition, the prevalence of the individual sub-frames was controlled by information from the interviews.

Techno-Economic Frame

It is noteworthy that the techno-economic frame is one of the most prevalent frames and primarily associated with positive aspects, as 77% of the statements highlighted positives, while 23% highlighted negatives (Table 8). The parts in documents featuring this frame focused on economic, innovative, and technical aspects discussed in the public debate on carbon farming. Furthermore, aspects of this frame were mentioned in all conducted interviews, with most respondents highlighting aspects of the technical sub-frame. The following sub-sections provide a comprehensive examination of the presence of this frame, shedding light on both its positive and negative associations.

Economic sub-frame

Statements within the economic sub-frame identified in the document analysis primarily concentrated on the potential business opportunities for farmers and the cost-effectiveness of carbon farming methods on arable land compared to other negative emissions technologies. This frame showed a clear tendency towards accentuating positive aspects (Table 8), such as the potential for "creating an incentive scheme with a focus on tradable "land mitigation units" (…) [which] could tackle today's bottleneck of financial nonpredictability" (Bayer, 2022). Additionally, it underscored farm productivity, farmer's income, and the advantages of digitalisation in measuring methods. Stakeholders emphasising these positive aspects were primarily businesses leading initiatives and carbon farming platforms (55%), followed by agribusinesses- and traders (13%) and conventional farmers' associations (12%).

However, certain stakeholder expressed reservations within this frame. Mainly academia (25%) and business-leading initiatives and carbon farming platforms (17%) raised concerns such as "current monitoring costs are problematic for cost effective certification" (Bayer, 2021), also related to a negative impact on productivity. Furthermore, the price of certificates was deemed crucial, as articulated by WWF et al. (2022), who note that "if it is lower than CO_2 abatement costs, the entrepreneurial incentive to reduce emissions will be lost".

Interviews further substantiated the importance of economic aspects in the context of carbon farming. Several respondents highlighted the following economic considerations: stabilisation of yields (Respondent C3, G1), costs of measurement (Respondents A2, AB1, C1, F3, N2), the costs of practices (Respondents G1, RF3) and financing options (Respondents A3, F2, FE1, G1, G2, N2), as well as the pricing structure of CO2 certificates (Respondent C1, F3, RF3).

Innovation

The innovation sub-frame often discussed the potential of farmers to mitigate climate change through carbon farming practices. It emphasised soil's ability to store carbon and examined how climate change challenges this carbon storage potential. Furthermore, the feasibility of scaling up carbon storage in soil was a recurrent theme. Within this sub-frame, as in the economic sub-frame, an overall tendency toward optimism prevailed (Table 8), with a strong focus on the sequestration potential of various carbon farming practices.

Positively inclined stakeholders, mainly businesses leading initiatives and carbon farming platforms (41%), agribusinesses and traders (11%), conventional farmers' associations (11%), government and policymakers (11%), and academia (11%) underscored the innovation's potential. For instance, Indigo Agriculture Europe (2021) asserted that "Carbon farming can play an important role in reducing emissions from the land use sector and removing carbon dioxide from the atmosphere", thereby contributing significantly to emission reduction goals and the German Farmers' Association stressed that it is possible only through the agricultural and forestry sector to generate or use natural carbon sinks in the sense of achieving climate neutrality (DBV, 2022).

Conversely, primarily academia (24%), businesses leading initiatives and carbon farming platforms (10%), environmental organisations and associations (9%), government and policymakers (9%), and conventional farmers' associations (9%) offered a more cautious perspective. WWF et al. (2022) raised concerns about the potential of carbon farming, noting that "carbon uptake in soils cannot always be equated with humus build-up" and emphasised a possible negated mitigation effect on climate change, as "leakage can occur if humus-building cultivation stores carbon in one place but causes humus depletion and therefore CO_2 emissions in another". Similarly, the agribusiness KWS Saat (2023) cautioned that "the overall potential of carbon sequestration via agricultural practices is limited".

Notably, in contrast to the findings of the document analysis, the respondents primarily questioned the potential for mitigating climate change through carbon farming on arable land. For example, respondent I1 mentioned that apart from organic farming and agroforestry, other agricultural practices are quantitatively insufficient in terms of carbon input to soil for climate purposes. The potential of carbon farming on arable land was also questioned by respondents A1, A2, A3, AB1, E2, F1, F3, FE1, FE2, RF1, RF2. The potential was also discussed by representatives of carbon farming platforms, who acknowledged an initial overestimation but pointed towards an untapped potential (Respondents C1, C3), which was further argued by respondent C3: "Carbon build-up might saturate at some point. It's not certain yet, but it might. But even if it does, with the right measures, it might not increase further, but it can be maintained. So that's the goal, even if it doesn't keep increasing". Respondent A2 further addressed potential displacement effects, that they should be taken into account, however, unlike permanence, "it's not something that can be easily communicated by writing it quickly on a poster".

Technical

In contrast to the economic and innovation sub-frames, the technical sub-frame shows a more balanced distribution with regard to the positive and negative aspects identified in the document analysis (Table 8). It brought to the forefront the technical intricacies associated with measuring and monitoring carbon farming practices, emphasising the need for precision and reliability in ensuring additionality and regulations for permanence.

Stakeholders who emphasised positive aspects within the technical sub-frame include primarily businesses leading initiatives and carbon farming platforms (62%) and agribusinesses and traders (22%). These highlighted the potential for technological solutions to enhance the credibility and effectiveness of carbon farming practices. Indigo Agriculture Europe GmbH (2021) underscored the importance of following the Verified Carbon Standard (VCS) methodology to ensure "the integrity of any carbon credit generated through the adoption of these practices, particularly with respect to realness, additionally, avoidance of double counting, and permanence". Bayer (2023) highlighted the value of digital technologies in "measuring carbon to set baselines as well as calculating the carbon removal and other co-benefits of carbon farming".

However, several stakeholders expressed concerns within the technical sub-frame, with academia (26%), businesses leading initiatives and carbon farming platforms (12% environmental organisations and associations (10%), conventional farmers' associations (8%), and government and policymakers (8%) offering a more cautious viewpoint. Their concerns primarily revolved around non-permanence and the challenges associated with accessing accurate and reliable measurements. The Agricultural Industry Association (IVA, 2021) highlighted the lengthy timeframes requires for adapting to changing land management practices and the inherent difficulty in measuring the small absolute increase in sequestered carbon. The agribusiness KWS Saat (2023) noted the challenge of guaranteeing an "accurate and reliable measurement of the achieved removal of emissions through sustainable land management practices", pointing out the risk of overestimation. Finally, WWF (2023) called attention to "critical aspects such as the permanence of carbon sequestration, [and] additionality to mandatory or already implemented measures", which they argue are not yet sufficiently addressed.

Among the respondents, mainly academic and farmers' association respondents mentioned measurability concerns and discussions about appropriate technologies (Respondents A2, A3, AB1, F1, F3, FE2, G2, RF1). They also talked about how to prove additionality from a technical point of view (Respondents A1, A2, E2, F2, F3, G2, RF3) and about the difficulties of setting a benchmark (Respondent F2). 14 out of 22 respondents within this sub-frame pointed towards questions of permanence (A1, A3, AB1, E1, E2, F2, F3, G1, G2, I1, N2). Similar to the results of the document analysis, these also included carbon farming platform representatives, who then countered this criticism with suggestions such as permanence buffers (Respondent C2) and the argument that farmers will deploy these practices continuously once the co-benefits of climate adaptation are realised (Respondent C3). Respondent A2 linked the strong emphasis on permanence to a communication problem, arguing that both additionality and displacement effects are crucial issues that are widely discussed in the scientific community but are "difficult to communicate publicly, which is why the public debate mainly focuses on permanence. And only that".

Social and Political Acceptability Frame

The analysis identified the social and political acceptability frame as quite prevalent in the public debate, appearing in 37% of the statements (Table 8). This frame encompasses discussion centred on the social and political dimensions that are argued to be integral to the successful implementation and expansion of carbon farming initiatives and showed a notable inclination towards highlighting positive aspects, as depicted in Table 8. The subsequent section offers a comprehensive examination of the prevalence of this frame and highlights the interplay between positive and negative associations.

Governance and accountability sub-frame

Within the social and political acceptability frame, the governance and accountability sub-frame presents a more balanced perspective, with stakeholders expressing both positive and

negative views (Table 8). Positive aspects included the establishment of governance structures and accountability mechanisms, which are seen as critical to overcome previous bottlenecks in carbon farming adoption. The primary stakeholders emphasising these included businesses leading initiatives and carbon farming platforms (50%), validation and verification businesses (12%), agribusinesses and -traders (11%), and government and policymakers (9%). For instance, Bayer (2022) highlighted the necessity of a "trustworthy governance structure" for high-quality carbon removals. TÜV Association (2023) advocated for European accreditation as a means of demonstrating competence, emphasising the importance of independence.

However, some stakeholders voiced concerns about the complexity of governance systems or potential gaps in accountability that could hinder the effective implementation of carbon farming initiatives. This group included mainly businesses leading initiatives and carbon farming platforms (29%), environmental organisations and associations (17%), and academia (15%). The agribusiness VKS (2023) highlighted concerns that the proposal lacked differentiation between various carbon removal activities and stressed the importance of stakeholder participation. Furthermore, the risk of double counting due to a lack of legal structures is pointed out (Özdemir, 2022; WWF, 2022). The German Farmers' Association expressed dissatisfaction with the lack of certification or remuneration frameworks in Germany, emphasising the need for acceleration (DBV, 2021).

Respondents focused primarily on the perceived challenges that the governance of certificates would bring, with the view that the "legal issues involved are absolutely not clear" (Respondent RF2). Power and bureaucracy were cited as challenges (Respondent RF1), as well as the problem of regulating data registries and funding streams to avoid double counting or double funding (Respondents C3, F3, FE1, G1, RF1, RF2, RF3). The problem of the lack of unregulated space in relation to the issue of competition for space and additionality was also mentioned (Respondents A1, G2), as well as the pending clarification of the appropriateness of selected market mechanisms (Respondent A1).

Social sub-frame

Within the social sub-frame, stakeholder expressed both positive and negative sentiments with a slight tendency towards highlighting positive aspects (Table 8). The primary stakeholders emphasising those included businesses leading initiatives and carbon farming platforms (55%), agribusinesses and -traders (13%), and conventional farmers' associations (7%). Respective statements focused on creating the right market incentives and ensuring market stabilisation. Bayer (2021) underscored the importance of high-quality removals for building trust in carbon farming. They also suggested the creation of an incentive scheme based on "tradable land mitigation units generated through a transparent, safeguards-oriented process" to incentivise farmers (Bayer, 2022). The role of independent entities to "reinforce the trust of market actors" and preventing greenwashing was emphasised by TÜV (2022). Furthermore, the German Farmers' Association (DBV, 2022) highlighted the importance of food security, arguing that a broad spectrum of measures should be considered

to ensure it, without excluding any options. Furthermore, Indigo (2020) noted that these measures build trust among international corporations purchasing carbon certificates and paying farmers.

In contrast, stakeholders such as businesses leading initiatives and carbon farming platforms (23%), academia (21%), and environmental organisations and associations (10%) voiced concerns. Bayer (2021) warned against the variety of existing frameworks, which could erode confidence in reported carbon removal activities. TÜV (2022) highlighted the risks of an "overly simplistic certification framework (…) of miscalculations, greenwashing and loss of trust in the system by economic operators and consumers". The think tank PCR (2023) criticised the framework for failing to build trust, clarity, and transparency in certification based on scientifically sound measurements.

In contrast to the slight positive inclination in the document analysis, the respondents in the interviews tended to emphasise negative aspects within the social sub-frame. The legitimacy of the use of certificates was questioned (Respondents F1, E2) and where the demand for them comes from (Respondent I2). Regarding public acceptance of carbon farming, respondents also took a negative stance. Several respondents indicated that they perceive academic actors to be critical of result-based financing of carbon farming for climate change mitigation, especially in the form of certificates (Respondents A2, A3, AB1, C1, C2, C3, F2, FE1, G1, I1, RF2), with RF3 considering that some academic actors also speak positively but remain vague and "give the most politically correct answer possible so as not to offend anyone". Furthermore, respondents indicated that public opinion has deteriorated over the years (Respondents A2, C3, F2) and that there will be little acceptance in the future (Respondent F1). In addition, trust was mentioned as a crucial aspect of the framework and critical for the provision of these solutions (Respondent E1) but can also be strengthened by creating such a framework (Respondent C1).

