Organic Waste Management and Carbon Credits as Climate Change Mitigation Strategies in Dutch Municipalities: Challenges and Opportunities

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Table of Contents

Introduction 5
Theoretical Framework 12
Political Ecology as a lens 12
Intersectionality of Theories: Liability of Newness and Liability of Smallness 13
Methodology 14
Data Collection 14
Phase I: Literature Review 14
Phase II: Interviews 15
Data Analysis 16
Ethical Considerations 21
Results 22
Challenges to sustainability and circular economy 22
Structure needed 22
Financial Reward 22
Sustainability transition risk 23
Collaboration required 24
Challenges with organizational goal 24
Sustainability priority 24
Financial Priorities 25
Valorization of environment 25
Organizational responsibility 26
Opportunities in climate mitigation strategies 27
Carbon offsetting 27
Importance of transparency 27
Carbon certification 28
Quantification for research 28
Opportunities in carbon credits 29
Knowledge sharing 29
Importance of OW 29

Value of transparency 30
Discussion 31
Conclusion 39
References 40
APPENDICES 46
Appendix A: Information sheet 47
Appendix B: Informed consent form 49
Appendix C: Interview guide with themes 52
Appendix D: Transcript examples (via Hyperlink) 53

List of Abbreviations and Acronyms (*alphabetical order)*

Abbreviations	Meanings
GHG	Greenhouse gas emissions
mCC	Micro-Carbon Credit Trader
MCC	Medium Carbon Credit Trader
mE	Micro-enterprise
ME	Medium enterprise
MSMEs	Micro, Small, Medium Entreprise
Mu	Municipality
OW	Organic waste
SCC	Small Carbon Credit Trader
SDG	Sustainable Development Goals
SE	Small enterprise

ABSTRACT

This paper explores the crucial role of micro, small and medium enterprises (MSMEs) in municipal organic waste management within the context of carbon governance, particularly framed by the Paris Agreement's Article 6.2. It highlights the necessity for local intermediaries to mitigate urban greenhouse gas emissions and generate carbon credits. Emphasizing the overlooked potential of organic waste material in carbon reduction, this paper underscores the challenges and opportunities in quantifying and commodifying resource flows. Additionally, it addresses the complexity of carbon credit valuation and the political and socioeconomic dynamics shaping waste management policies. By employing political ecology theory, this study focuses on a selected municipality and its MSMEs, aiming to highlight how these entities identify and create carbon credits, thus contributing to local carbon mitigation efforts.

Keywords:
OW, Political Ecology, Urban Carbon Governance, Climate Change, SDG, Job creation, Carbon Credits

INTRODUCTION

Signatories to the Paris Agreement acknowledge the role of carbon-intensive urbanization and its anthropogenic effect and the importance of managing global carbon emissions (Kuyper et al., 2018; Silver, 2017). Research indicates a need for multi-scale urban carbon governance and carves a critical role for local intermediaries, as represented by micro, small, medium enterprises (MSMEs) that handle organic waste (OW) material, to play in addressing the urban contribution to greenhouse gas (GHG) emissions (Bulkeley & Betsill, 2005). Urban carbon governance is critical for municipalities' need to lower carbon emissions (Silver, 2017; Soberón et al, 2023).

The focus on urban carbon governance has increased the role of financial and technical efficacy of carbon reduction solutions, which has led to a focus on renewable energy production (Aylett, 2013; Silver, 2017; Su et al., 2023). In turn, the Dutch central government of has shifted urban carbon governance to cities (Bulkeley & Betsill, 2005; Götze & Hartmann, 2021). This has skewed the techno-politics of infrastructure to address carbon mitigation towards renewable energy projects (Aylett, 2013; Ricciardi et al., 2023; Silver, 2017).

The framework of the Paris Agreement could help redefine the work of waste management companies beyond logistics of waste material transport in the Netherlands towards the creation of carbon credits through the already accepted practice of aerobic composting (Catorza et al, 2022; Demiralay et al., 2022). OW can help solve serious environmental problems such as soil degradation, with organic material being transformed to compost and returned to degraded lands, thus returning nutrients and restoring soil health and soil composition (Catorza et al., 2022; Silver, 2017). However, so far there have been limited models or examples on how this can consistently be done successfully, and the validity of some carbon credit generation from such activity remains unknown (Rakshit & Gupta, 2023; Catorza et al., 2022). Article 6.2 of the Paris Agreement

outlines the need to decrease carbon emissions through a cooperative approach that can facilitate actions beyond emissions reductions and climate mitigation projects (Rogelj et al., 2016). These projects can yield numerous direct or indirect benefits. Such benefits include job creation, technology transfer to increase access to energy, support to livelihoods and food security, and gender empowerment (Ram et al., 2022). Another example are OW management projects in Taiwan that include energy recovery in the form of methane, with carbon credits claimed by application of advanced anaerobic processes to treat waste water, and reduce emissions of greenhouse gas (GHG) (Show & Lee, 2008; Maalouf & El-Fadel, 2020). Catorza et al. (2022) present an example of carbon credits being created from OW in the OW management sector. In this example, the sale of these carbon credits can help raise revenue to offset the cost of compost operations.

Carbon credits, also referred to as internationally transferable mitigation outcomes (ITMOs) can be attained through any number of projects, once mutually agreed by the issuing and transfer parties. Recently, the obligation for carbon reduction has been increasingly transferred to municipalities (Silver, 2017; Show & Lee, 2008), with critical studies of this low-carbon shift in contributing toward struggles for smaller municipalities (Bulkeley and Betsill, 2005). The burden of proof of carbon credit value lies with the organization creating the carbon credits, and needs to be verifiable through established processes, within given timelines, to ensure trustworthiness in the whole chain of the creation of carbon credits (Catorza et al, 2022; Islam, 2022; Silver, 2017) and can represent a challenge to smaller, less organized municipalities and MSMEs. It is unclear why municipalities, in general, prefer other kinds of projects, such as renewable energy (solar, wind, wastewater treatment), which are quantifiable, and modular "turnkey" operations, as compared to the treatment of OW but come with higher implementation

costs (Aylett, 2013; Show & Lee, 2008). In general, OW material represents a resource which municipalities have at hand, while renewable energy projects seen as easier to assess and coordinate (Aylett, 2013; Jonker et al, 2022). Results on local strategies that focus on renewable energy projects show that specific municipal goals always lead to increased costs for the municipality, even as these renewable energy projects also represent GHG emission reductions and possible carbon credits (Maldet, 2023).

To achieve the net-zero greenhouse gas emissions goal of the Netherlands by 2050, local municipalities will need