Morality sub-frame

In contrast to the predominantly positive tendencies in the social and political acceptability frame, the morality sub-frame featured only stakeholders who voiced negative sentiments (Table 8), including environmental organisations and associations (19%), conventional farmer' associations (12%), government and policymakers (11%), academia (11%), businesses leading initiatives and carbon farming platforms (9%), foundations (8%), ecological farmers' associations (7%), regenerative or conservative agriculture (6%), and consultancies and advisors (5%). WWF et al. (2022) expressed concerns about the potential offsetting of fossil fuel emissions with short-term carbon sequestration, and BUND (Friends of the Earth Germany, 2023) worried about the lack of clarity regarding the use of associated allowances. The German Farmers' Association (DBV, 2023) strongly opposed the use of carbon farming to compensate for emissions from other sectors. The Federal Minister for Food and Agriculture Özdemir (2022) asserted that land use should not be leveraged to offset emissions, and BLEM (2022) emphasised the importance of not allowing industries to sidestep their own climate commitments.

This was confirmed by the interview results, with respondents citing a greenwashing risk (F1, FE1, RF3) and mitigation deterrence hazard (Respondents A1, E2, FE1, N1, RF1, RF2, RF3).

Responsible Development Frame

In the field of carbon farming, the responsible development frame takes a central role as it puts a spotlight on the ethical and environmental sustainability dimensions of this evolving concept. This frame comprises three sub-frames. The frame was with 17% of the statements coded significantly less represented in the content analysis than the other two frames (Table 8). The general sentiment of this frame tended to highlight more positives than negatives, however, the nuanced perspectives in the sub-frames are important to acknowledge.

Environmental and Ecological Sub-frame

Statements within the environmental and ecological sub-frame primarily concentrate on the potential benefits that carbon farming can bring to the environment. This resulted in a clear tendency towards emphasising positive aspects within this frame (Table 8). Stakeholders who emphasised these positives were primarily business leading initiatives and carbon farming platforms (42%) and agribusinesses and -trader (12%). Arla (2021) highlighted the creation of co-benefits such as improving "soil health, carbon sequestration, biodiversity and other ecosystem services on owner farms". Further, the conservative farmer's association GKB (2021) emphasised the multifaceted benefits of humus, stabilising soil, enhancing water absorption, and rendering nutrients accessible, all contributing to overall agricultural sustainability.

Notably, concerns within the environmental and ecological sub-frame are very limited and were only voiced by businesses leading initiatives. They "urge caution for including overly optimistic language regarding the economic valuation of (…) co-benefits", particularly those associated with biodiversity and further highlighted that while "economic value for operators might be [a potential outcome], it is not guaranteed" (Bayer, 2023). Finally, they cautioned against an overly simplistic certification framework, emphasising that "synergies and trade-offs and synergies between different sustainability objectives" cannot be excluded (Bayer, 2023).

The interview results showed primarily positive segments, highlighting climate adaptation and environmental co-benefits (Respondents F3, N1, RF2). Respondent A3 additionally warned against trading certificates if the promotion of carbon farming is at the expense of the environment.

Equity sub-frame

Compared to all other frames, this sub-frame was identified the least in the content analysis. It was identified only twice and both times negatively (Table 8). Environmental organisations and associations, along with information and communication networks, raised concerns within the equity sub-frame. WWF (2023) asserted that the framework overlooks "any social safeguards, such as land rights that are commonly under attack when land and its

characteristics are turned into an asset, in this case carbon credits". The global human rights organisation FIAN (2022) also expresses unease about carbon farming turning agriculture land into tradable assets, potentially exacerbating commercialisation in agriculture. This was confirmed by the results of the interviews, where several respondents pointed out the potential risk of land grabbing (Respondents E2, FE1, I1, N1, RF1), and confirm that this is currently not an issue in Germany specifically for carbon farming and has therefore not really been addressed (Respondents E2, I1).

Justice sub-frame

The justice sub-frame scrutinises issues of fairness and justice in the context of carbon farming. This sub-frame has been less frequently held by stakeholders compared to most other frames and encompassing sub-frames and tended to emphasise more negative than positive aspects (Table 8).

Stakeholders emphasising positive aspects included businesses leading initiatives and carbon farming platforms (85%), financiers and investors (7%), and conventional farmers associations (4%). For instance, Bayer (2023) highlighted how "a harmonised standardised baseline offers opportunities to reward front runners while at the same time incentivising the ones that are behind to catch up". Arla (2023) underscored recognising "the farmers that have already been proactive with their grassland and soil management" within any policy development, while the financial institution AGCO Finance (2022) highlighted the potential for increasing yield sustainability while leaving a sustainable legacy of future generations.

Conversely, concerns within the justice sub-frame were expressed by academia, business-leading initiatives and carbon farming platforms, government and policymakers, conventional farmers' associations, environmental groups and associations, foundations, consultancies and advisors, ecological farmers' associations, and regenerative or conservation agriculture platforms, all ranging between 12% and 8% of the share in the total statements of the frame. Their apprehensions revolved around the regulatory challenges of addressing additionality and permanence while ensuring fairness, seeing that the "current carbon credits market design punish[es] the leaders by not being able to reward them for the practices of the past (Climate Farmers, 2022). The Thünen Institute (2021) pointed out that carbon certificates could potentially favour farms that have neglected their soils and disadvantage those that have maintained good soil health. Finally, the lack of legal security for farmers is stressed (WWF, 2021).

In interviews, the issue of justice was frequently raised, primarily with negative connotations. Several respondents highlighted concerns about liability, with farmers potentially bearing the risk if soil carbon targets were not met (Respondents A1, E2, F1, F2, F3, FE2, G1, I1, N2, RF1, RF2). While respondent FE1 indicated in this context that outcome-based schemes are usually low-risk, as either additional income is generated through compensation or no compensation is paid, respondent N2 still saw a risk, as farmers usually bear at least the costs of measurements. However, they do not consider this a major point of discussion so far.

Most respondents confirmed the document analysis results and discussed the disadvantage pioneers may face, particularly regenerative or ecological farmers already employing respective measures (Respondents A1, E1, E2, F1, FE1, FE2, G1, G2, I1, N1, N2, RF1, RF2, RF3). However, some respondents noted that fairness in terms of potential improvement was rarely seen as unusual in the context of payment-based systems (Respondents A2, C3). Positive justice aspects were mentioned by carbon farming platform representatives, focusing on improved farmer image and financial support for sustainable practices (Respondent C2). Respondent C3 suggested that the focus could shift from certificates to product sales and potential knowledge transfer options.

Respondent N2 highlighted unfair aspects of farmers' potential to achieve the targeted increase in soil organic carbon based on their soil properties. Finally, the composition of the expert committee responsible for advising on the establishment of the carbon certification framework was addressed, pointing to a potentially unfair and inequitable selection process (G1).

Table 8 provides an overview of the positive and negative aspects that were mostly highlighted in the respective statements illustrating the frames.

Table 8

Identified Frames Including Sub-frames and Examples Highlighting Positives/Benefits and Negatives/Risks

Main frame	Example highlighting positives	Example highlighting negatives
	Techno-Economic	
Economic	Business opportunities; Higher yields; low costs	Costs of monitoring, verifying, reporting; loss of yield; Costs of technologies
Innovation	Potential to mitigate climate change	Lack of potential, technical skills and knowledge to mitigate climate with carbon farming
Technical	New effective measurement methodologies and robust standards	Scientific uncertainty about measurement methodologies; unreliability; lack of testing; incompatibility with existing technologies
	Social and political acceptability	
Governance	Positive authority enables harmonisation of framework	Issues of power and political feasibility, legal structures, regulatory procedures
Social	Needed for food security; positive resilience effects; right market incentives	Wrong market incentives and mistrust among stakeholders
Moral Hazard	/	Delays mitigation action and efforts
	Responsible development	
Environment / Ecological	Highlights environmental and ecological co-benefits	Potential land use conflicts impacting food security and biodiversity conservation
Equity	/	Risk of displacement of land use change or land grabbing

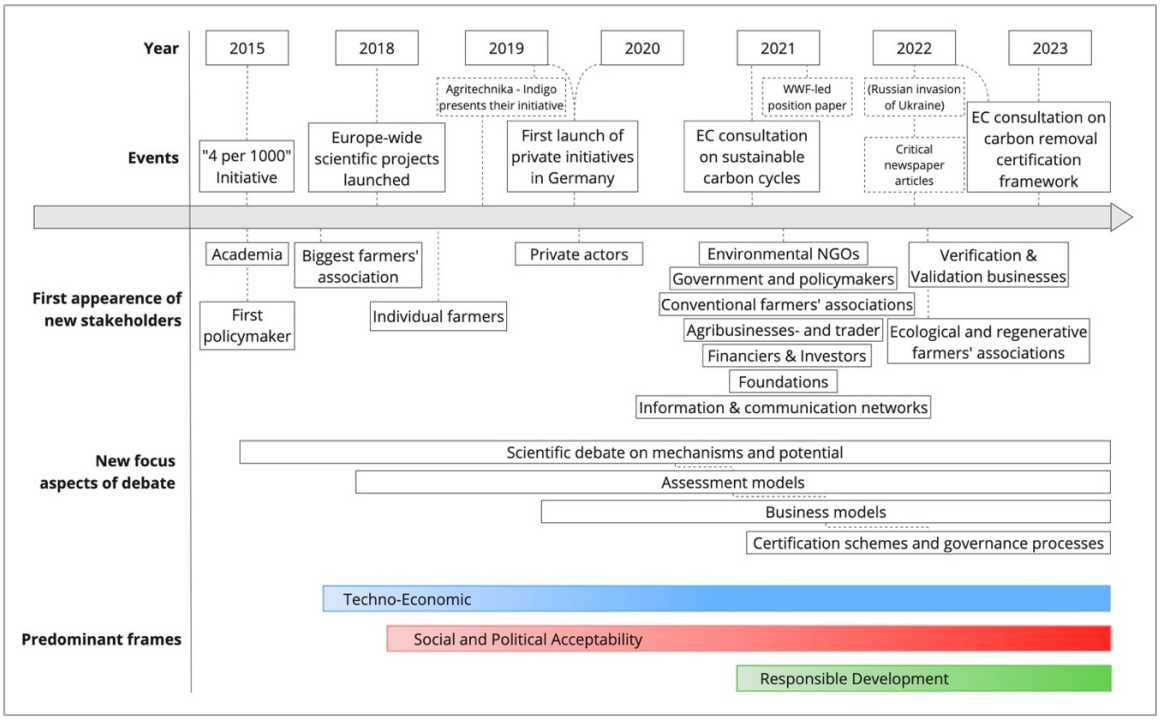
Justice	Farmers will be financially supported for practices that some already do	Unjust for pioneers and issue of liability

4.1.4 Development of frames

This chapter delves into the evolving frames that have shaped the debate on carbon farming, offering a comprehensive perspective on the changing landscape of carbon farming in Germany. The analysis focuses on examining how the three main frames: the techno-economic, the social and political acceptability, and the responsible development frame have evolved. The analysis is grounded in both content analysis and interview findings, providing valuable insights into the dynamics of the carbon farming debate. Figure 5 offers a graphical visualisation of the development of the carbon farming debate, incorporating historical events, shifts in the stakeholder landscape, changes in focus aspects, and emergence und consolidation of the main frames.

Figure 5

Development of the Debate Including Key Events, Changes in the Landscape of Stakeholders, Focus Aspects of the Debate, and Frames (own depiction)

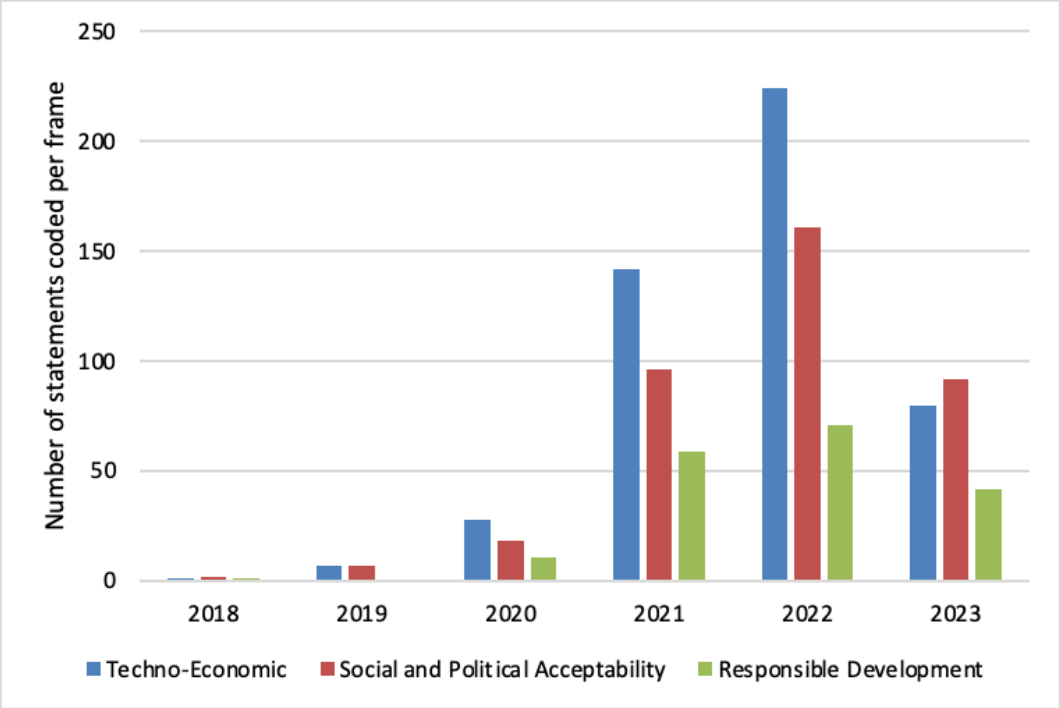


Note. The colour gradient in the representation of the predominant frames shows their increasing presence.

Figure 6 complements the analysis by presenting the quantitative aspects of frame development. This diagram outlines the yearly distribution of the frames and enables a more precise tracking of the development of these frames.

Figure 6

Number of Frames per Year (own depiction)



Note. The frequency is the number of coded statements in NVivo in which the respective frame was detected. The frequency of statements coded per frame does not reflect the entire year, as no new documents were included after 15 June 2023.

Drawing on Figures 5 and 6, the development of the debate and its associated frames is outlined in chronological order based on the documents reviewed and interviews conducted. The main frames were considered individually to gain the greatest possible understanding of the connections between the development of the debate, the contextual factors, and the evolvement of the individual main frames.

A more detailed representation of the dynamics of the stakeholder frames based on the results of the document analysis can be seen in two figures in Figure C1 and Figure C2 in the Appendices. Figure C1 (Stakeholder Dynamics per Year) supports the claims made in Figure 5 and in the following examination of the historical debate by showing how the presence of stakeholder groups has evolved over time. It indicates which stakeholder groups were represented in the public debate to varying degrees in the different years. Figure C2 (Frame Development from a Stakeholder Perspective) provides an alternative perspective on frame development, based on the number of coded frames per stakeholder group instead of coded statements. It suggests, for example, that the responsible development frame has become much more prevalent than Figure 6 might indicates, as it is addressed by a broad range of stakeholders. Despite this, however, Figure 6 shows that the other two frames have strongly dominated, at least until 2022, as they were most frequently addressed in the coded

statements. This change in perspective complements the quantitative analysis by showing the range of stakeholders using the frames.

Techno-Economic frame

Emergence and early debates (2016-2020)

The debate on carbon farming in German only gained significant traction after the introduction of the "4 per 1000" initiative in the time of the Paris Agreement in 2015 (Respondents A1, A2, C1, E1, F3). This initiative aimed to explore strategies for carbon storage in response to the threat of overshooting emissions targets. Following, the techno-economic frame made its initial appearance in the public debate in 2018 and 2019 (Figure 6). However, by not including additional academic articles in the content analysis, prior appearances of the frame were only indicated by the respondents. This phase primarily featured scientific debates on the potential of soil carbon sequestration and technical aspects, with research institutes and policymakers leading discussions on the feasibility in the German context (Respondent A1, A2, E1, F3, N1), as well as German stakeholders participating in pan-European projects exploring carbon farming methods around 2018/19 (Respondents AB1, N1; Table 5). The German Farmers' Association (DBV) also became involved, showing interest from 2016 onwards and then working together with the research institute to get a picture of the storage potentials and forecasts from 2017/2018 onwards (Respondent F3). Around 2018, research institutes were commissioned in the context of the Green Deal and Farm to Fork strategy to write a technical guidance handbook on carbon farming to provide initial definitions and exploring result-based payment schemes (Respondent A3).

The potential of carbon sequestration in mineral soils in agricultural was initially considered to be relatively high, capable of offsetting a significant quantity of emissions (Respondent A2). However, with the publication of a well-known critical study of the 'BonaRes' initiative in 2020 and further critical voices from the scientific community, the initial enthusiasm gradually waned (Respondents E1, F1, I1). This led to a deceleration of the debate, even among policymakers who initially saw carbon farming "as a fantastic topic [, where] suddenly agriculture wasn't just the scapegoat [anymore]" (Respondent A1). This initial shift is indicative of the complexity of the techno-economic frame.

Private sector influence (2019-2020)

Significant changes occurred in the years 2019 and 2020, as companies operating within the food industry and other "private actors [were] actively seeking ways to achieve their corporate climate neutrality goals" (Respondent A1). The emergence of private initiatives, marked by the entrance of the US-based company 'Indigo Agriculture Europe GmbH' in the European and German market, underscored the growing private sector influence within the debate (Respondent RF3). In 2019, the company emerged as a vocal advocate of carbon farming, stressing its importance and relevance within the broader sustainability agenda. In particular, the company opened to the German market and introduced their carbon farming scheme as an exhibitor at "Agritechnica" 2019, a trade fair for agricultural machinery, which

was perceived by some respondents as the first contact with carbon farming as a potential business model (N1, RF2). From 2019/20 and in subsequent years, other private initiatives emerged in Germany with the aim of marketing sequestered soil carbon and experienced initial enthusiasm (Respondents A1, A2, AB1, C1, C2, C3, G1, I1, RF1, RF2).

European Commission's involvement (2019-2022)

The European Commission played a pivotal role in promoting the techno-economic frame within the European Union, which also has to do with the fact that the banking and financial sector requested this to invest in sustainable agricultural practices and to create market-based incentives for carbon sequestration (Respondent I1). In 2019, to advance the debate on carbon farming, it held a roundtable discussion aiming to provide guidance on result-based carbon farming schemes in Europe. In 2020, a significant milestone occurred with the presentation of findings from a study on the operationalisation of an EU Carbon Farming Initiative. This marked a critical step in defining the framework for carbon removal certifications across the EU. These were carried out and led in collaboration with the research institute Ecologic, and European offices. The frame brought from the European Commission was techno-economic focused and aimed at adopting result-based schemes.

In 2021, the European Commission initiated a public consultation process aimed at exploring sustainable carbon cycles and formulating a unified framework for carbon removal certification in 2022. This led to the financing of soil organic carbon sequestration being brought into focus and the debate really taking off, with a significant increase in attention, a variety of opinions being expressed, and several information events being held from different sides (Respondents C1, C3, E2, F2, I1, RF2 FE1). According to respondent C1, there was a notable shift in the nature of the debate during this period. They perceived it as becoming increasingly academic, particularly with the introduction of the EU Commission's regulatory proposals and discussions revolving around data.

Social and political acceptability frame

Emergence (2018-2019)

The social and political acceptance frame began its journey also around 2018/19 (Figure 6). Initial debates centred around the feasibility and acceptability of carbon farming initiatives. Research institutes were commissioned to formulate technical guidance for result-based carbon farming payments schemes, which also introduced social and governance aspects, including the creation of definitions of what is to be understood and included under carbon farming (Respondent A3). Policymakers and research institutes were key actors during this phase (Figure C1).

Policy shifts and EU Certification Framework (2021-2022)

In 2021, significant policy shifts occurred. One the one hand, Germany committed to reducing emissions from land use by 25 million tonnes by the year 2030. This commitment signalled the governments' heightened dedication to carbon sequestration efforts. One the other

hand, the European Commission initiated the public consultation processes. This marked a notable development and uptake of the social and political acceptability frame (Figure 6), signifying increased government commitment to carbon sequestration efforts. Several respondents noted that this has brought academic and regulatory dimensions to the forefront of the debate (Respondents A1, A2, C1, E2, RF3). They emphasised the increasing complexity of addressing private initiatives and the assessment of certificates, leading to a more political and governance-oriented debate. Respondent A2 took this even further, saying: “The point of contention in the current debate is not even about the methods used in this field, but mainly the question of which governance instruments can generate this climate impact”.

Russian Invasion of Ukraine (2022)

With Russia's invasion of Ukraine in 2022, the focus was temporarily shifted towards production security and related issues, according to respondent F1, who further reported that the previous level of attention has not been regained even in 2023.

Impact of Recent Newspaper Articles (2022)

In 2022, critical newspapers articles were published about scientific uncertainties and regulatory concerns regarding carbon removal credits. These articles prompted a shift in public sentiment and social acceptance, impacting the willingness of companies to buy offset certificates (Respondent A1, A2, AB1, C1, C2, C3, F2). The initial enthusiasm that carbon farming platforms felt from farmers and certificate buyers when they entered the market, has, in their opinion, subsided, especially in 2022 (Respondents C1, C3).

Responsible development frame

Before carbon farming emerged as a political business model, there were already grassroots initiatives focusing on enhancing soil organic matter. Not all of them had the original goal of marketing the sequestered carbon but addressed holistic aspects around soil organic matter and soil organic carbon with a focus on climate change adaptation (Respondent I1). An Austrian eco-region initiative (Ökoregion Kaindorf) was mentioned by several respondents as example for German initiatives (Respondents A1, C3, F1, I1, N1).

Emergence and Expansion (2018-2023)

While the responsible development frame started to gain prominence in the carbon farming debate around 2020, aspects of it were discussed before, starting with 2018, which was a particularly dry year (Respondent FE2), who further reported that farmers and other stakeholders in the agricultural sector have since become more interested in climate adaptation and land preparation for climate change. The expansion of this frame continued from 2020 to 2023, as shown in Figure 6. This period was marked by the emergence of private initiatives in Germany around 2020 and in the following years, also partly aimed at improving soil health and selling stored carbon, driving the debate without waiting for policy developments (Respondents A1, RF1). This has also led to the burgeoning interest of regenerative agriculture associations around 2021 (Respondent RF1).

Environmental Organisations' Position (2021)

In November 2021, over 30 organisations and associations, led by WWF, published a joint "Position statement on soil carbon sequestration and its possible remuneration through CO2 certificates". This represented an important development in the responsible development frame and triggered broader discussions on environmental issues (Respondents C1, C3, E2, F2, FE2, I1, RF2, RF3). The joint statement attracted the attention of various environmental NGOs and farmers' associations. The sheer number of signatories surprised even the original authors: "a few people came along for this paper who had never previously taken part in the discussion, whereas we have discussed it for 10 years on a higher level" (Respondent RF2). Remarkably, the paper surprised the carbon farming platforms with a rather negative attitude. The signatories took a clear position on the paper that differed from their previous expectations based on previous discussions (Respondents C1).

Policy shifts and EC Certification Framework (2021-2022)

This development coincided with the EC's public consultation process, which for the first time attracted the attention of organic farming organisations (Respondent FE1). This was a notable milestone in the debate, signalling increased engagement of key stakeholders in the context of responsible development. Environmental organisations also became more involved (Respondent A3). Respondent E2 argued that many environmental organisations had not looked at the issue in depth before, but with the proposal came the need to take a stand. Several respondents felt that this led to a wide range of stakeholders taking a stand (Respondent RF3). In addition, the justice strand of the process came to the fore, focusing on the disadvantage of the pioneers of results-based funding and criticising the composition of the expert group convened during the proposal phase of the European Commission's framework (Respondents E2, G1).

Focus on ecosystem services (2023)

Stakeholders noted that the focus has shifted from initial pure carbon sequestration to value creation based on biodiversity or other agricultural ecosystem services (Respondents FE2, G2, RF3). This was confirmed by carbon farming platforms, which noted a greater demand from farmers and businesses for ecosystem services to be represented. As a result, they introduced more holistic systems in which they calculate them (Respondent C2).

Conclusion

The chapter showed the dynamic evolution of frames in the carbon farming debate from 2018 to 2023. These frames have shaped understanding and impacted the roles and positions of different stakeholders. The intertwined evolution of techno-economic, social and political acceptance and responsible development frames underlines the complexity of carbon farming in relation to climate change mitigation and sustainable agriculture goals in Germany.

4.2 Navigating Diverse Views: Implications of Stakeholder Frames

This section looks at the multiple implications arising from the different frames held by the stakeholders involved in the public debate on carbon farming in Germany to address the second sub-question. The implications identified in the theory can influence **stakeholder collaboration and conflict**, **discourse and policy agenda setting**, and **influence stakeholder discussions**. Furthermore, the complex interplay of frames and implications draws attention to factors such as historical events, mistrust and scepticism.

While different frames do not necessarily lead to polarising divisions, they do underline the major challenge of finding common ground amidst diverging positions and interests. Cross-frame dynamics highlight the difficulty of finding consensus, especially on an issue as complex as carbon farming. Therefore, to discuss the resulting implications, the conflicts and commonalities between the stakeholder frames are first elaborated.

4.2.1 Conflict and commonality among frames

In the realm of carbon farming, stakeholders placed different emphasis on certain risks and concerns and had varying views on appropriate solutions (Respondents A3, FE2). This is not atypical in scenarios with multiple stakeholder groups, which is also reflected in findings from Dewulf et al. (2011), who proposed that expert and laypeople frames usually differ greatly. However, some respondents emphasised that the different interests harbour a considerable potential for conflict (Respondents A3, C3, F1, F3, FE2, G2, N2). These conflicts not only emerged between stakeholder groups but also within them (Respondents A3, N2), leading to the perception that private sector actors might primarily be guided by lawsuits, given their financial interests and limited interest in a harmonisation process (Respondent E2). In addition to the different priorities and interests expressed by stakeholders, interview participants pointed to other underlying issues that lead to disagreements and tensions between stakeholders.

Concept of carbon farming: Respondents perceived that the concept of carbon farming remains subject to interpretation, increasing the risk of misuse (Respondent E1) and disagreement on what should be included in the certification framework. Stakeholders even debated whether preserving and sequestering organic carbon in agriculture is mandated by the Federal Soil Protection Act and whether it should be introduced as a new business model in the first place (Respondent E2). These interpretational discrepancies fuelled potential conflicts in the debate.

Intertwined political disputes and scientific controversies: Conflicts extended beyond stakeholder groups, encompassing differences in opinions at international and expert levels. Political disputes and scientific controversies intertwined, particularly regarding soil carbon sequestration, resulting in challenges to reaching a consensus on effective approaches (Respondent G2) and on perceptions of which agricultural methods should be included in the certification framework (Respondents G2, I1). Respondent F1 stated they perceived the appropriateness of sustainable agricultural practices as a matter of beliefs, introducing

uncertainty among farmers and highlighting their perceived scientific knowledge gaps in implementing carbon farming (Respondent RF3).

Purpose of the EC's certification framework: Furthermore, disagreements surfaced regarding the primary purpose of the European Commission's certification framework, with some viewing it as a future mechanism for creating tradable certificates and others as a tool to counter the proliferation of carbon farming activities on the voluntary market (Respondent G2). Diverse interpretations could potentially alter stakeholder frames and their implications for the overall debate.

Technical vs. agricultural debate: Conflicts within the technical and agricultural aspects of the debate arose, such as the differentiation between emissions reductions and removals within the certification framework. In his debate, the question was raised whether they should be distinguished (Respondent A3) or whether such a distinction would be technically challenging because "the heading comes from the technical domain and cannot be applied to agriculture in this way. (…) We use indicators, where data are observed and measured, and it can't be clearly separated" (Respondent FE2). Similarly, within environmental organisations, while respondent E2 argued that there is agreement on many inherent issues of the certification framework, they perceived opinions on the differentiation between carbon reduction and removal as diverse.

Commonality between frames: Amidst the diversity of stakeholder frames and the potential for conflict, there are also opportunities for collaboration and consensus-building. While stakeholders within each frame often prioritised distinct aspects and concerns, they also recognised shared interests and principles that can serve as a basis for cooperation. One notably commonality is the recognition of the benefits of soil health and increased soil organic carbon level within the natural carbon cycle (Respondents N1, RF2). This shared recognition can serve as a starting point for collaboration and consensus-building, that transcends the boundaries of individual frames. Other commonalities are diverse such as an interest in jointly developing a business models based on a shared understanding of the techno-economic requirements and perceived benefits (Respondent C3), capacity building with other partners (Respondent N1), or sharing their understanding of the techno-economic and governance requirements and taking that as a basis for collaboration to develop their own validation and verification standard (Respondent AB1).

4.2.2 Dynamics and complexities of stakeholder interactions

This section explores the intricate complexities of stakeholder interactions and highlights the challenges and opportunities that arise from stakeholder dynamics.

Perceptions and mistrust as sources of conflict potential

Mistrust/scepticism: Mistrust or scepticism, predominantly expressed in the relation from farmers towards politics, have been central to the discourse (Respondents A1, E1, F3, FE2, RF3). It was highlighted that such scepticism stems not only from practical concerns but also

from past experiences, notably with the Common Agricultural Policy (CAP), where they perceived initially voluntary measures later evolving into mandatory ones without additional compensation (Respondent A1). In line with the theoretical concept of mistrust (Dapilah et al., 2021; Gamson, 1992), these historical conflicts and this mistrust towards policymakers has fuelled apprehensions and contributed to farmers' hesitance in embracing carbon farming, preferring to wait for a clear legal situation (Respondents A1, RF3).

The lack of trust towards politicians is echoed by Rtespondent E1, who further reported a general lack of trust of the society in politics: "creating a model and involving society in it is a big challenge. The trust to do so is lacking in politics, but it is urgently needed to provide real solutions".

Additionally, scepticism within the organic sector is unanimously perceived, pointing on the one hand to site-specific constraints and various agricultural and environmental factors influencing success, and on the other hand to the disadvantage their farmers would encounter as pioneers, as they usually have an average humus content (interviewee FE1), which aligns with the view of respondent C2, who is a representative of a carbon farming platform, who mentioned that their target audience is primarily conventional farmers, as organic or regenerative farmers already have high soil carbon levels, which goes against the principle of additionality in their carbon farming scheme.

Moreover, the possibility of individual farmers having to demonstrate emissions reduction and carbon sequestration efforts in the future, when selling their climate performance to other industries now could jeopardise their ability to meet future targets, reinforced apprehensions (Respondent FE2).

It's worth noting that the critical newspaper articles in 2022 extended the mistrust beyond farmers, reaching the public and companies regarding the credibility and effectiveness of carbon offset schemes (Respondent A1). This observation is in line with Cox et al. (2020), who discussed the implications of a lack of trust in that it not only impedes cooperation but can also lead to stakeholders attributing responsibility to others or accusing them. In this context, some expressed concerns that farmers might deliberately degrade humus before initiating the carbon farming procedures, or that companies may engage in greenwashing (Respondents A3, F1, FE1).

Perceptions of start-ups: Start-ups face challenges when collaborating with established entities such as Nestlé, with the perception that they are primarily profit-driven further complicating stakeholder collaboration (Respondent C3). Furthermore, the emphasis on "start-ups from Berlin" (Respondent RF2) as the driving force in an agricultural debate adds a unique dimension to the stakeholder dynamic.

Challenges in the political arena: Respondent RF1 further pointed out that the political will to support carbon farming is regarded as politically sensitive, adding complexity to navigating political landscapes and finding allies for carbon farming initiatives, mentioning the unique position of one political party (the AFD) that has expressed an interest in advancing carbon

farming. Inconsistencies in political stances, both within and among state governments and ministries, further add to the intricacies (Respondents E1, G2). Respondent E1 further stressed the need for clear goals and decisions on policy instruments, expressing concerns about the lack of a clear position from the federal government and attributes this to technical discussions within the ministries, because of the experts who doubt the effectiveness of soil carbon sequestration in relation to certificate trading.

Challenges in agricultural attitudes: Farmers' caution is further attributed to concerns about global market conditions, the gap between production standards and world market prices, and the lack of concrete implementation plans in agriculture (Respondent F1).

Uncertainty Surrounding CAP Funding: Another significant concern influencing the debate is the uncertainty surrounding the funding of the Common Agricultural Policy (CAP). Respondent G1, a policymaker, highlighted this issue, noting the ongoing discussions regarding the extent to which CAP funding could already cover aspects of carbon farming and carbon certificates. Similar concerns were echoed by respondent C3, who emphasized that this uncertainty could lead to challenges for carbon farming schemes to avoid double funding. The ambiguity arises from the fact that carbon farming initiatives may need to operate "on top" of existing funding mechanisms. This uncertainty has persisted, particularly in light of the initial monitoring of CAP funding, which revealed significant challenges and the non-adoption of many measures.

Perceived academic nature of the debate: The notion of the debate as being primarily academic, particularly since the European Commission's proposal, has the potential to generate conflicts. Respondents C1 and N1 observed that the debate occasionally is led in newspapers and magazines demonstrating clear positions. However, there is a perceived scarcity of regular meetings and discussions among different stakeholders, as pointed out by Respondent C1, which can impede stakeholder interactions and consensus building. Additionally, the debate's technical complexity is already seen as a participation barrier, according to Respondent FE2. This sometimes leads to unproductive discussions conducted ad levels that hinder constructive dialogue (Respondents FE1, FE2) and makes it also more difficult to produce position papers (Respondent FE2).

Stakeholder dynamics as sources of cooperation potential

Amidst the complex stakeholder landscape, various shifts are occurring, fostering potential for cooperation and alignment.

Stakeholder united in opposing carbon farming certificate trading and result-based financing: Despite the diversity of emphases within large environmental organisations, reservations against converting the system into a certificate-based one are common (Respondent E1). These reservations may offer common ground for collaborative efforts. A similar united stance was perceived by stakeholders within the organic sector (Respondent FE1). According to respondent RF1, regenerative farming stands out as a possible solution without needing subsidies or carbon certificates, promoting practice that enhance soil health, reduce resource

usage, and maintain or improve yields. They further elaborate on this approach being a sustainable alternative, although its widespread adoption requires education and support for farmers.

Shift of stakeholders to openness and constructive discussions with learning process: A generational shift was mentioned among farmers, leading to greater openness to climate-friendly and regenerative agricultural practices, including carbon farming. Increased interest in soil health and organic matter is evident, driven by factors such as dry years (Respondents C3, FE2, RF2). The interviews revealed significant debates within policymakers at both federal and state levels (Respondents E1, G2). This was supported by respondent G2, who underscored the role of departmental research and varying interests in shaping federal government policies but highlighted a sense of constructive discussion within politics, despite differing viewpoints. Respondent N2 added that the private sector's involvement in carbon farming, particularly through certificate financing methods, could alleviate pressure on subsidy measures and potentially influence policymaker perspectives. Stakeholders within the farming sector seem to largely agree on the importance of accumulating organic matter, including organic carbon. However, an ongoing learning process was mentioned, marking a shift from traditional agricultural policy debates (Respondent F3).

Trust: Trust is emphasised as a critical factor for addressing the broader implications of carbon farming (Respondent E1). This links back to trust being recognised as a fundamental component that underpins stakeholder interactions, influencing their willingness to cooperate and collaborate (Dapilah et al., 2021). Gaining trust in politics is seen as vital to tackling the challenges posed by carbon farming, fostering a sense of unity and cooperation among stakeholders, and is it further argued that the proposed framework would increase the trust among farmers (Respondents E1, C1).

4.2.3 Observed or expected conflicts

Anticipated conflicts: Conflict are expected between or within stakeholder groups, especially regarding the role of private sector actors, as well as different positions between companies seeking to inset and offset their emissions (Respondent A3). Some anticipate conflict between politicians regarding natural sink targets. For instance: "there is no way around a massive expansion of the sinks" (Respondent F2) and "I definitely have serious concerns about the sink targets set by the Federal Climate Protection Act". They further argue that they doubt that "any politician, regardless of the party, will be persuaded to take a step back here, because the climate movement in general will probably hit you in the face about it in the media" (Respondent F3).

Niche topic: Most perceive carbon farming as remaining a niche topic, discussed more actively within specific circles and academic settings and is not experiences a significant uptake (Respondents I1, N2, RF1, RF3). One respondent highlighted, "Carbon farming, as such, is discussed much more within the scene of people who want to offer it rather than in the scenes where it should actually take place" (I1).

Need for constructive dialogue: Stakeholders emphasise the need for constructive debate and dialogue, emphasising the practical experience of farmers and scientists to avoid top-down impositions, as respondent RF2 argued: “If politics simply impose something on you, and that’s what we’re doing now, then I almost think it’s not productive (…) and I believe that it is doomed to failure”.

Early debate: Some respondents caution that the debate is still relatively early (C1, FE1, N2). This early stage might contribute to the limited intensity of opposition or conflict within the organic farming sector, where currently other topics are prioritised and are consuming most resources, as well as a lack of political pressure currently. However, the representative believes “that when this legislative process becomes more concrete, the organic sector will strongly oppose it, because it would be a significant disadvantage, and it’s not productive” (FE1). Respondent N2 offers an interesting perspective by pointing out that the prominence of carbon farming varies among different stakeholders and circles, with it being discussed more intensively in certain academic circles and niches than among farmers. However, according to them, it is gradually gaining interest, particularly in circles where financing options and start-up initiatives play an important role.

These dynamics underscore the evolving nature of the carbon farming debate, where the intensity of opposition or conflict may fluctuate as the discourse matures. This context highlights the significance of considering the current stage of the debate when assessing potential conflicts and challenges arising from frames.

4.2.4 Observed or expected collaborations

The sense of unity and willingness to engage among stakeholders is a prominent feature of the evolving carbon farming debate. Although stakeholders hold distinct perspectives and interests, respondents FE2 and N2 observed a shared commitment to meaningful discussions. They recognised the existence of distinct stakeholder positions but emphasised an overall receptivity to dialogue and collaboration. As respondent N2 put it, “although this is really an area of tension, in the end some really reasonable compromises and solutions were proposed, especially when people never really expected that.” This observation highlights that, in practice, stakeholders exhibit a willingness to explore common ground, even when theoretical implications might suggest strong divides.

Collaborations observed

The collaborative landscape within the carbon farming domain is both diverse and dynamic, as evident in both document analysis and interviews. The document analysis revealed instances of collaboration among stakeholders such as in the publications of shared position papers and the development of carbon farming projects and schemes.

Over the years, a wide range of stakeholders have come together in various collaborations: Academic institutions have actively joined forces to publish joint research articles and position statements (Document analysis - March 2020, October 2020, October 2021, May 2022,

January 2023). In addition, renowned environmental organisations such as WWF, BUND and others have jointly written publications and issued position papers (Document analysis - Nov 2021, Jun 2023). Moreover, farmers' organisations have collaborated with environmental organisations, scientists and experts (Document analysis - Nov 2021, Jun 2023).

Beyond this, projects and programmes related to carbon farming that involved German stakeholders or were relevant in Germany added another layer to this collaborative landscape. While the European Carbon+ Farming Coalition does not exclusively involve German actors, it does involve key stakeholders with carbon farming initiatives from the German agri-businesses, indicating cross-border cooperation in the field of carbon farming. The Carbon Farming Platform 'Klimahumus GmbH' was launched in 2021 as a joint venture between a foundation, an agri-business and a validation and verification company. 'KlimaHumusNetz', another project created in partnership between a research institute, organic and conventional farming associations is an example of cooperation across German stakeholder boundaries.

The findings from interviews with stakeholders further illuminated various collaboration and cooperation efforts. For instance, agri-business stakeholders have explored various business models related to carbon farming in collaboration with private certificate providers, as mentioned by respondent AB1. Respondent F1 pointed out cooperative initiatives between farming associations, research institutes, and academia. Moreover, regular exchanges between ecological farming associations and certificate providers, highlighted by respondent FE2, indicate a high level of interests by carbon farming platforms in involving organic farms. FE2 further noted that the usual exchange between them as an ecological farmers' association primarily occurs with agricultural chambers and foundations. They found it surprising how well the different actors work together, especially considering the different interests between private sector actors and agricultural sector representatives along with advisory services.

Notably, collaboration extended to government and public sector institutions, with information and communication networks providing opportunities for dialogue between scientists and farmers. State ministries have received multiple requests from carbon farming providers regarding support through regional and national policies, as noted by respondent G1. In addition, the 'THeKLa' expert network has been connecting scientists, farmers, and policymakers across Germany in the field of greenhouse gas emissions accounting and climate protection in agriculture for years (Respondents FE2, N1).

These efforts were further reinforced by discussion groups involving nature conservation organisations, ecological farming associations, regenerative farming platforms, academia representatives, and political advisors, organised by entities like WWF, as reported by respondent RF2. Exchanging ideas and knowledge sharing among stakeholders have been integral to this nascent debate. Scientific research played a crucial role in informing decisions and partnerships with research institutions are seen as essential (Respondent C1). However, they also emphasised that the final decision on platform actions rest with the platforms themselves, guided by their objectives and available knowledge. This representative also

pointed out that while companies often approach them directly to enter partnerships, it is more common and valuable to dialogue with associations and organisations. These exchanges are characterised by ongoing enquiry and adaptability, as the debate remains in the early stages of development.

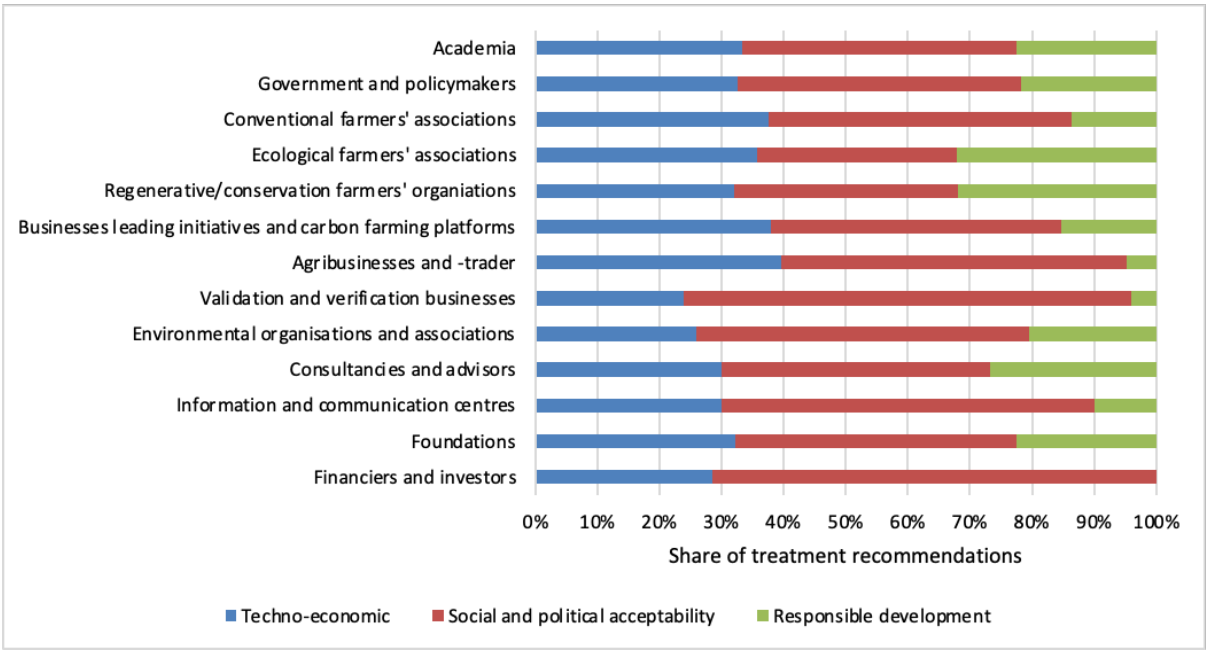
The collaborative efforts observed among stakeholders underscore the significance of achieving common goals and visons in collaborative endeavours, where mutual frames and shared values among stakeholders play a pivotal role (Ansell & Gash, 2007; Buuren, 2009; Dewulf, 2013). In practice, it is evident that stakeholders in the carbon farming domain are actively working towards such shared goals, even in the face of diverse perspectives and interests. This mirrors the unity and willingness to engage, reflecting the practical applicability of these theoretical findings.

4.2.5 Discourse and policy agenda setting

The diversity of stakeholder frames prompted distinct policy treatment recommendations, such as support or opposition to carbon farming as a business model and tradable certificates, the need for awareness building, capacity development, and clear definitions, among others (Respondents A2, E1, E2, F1, FE1, G2, I1, N1, RF1, RF2). The results of the document analysis also revealed treatment recommendations endorsed by stakeholder groups. However, Figure 7 shows that most stakeholder groups adopted treatment recommendations from all three main frames. Therefore, it is not possible to derive direct policy implications from the proposed solutions of the frames alone.

Figure 7

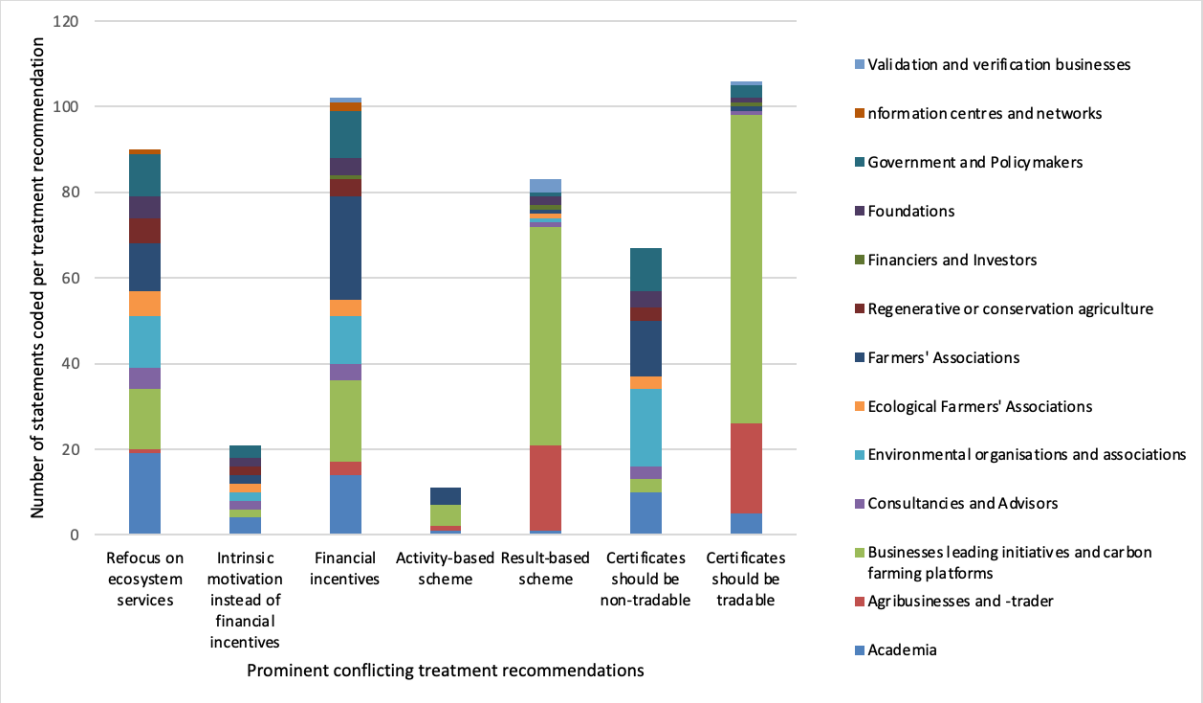
Share of Treatment Recommendations per Main Frame across Stakeholder Groups (own depiction)



However, when examining individual treatment recommendations that contain counter-recommendations, a different picture emerged, illustrated in Figure 8.

Figure 8

Selected Conflicting Treatment Recommendations (own depiction)



Note. The treatment recommendations were selected based on the frequency of occurrence and the presence of a counter-recommendation, resulting in a potential for conflict. These points were also confirmed by the respondents in the interviews.

In examining the diverse stakeholder frames within the realm of carbon farming, several points of contention became evident. One of the most prevalent points of conflict revolves around whether certificates based on soil carbon sequestration should be tradable with other industries (Figure 8), a concern also highlighted by several respondents (A2, E1, E2, F1, FE1, G2, I1, N1, RF2). The issue is predominantly discussed within the social and political acceptability frame. Another significant point of contention centres on the desirability of result-based renumeration systems. Findings from the document analysis show a strong emphasis on the development of result-based systems (Figure 8), with numerous statements further expressing various criticisms but not explicitly rejecting them. Simultaneously, proponents, such as carbon farming platforms, have become actively and vocally involved in the public debate (Figure C1; Respondents FE2, G1). Alongside the EU's focus on the certification framework, which stakeholders anticipate will lead to tradable certificates in a result-based system (Respondent G2), the political focus is perceived to be on these systems.

In the document analysis, only a few voices advocated for alternatives such as activity-based financing of carbon farming (Figure 8). However, during the interviews, it became apparent

that activity-based financing approaches were clearly voiced and preferred by several respondents (Respondents E2, F1, F2, FE1, FE2, G2, N1, N2, RF2). Although Germany exhibits different approaches in the carbon farming system landscape (Carbon Schemes Inventories, n.d.), with most business models being result-based, the country appears to be awaiting EU decisions on this framework and subsequent implementation (Respondents AB2, E2, F3, G1, N1, RF3). Concurrently, it has initiated its own programme[5], primarily aimed at increasing natural carbon sinks through activity-based financing (Respondent G2).

The issue of whether farmers should receive financial incentives has further sparked discussion, with a clear majority supporting some sort of financial incentives to encourage the adoption of appropriate practices, not necessarily limited to climate change mitigation (Figure 8). In contrast, the opposing view, that farmers' intrinsic motivation should be sufficient once socio-ecological benefits become apparent, was expressed only by a few (Figure 8, Respondent RF1). Conversely, many stakeholders have put forth the argument and solution that prioritising ecosystem services over soil carbon sequestration is crucial for climate change adaptation (Figure 8; Respondents A2, AB1, C2, F1, F2, F3, FE1, G2, I1, N1, N2, N3, RF1, RF3). This frame treatment recommendation appears to have had policy implications. For instance, carbon farming platforms noted an increased demand for ecosystem services and a shift away from the notion of carbon certificates, resulting in adjusted promotion that highlights socio-ecological benefits rather than solely focusing on carbon sequestration (Respondents C1, C2, C3, F3).

In analysing the diverse stakeholder frames within the realm of carbon farming, tangible policy implications were identified. Stakeholders' treatment recommendations are deeply influenced and rooted in the complex dynamics between stakeholder groups and their frames. As suggested by Adger et al. (2011) and (Dewulf (2013), frames play a critical role in shaping policy agendas and discourse.

Unlike other researcher who study this link and mostly analyse active framing processes by examining the influence of the media, actors or organisations on farmers' engagement and participation (Kusmanoff et al., 2016; Puttkammer & Grethe, 2015) to demonstrate the actual influence of selected frames, the focus of this study was not on identifying active frames and their impact on people's perceptions. Instead, this study explored for the time being the presence of frames in the public debate that may be held by individuals and organisations but are not necessarily actively used to cause change. Therefore, nothing more tangible can be said about the eventual adoption of carbon farming practices due to the use of a particular frame.

[5] Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK) (BMUV, 2023b).

4.2.6 Influence on stakeholder discussions – dialectic focus

The interplay between frames and events reveals their reciprocal influence, reinforcing the implications associated with these frames (Gamson, 1992). This can be reconciled with the theoretical perspectives that underscore the pivotal role of early frames in shaping discourses and guiding actions (Ellingson, 1995). This statement bears relevance to the ongoing debate on carbon farming, which according to the interviewees is still in its early stages (Respondents C1, FE1, N2).

This observation aligns with a thorough examination of all three frames and their development, as detailed in Section 4.1.4, “Development of the Frames.”

Techno-Economic Frame: The diffusion of the techno-economic frame emerged between 2016 and 2018, following the launch of the “4 per 1000” initiative. The frame began to gain prominence in 2018-2019 with the phase focusing on scientific debates and technical aspects. The subsequent scientific discourse on potential methods and the advent of ground sampling in Germany further shaped this frame (as discussed in Section 4.1.4). In 2018, a research institute was commissioned to produce a technical guide focused on outcome-based procedures (Respondent A3). Shortly after, the entry of private actors into the market in pursuit of successful business models primarily underpinned this technical frame (Respondent A1). The European Commission's consultation phase on sustainable carbon cycles amplified the influence of the techno-economic frame, reinforcing the emphasis on outcome-based measures and the technical underpinnings of carbon farming (Respondents C1, C3, E1, F12, RF2, FE1). The initial optimism about carbon farming’s potential to address emissions targets gradually wanted with the publication of critical studies in 2020 (Respondents E1, F1, I1), illustrating the dialectic relationship between scientific optimism and critical assessments. Despite critical voices, these measures remained central in the public discourse.

Social and political acceptability frame: With the increasing presence of private market actors, considerations regarding the governance of carbon farming practices gained prominence (Respondent A3). This focus was further accentuated by the proposal for a framework at the European Commission, which contributed to a more pronounced emphasis on governance (Respondents A1, A2, C1, E2, RF3). A similar dynamic was observed within the morality sub-framework, especially following last year's newspaper articles (Respondents A1, A2, AB1, C1, C2, C3, F2). These events naturally reignited concerns related to morality and ethics.

Responsible Development Frame: The responsible development frame gained prominence, particularly accompanied by the involvement of environmental organisations in 2021 resulting in the publishment of position papers (Respondents C1, C3, E2, F2, FE2, I1, RF2, RF3 With the bigger prominence, carbon farming schemes are increasingly aligning with this frame and focusing on ecosystem services (Respondent C2, FE2, G2, RF3), thereby shaping the discourse. The evolving strategies promoted by carbon farming platforms has the potential to further shifts in the future.

5. Discussion

The aim of this research was to investigate the prevailing frames of stakeholders engaged in carbon farming on arable land and to understand the potential impact of these frames on stakeholder interactions. A key result was the finding of several diverse, complex, co-existing and sometimes conflicting frames of carbon farming, covering numerous aspects. This complexity in stakeholder understanding and positions highlight their potential implications for policy discussions. Additionally, the study investigated stakeholder dynamics and interactions.

This section discusses main and surprising findings, implications for research and practice, as well as limitations and recommendations for future research.

5.1 Discussion of findings

In response to the first sub-question, which aimed to identify the predominant frames, the results indicate that roughly 46% of all coded statements were associated with the techno-economic frame, with 37% for the social and political acceptability frame and 17% for the responsible development frame (Table 8). Comparing these findings with Rust et al.'s (2021) research, it is interesting to note that their findings similarly indicate that the economic and agronomic dimensions of sustainable agricultural practices were most frequently discussed, emphasising economic sustainability over environmental sustainability. While in this research the responsible development frame may not be mentioned as frequently as the others, it remains a significant consideration among most stakeholders (Figure C2), indicating its presence in their deliberations. Further, considering that soil carbon sequestration is generally framed more positively than other negative emissions technologies, as suggested by Jaschke & Biermann (2022), one might have expected stronger support for agricultural carbon farming. However, the evolving nature of the debate and the variation among stakeholder groups and contexts could influence this.

Notably, both the economic and innovation sub-frames exhibited a strong inclination towards highlighting positive aspects (Table 8). The optimism within the innovation sub-frame was particularly surprising, considering that most respondents perceived a widely accepted lack of potential for carbon farming on arable land to mitigate climate change (Respondents A1, A2, A3, AB1, E2, F1, F3, FE1, FE2, RF1, RF2), while this constitutes the core of the innovation sub-frame highlighting positives. Additionally, there was a notable emphasis on result-based financing schemes in the analysed documents, despite the preferences of many stakeholders for alternative approaches, as noted by respondent RF1. Both findings could be attributed to the belief that result-based financing is inevitable due to preparations by the European Commission in the ongoing debate. Some perceive German stakeholders merely waiting for the certification framework to be in place (Respondents AB2, E2, F2, F3, G1, G2, N1, RF3). Another explanation for the persistence of the result-based financing treatment recommendation comes from frame theory, which suggests that widely recognised frames tend to become institutionalised over time (Gamson, 1992; Schön & Rein, 1994). However,

given the rapid evolution of the debate and the perception that it is still in its formative stages, the institutionalisation of a single frame appears unlikely at this stage.

While addressing the first sub-question regarding the identification of predominant frames among stakeholder groups in section 4.1.3 Prevalence of Frames, the study found that some individual stakeholders, as well as entire stakeholder groups, encompassed all three frames and considered various aspects without focusing on one frame. This was supported by Figure 7, which illustrates that most stakeholder groups advocate treatment recommendations from all three frames. Despite the diversity within and between stakeholder groups (Respondents A3, FE2), it was challenging to pinpoint specific stakeholder groups representing distinct frames. While clear coalitions regarding opposing interest groups associated and specific frames were elusive, clear positioning within frames in the analysed documents, particularly concerning treatment recommendations, was present (Figure 8).

It is worth highlighting that in answering the second sub-question on the implications for stakeholder interactions, it was surprisingly found that expectations based on the conceptual framework underlying the frame theory here did not match experiences in practice. The theory suggests that shared frames facilitate stakeholder cooperation, while fragmented frames are more likely to lead to conflict or misunderstanding (Ansell & Gash, 2007; Buuren, 2009; Dewulf, 2013). Respondents mentioned that real-life discussions did not exhibit the same level of clear positioning as seen in newspaper articles and position papers, which they do, however, also perceive as such. Instead, stakeholders engaged in fruitful and meaningful discussions (Respondents FE2, N2). This is also reflected in the substantial number of diverse forms of collaborations between a wide range of stakeholders reported in section 4.2.4 Observed or expected collaborations. Respondent F3 further describes the debate as a “shared learning process”. Furthermore, the ongoing debate was perceived as being in its early stages (Respondents C1, FE1, N2), where new insights were still emerging and the right path has yet to be found, providing one possible explanation for the willingness of the various stakeholders to cooperate. Another explanation could come from research on belief divergence, where Koebele and Crow (2023) suggest that in early stages of policy processes, there is not yet too much disagreement among most stakeholders, simply because there is still too much scientific uncertainty to date and coalitions have not fully formed.

Finally, the study confirmed the role of contextual factors and the relationship between frame development and events in several contexts.

5.2 Implications for research

This section shifts the focus to a critical reflection on the application of frame theory in understanding the complexities of the carbon farming debate. The application of frame theory has proven invaluable in providing insightful perspectives on the lenses through which stakeholders perceive and communicate about carbon farming. Furthermore, the Entman (1993) framework’s treatment recommendation function has been introduced, offering a

method to delineate tensions between different frames. This application not only reinforces the utility of frame theory but also broadens its applicability.

Examination of frame theory in the context of carbon farming reveals some insights into the prevalence of frames. The risk frame, while an essential component in the broader discourse on climate change (Cox et al., 2018, 2020; Dooley & Kartha, 2018; Huttunen & Hildén, 2015; Porter & Hulme, 2013), appears to be less relevant or predominant in the specific context of carbon farming, at least not in the German debate. This could be due to the unique nature of carbon farming, which involves long-term environmental and economic considerations rather than immediate risks. Scientific uncertainties underling the risk frame in geoengineering debates was integrated in the technical and innovation sub-frames.

Similarly, the equity frame is not widely held or currently emphasised by stakeholders in the debate on carbon farming in Germany. This could be because carbon farming initiatives in Germany are not yet perceived as causing significant displacement or equity problems. However, identifying this frame allows recognising the economic pressures that landowners are under, as mentioned by the respondent FE1. The fear of having to sell land and being in debt to carbon credit holders, mentioned in some interviews, could be a potential equity issue that deserves further investigation. Furthermore, lack of consideration of equity and justice aspects among key decision-makers could lead to unbalanced outcomes and prevent meaningful social change within a debate (Hassenforder et al., 2016).

In conclusion, the application of frame theory has not only provided valuable insights into the various frames shaping the discourse on carbon farming but has also highlighted areas where certain frames may not be as pertinent or where new considerations should be explored. Understanding the nuanced dynamics of frames can contribute to more effective communication and policymaking in the realm of carbon farming (source).

5.3 Implications for practices

The results of this study highlight the complexity of the carbon farming debate in German agriculture, but given the willingness of actors to cooperate, learn together and the lack of polarisation, it can be steered in a direction where there is less conflict and more agreement. Several points can be derived from this study that could be considered to promote implementation with fewer drawbacks and avoid conflicts.

Stakeholders agree that there is an urgent need to support the shift to sustainable agricultural practices, especially in the context of soil organic matter accumulation. However, the debate on carbon farming shows that the current focus on outcome-based incentive mechanisms can lead to conflicts, especially when the goal of climate change mitigation is emphasised. To address certain issues, such as the risk of neglecting ecosystem services, lack of regulations on liability and additionality, and significant knowledge gaps, it is crucial to protect both farmers and the climate by ensuring that efforts towards sustainable agricultural practices are not compromised by uncertain climate change mitigation efforts. Therefore, the focus should be where there is most agreement, and according to the findings, this is the case once

ecosystem services are emphasised and holistic approaches that include environmental and social aspects.

Therefore, the study suggests a move away from results-based financing. While there are some proponents of results-based financing, such as the providers of these measures, as well as those who see the benefits of rewards, a more comprehensive approach is needed. In this context, it is also important to recognise that presenting carbon farming solely as a financial opportunity can lead to negative perceptions and discourage farmers from adopting it, as Fleming et al. (2019) pointed out.

During data collection, almost no one expressed negative perceptions about activity-based schemes, except if it was simply a land set-aside, which would mean a loss of competition for farmers. However, some stakeholders expressed concerns about financing, as it would remove the incentive for companies to pay compensation, and they expressed low perceived demand for products generated through activity-based schemes. However, it was also reported that criticism of carbon credit offset mechanisms has increased since 2022. It is therefore recommended to present activity-based carbon farming as a holistic solution, as most stakeholders agree with this view.

In addition, stakeholders can benefit from communication strategies that counteract potential misconceptions and clearly communicate the social agreements associated with carbon farming practices, as suggested by Bellamy and Raimi (2023). To avoid misunderstandings, it is important to clarify that carbon farming offers less potential for conflict in insetting than in offsetting. Communicating the insetting approach can convey a more proactive and committed attitude towards carbon farming and emphasise the integration of sustainable practices into the core activity.

Finally, the debate is perceived in certain circles as being very academic with a high barrier to entry due to technical complexity. This complexity, as reported in the interviews, leads to ineffective discussions as not all participants have the same level of knowledge and to a shift of attention from some perceived more complex aspects such as additionality and leakage to more familiar concepts such as permanence. To overcome these challenges, more regular awareness-raising campaigns and building capacity can help to ensure a more meaningful debate. In this context, some have complained about a lack of regular meetings. However, as others reported various working groups and meetings, the communication of meetings and other opportunities could be addressed.

By taking these recommendations to heart, stakeholders can contribute to a more holistic and nuanced discussion on carbon farming and ensure that its multiple benefits are properly communicated and understood by all stakeholders.

5.4 Limitations and future research

Although this study provided valuable insights that contribute to the understanding of the impact of frames and the dynamics of stakeholder interactions within the Germany

agricultural carbon farming scene, some limitations need to be addressed, some of which lead to recommendations for future research.

First, the study's data sources, which inadvertently focus on the certification scheme and the Carbon Removal Certification Framework (CRCF) and may overlook the historical evolution of ideas. The exclusion of academic articles and industry publications from the analysis may have limited the depth of perspectives, especially during the 2015-2018 period when the debate mainly involved policy makers and academics. In addition, feedback from international and European umbrella organisations was not taken into account, which may have undervalued certain perspectives from organic farmers' organisations. While these limitations are acknowledged, they provide opportunities for future research to achieve a more comprehensive understanding of the topic.

Second, the use of a single case study design raises concerns about the validity, reliability and external generalisability of the findings (Clark et al., 2021). Concerns about validity were addressed by deliberately diversifying the selection of interview participants and supplementing the data with newspaper articles and public consultation documents from the European Commission. These triangulation efforts provided a solid foundation for the study. Reliability concerns arise from differences in the original purpose of the data sources (Krippendorff 2018, in Clark et al., 2021), such as newspaper articles, which primarily convey information about events and were not created with the intention of identifying frames. However, this reliability problem was mitigated by cross-referencing the identified frames with the interviews. In terms of external generalisability, the analysis shows that the debate on carbon farming in Germany is rather unique and is perceived by stakeholders as cautious and reserved compared to neighbouring countries (Respondents A1, C1, G1).

Factors contributing to this caution include numerous environmental NGOs and research institutes (Respondent A1), as well as the strong environmental lobby (Respondent C1). Respondent G1 noted that this cautious approach reflects the Germans' desire for thorough research before implementing carbon farming initiatives. Respondents also perceived it as a niche topic (I1, N2, RF1, RF3). Despite this cautious approach, German stakeholders actively participated in the European Commission's public consultation on the certification framework proposal, indicating a more engaged role in shaping carbon farming policy (Document analysis). This was echoed by Respondent E2, who also perceives a general critical attitude, but is committed to "preventing the worst". This multi-layered engagement highlights the complex dynamics of the German context within the broader carbon farming landscape. The study also encountered difficulties in providing a comprehensive overview of private carbon farming schemes in Germany, as there is little online information, reflecting the dynamic nature of these schemes.

Lastly, it is essential to address the inherent subjectivity associated with frame identification. Although frame analysis offers valuable insights, it demands a degree of subjectivity in the identification of frames within texts and interviews. Frames can be implicit or multifaceted (de Vreese, 2005), requiring a cautious approach to maintain rigor and objectivity during

interpretation (Borah, 2011; Van Gorp, 2009). Establishing a causal relationship between frames and behaviours, or dissecting frame effects on perceptions and behaviour, remains a complex undertaking due to the multitude of influencing factors beyond the scope of frames.

Drawing upon the constraints of to this study, several recommendations for future research can be formulated. Further research could focus on conducting a comparative frame analysis in different countries to understand how different contexts shape frames and their impact on the carbon farming field. Most useful could be a review of stakeholder frames in other European countries, as the envisaged harmonised certification framework is a European issue and highly topical. This would help to identify similarities and differences and could contribute to generalisable insights into the dynamics of carbon farming frames. Furthermore, the role of active framing efforts in shaping the discourse on carbon farming should be explored. This could lead to the identification of successful frames that bring about meaningful change and encourage collaboration.

Staying with the topic of carbon farming, interesting research could be to compare frames of regenerative agriculture or other climate-friendly agricultural practices with carbon farming frames, as well as including stakeholders who do not actively participate in the public debate as used in this study. For example, individual farmers and stakeholders who attend events but do not appear in newspaper articles. Industry publications could also be included, whose target audience is often different, which could lead to different results than the frames identified in this study.

The results of the study underline the scepticism and reluctance of German stakeholders towards the concept of carbon farming, especially when it comes to quantifying carbon sequestration in combination with results-based financing and carbon credits. This apprehension has led German policymakers to focus on 'natural climate action' (Geden, 2023), exemplified by the recent launch of the Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK) in 2023 (BMUV, 2023b). While this approach prioritises the conservation and development of natural ecosystems, it may not be suitable to promote the adoption of climate-friendly practices among farmers. The president of the German Farmers' Association publicly criticised that this programme does not provide farmers with viable business models for natural climate mitigation, which could affect farmers' competitiveness (Deutscher Bauernverband, 2023). This tension highlights different possible directions for Germany's future approach, including the exploration of business-model and outcome-based financing as envisaged by the EU, as opposed to an activity-based and more tentative approach currently simultaneously pursued in Germany. Further research in the form of frame and position analyses on natural climate action holds significant potential to explore and understand this evolving dynamic.

5.5 Conclusion

This research sought to investigate the prevailing frames held by stakeholders engaged in the public debate on carbon farming in the German agricultural sector and to decipher the potential implications of these frames for stakeholder interactions. This was done by determining the stakeholders, the occurrences and dynamic of frames, and the following implications: Cooperation and conflict, policy agenda setting, and stakeholder discussion.

The application of frame theory has not only provided valuable insights into the lens through which stakeholders perceive and communicate about carbon farming but has also highlighted areas where certain frames may not be as relevant or where new considerations should be made. Understanding the nuanced dynamics of frames can contribute to more effective communication and policy making on carbon farming and ensure that it is aligned with broader sustainability goals.

The findings have shown that despite the diversity of frames within the carbon farming landscape, the level of conflict among stakeholders is relatively low, which can be attributed to the early stage of the debate, the perception of shared learning and the niche status of carbon farming. However, it is important to recognise that carbon farming, although currently perceived as a niche issue, has the potential to become a critical component of sustainable agriculture and climate action in the future. As the field continues to develop and mature, the evolving landscape highlights the need for continued dialogue and collaboration between stakeholders to address the challenges and uncertainties that lie ahead in the complex area of carbon farming in the German agricultural sector.

Furthermore, the study highlights the importance of promoting ecosystem services and holistic approaches that incorporate environmental and social aspects to reduce conflicts associated with result-based incentive mechanisms. It suggests a move away from result-based financing and towards a more comprehensive approach that recognises the multi-faceted nature of carbon farming in agriculture. In addition, effective communication strategies that address potential misunderstandings and highlight the social agreements associated with carbon farming practices can facilitate collaboration and understanding among stakeholders.

Finally, the evolving debate in Germany, characterised by scepticism towards carbon farming and the recent emphasis on ‘natural climate action’ in policy, presents an interesting area of tension to explore. Research that focuses on frame and position analyses related to natural climate action can provide valuable insights into the evolving dynamics of the field and the potential directions for Germany’s future approach.

This research has provided a foundation for understanding the frames and dynamics within the German carbon farming domain and opens the doors for future studies to further explore these complexities and contribute to more informed decision-making and collaborative efforts in the carbon farming field.

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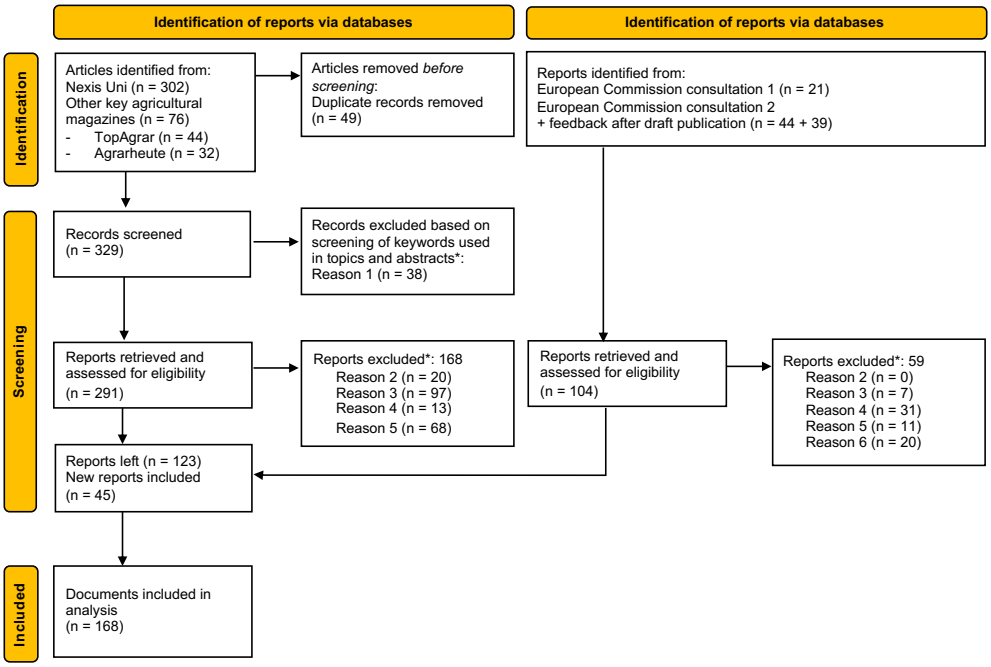
Appendix A – Prisma diagram

Appendix A

Prisma Diagram to Illustrate the Identification and Screening Process of the Documents Analysed (own depiction)



*Reason 1: No full article, instead e.g. only a brief; Reason 2: Excluded due to same content but published in different newspapers or on different dates; Reason 3: Excluded due to focus mainly on the global or European situation or no relevant stakeholders for the German context mentioned; Reason 4: Focus on other carbon removal technologies or carbon farming practices not related to agriculture; Reason 5: Excluded due to mentioning carbon farming without containing relevant content; Reason 6: Excluded due to being a citizen and/or anonymous (EC consultations). (A removed article can be excluded due to multiple reasons but is only counted once.)

Appendix B – Semi-structured interviews

B1 – Informed consent form

This informed consent form was provided by the UU secretariat.

In this study we want to learn about stakeholder perceptions and engagement in agricultural carbon farming in Germany. Participation in this interview is voluntary and you can quit the interview at any time without giving a reason and without penalty. Your answers to the questions will be shared with the research team. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act). Please respond to the questions honestly and feel free to say or write anything you like. Any information that is obtained in connection with this study and that can be identified with you will be disclosed only with your permission. Choose one of the following options.

I prefer to be treated: o Anonymously (stakeholder group/sector only)
o Name of organization/company
o By name

I confirm that:

- I am satisfied with the received information about the research;
- I have no further questions about the research at this moment;
- I had the opportunity to think carefully about participating in the study;
- I will give an honest answer to the questions asked.

I agree that:

- the data to be collected will be obtained and stored for scientific purposes;
- the collected, completely anonymous, research data can be shared and re-used by scientists to answer other research questions;

I understand that:

- I have the right to see the research report afterwards.

Do you agree to participate? o Yes o No

_____

Name of Interviewee

_____ _____

Signature Date

B2 – Information sheet

This information sheet was provided by the UU secretariat.

Introduction

You are invited to take part in this study on agricultural carbon farming in Germany. The purpose of the study is to learn about stakeholder perceptions and engagement in agricultural carbon farming in Germany. The study is conducted by Nora Dirks who is a student in the MSc programme Earth System Governance at the Department of Sustainable Development, Utrecht University. The study is supervised by Prof. Hens Runhaar.

Participation

Your participation in this interview is completely voluntary. You can quit at any time without providing any reason and without any penalty. Your contribution to the study is very valuable to us and we greatly appreciate your time taken to complete this interview. We estimate that it will take approximately 60 minutes to complete the interview. The questions will be read out to you by the interviewer. Some of the questions require little time to complete, while other questions might need more careful consideration. Please feel free to skip questions you do not feel comfortable answering. You can also ask the interviewer to clarify or explain questions you find unclear before providing an answer. Your answers will be noted by the interviewer in an answer template. The data you provide will be used for writing a Master thesis report and may be used for other scientific purposes such as a publication in a scientific journal or presentation at academic conferences. Only patterns in the data will be reported through these outlets. Your individual responses will not be presented or published.

Data protection

The interview is also audio taped for transcription purposes. The audio recordings will be available to the Master student and academic supervisors. We will process your data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act). Audio recordings will be deleted when data collection is finalized and all interviews have been transcribed.

[In case of anonymous interview: Everything you say in this interview will be confidential and completely anonymous. This means that we will not ask for your name or other personal information that can be traced to you by us or a third party.]

B3 – Interview guide

Utrecht University

Carbon Farming in Agriculture
Interview Guide

Nora Dirks

1. Introduction

Thank you for taking the time to review the preliminary interview guide. As mentioned in the email, I am writing my master's thesis on the perspectives and engagement of stakeholders in Germany regarding carbon farming in agriculture. I am examining the narratives used by interest groups and how they align or clash in the political process, and how this can either promote or hinder collective action.

The interview is divided into several thematic blocks and will require approximately 60 minutes. The data protection agreement has either been provided to you beforehand or is attached to this message.

2. Introduction of the Interviewee and Involvement in the debate on Carbon Farming in Agriculture

3. Explanation of Concepts

The concepts we will be discussing today revolve around narratives used by actors to describe carbon farming in agriculture. These narratives typically emphasize certain positive or negative aspects of the topic to express opinions, whether consciously or unconsciously. Below are brief explanations of the aspects that play a significant role in this discussion, along with subtopics:

Aspect	Brief Explanation
Technical-economic aspects	Focuses on whether carbon farming in agriculture can be implemented in a technically, economically, and environmentally friendly manner.
Economic questions	e.g., costs related to measurement systems and yield challenges, as well as compensation/financial systems for farmers.
Technical questions	e.g., can the exact CO2 content in the soil be measured, and how permanent is the storage?

Environmental aspects	e.g., what is the contribution of increased CO2 sequestration to promoting soil quality and biodiversity?
Questions of risks	e.g., risks associated with not pursuing carbon farming in agriculture as part of decarbonization carbon removal strategies and negative emissions technologies.
Social aspects	Focuses on social and political barriers to the large-scale implementation of carbon farming in agriculture.
Resilience	e.g., resilience aspects through improved water retention and reduced erosion risks in soils with increased humus content.
Social aspects	e.g., access to healthy food due to reduced need for pesticides and fertilizers resulting from improved soil quality and fertility.
Market incentives	e.g., financing options for farmers, as well as risks and uncertainties related to vague regulations regarding the measurability of carbon storage and financial remuneration.
Responsibility-related aspects	Focuses on whether carbon farming in agriculture can be developed responsibly.
Equity	e.g., potential pressure on land as a resource arising from carbon credit trading, financialization of agriculture, and land speculation.
Justice	e.g., ensuring fair compensation for farms and full inclusion of long-time ecological humus-building farmers in the system.
Responsibility	e.g., who is responsible for ensuring long-term carbon storage?
Moral	e.g., concerns that compensatory options (by other industries) may divert attention and efforts from emission reduction.
Governance (processes)	e.g., aspects of the political process and stakeholder involvement.
Narrative about other actors	e.g., the allocation or withdrawal of responsibility from certain actors in the debate, or portrayal of specific actors as drivers or obstacles.

4. Interviewee's Views on Carbon Farming in Agriculture

a. What are your thoughts on incentivizing carbon farming practices in agriculture and creating emissions certificates?
b. What are the main aspects that hinder your support for or convince you of carbon farming in agriculture?

5. **Impressions of Other Actors in the Debate and Potential Coalitions**
    a. Could you provide an overview of the stakeholder landscape and highlight prominent actors in Germany?
    b. How do other actors perceive and approach the topic based on your opinion and experience?
    c. With whom do you share your views on the topic? Are there tensions between the priorities emphasized by different actors?
    d. Are there potential coalitions or alliances among the actors?

6. **Impressions of the Debate's Development**
    a. How are the actors driving the debate forward?
    b. Have there been specific events or actors that have accelerated the pace of the debate or the implementation of initiatives?
    c. Have the themes and focus of the debate changed?
    d. Are there actors who may have been or are being marginalized in the debate?
    e. Are there any particularities in the debate in Germany and specifically in agriculture?
    f. How do you envision the future of the debate? What developments do you expect or hope for regarding the topic in Germany?
    g. How do you assess the pace of progress in the debate so far? Does it meet your expectations, or did you anticipate faster development? What reasons do you see for the speed and progress?

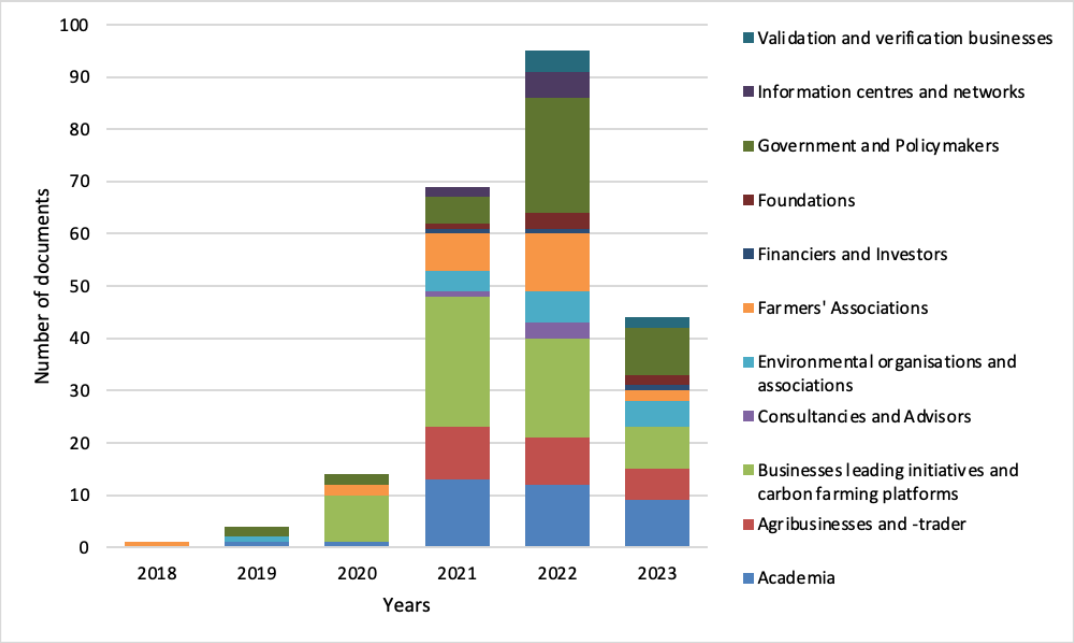
Appendix C – Stakeholder and frame dynamics

The following two figures are intended to support the claims made in chapter 4.1.4 Development of frames by tracing the dynamics of stakeholders and frames per year from a different perspective based on the documents analysed.

Figure C1 shows the evolution of stakeholder dynamics over the years. It shows how different stakeholder groups have emerged and evolved over time in the public debate in the documents analysed.

Figure C10

Stakeholder Dynamics per Year (own depiction)

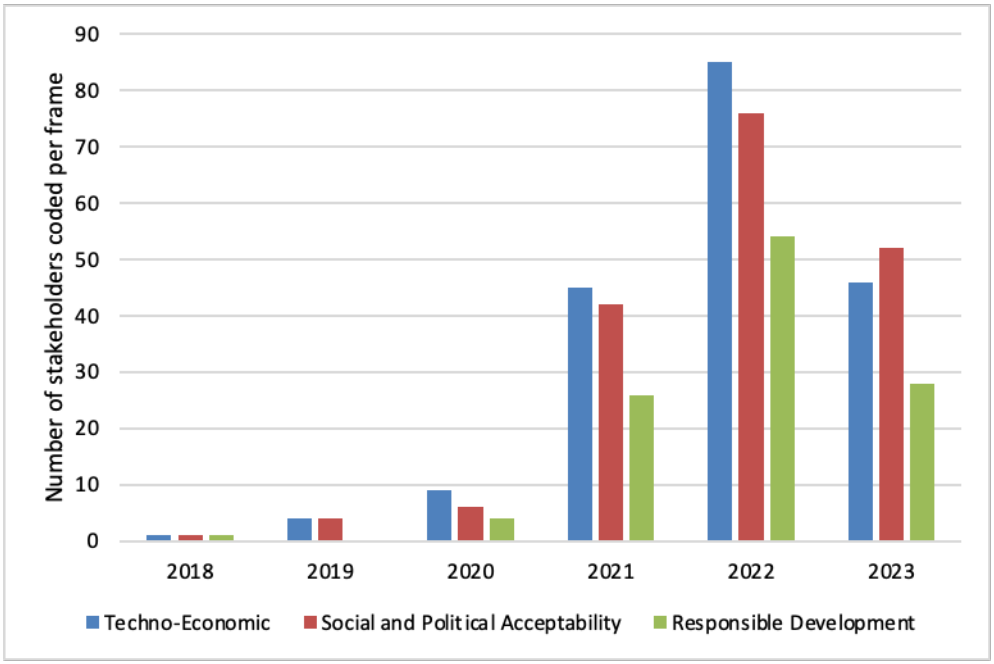


Note. The number of documents in 2023 does not reflect the full year as no new documents were included after 15 June 2023.

Figure C2 provides an alternative view of frame development, focusing on the number of stakeholders associated with each frame per year.

Figure C2

Frame Development from a Stakeholder Perspective (own depiction)



Note. The number of stakeholders coded per frame in 2023 does not reflect the full year as no new documents were included after 15 June 2023.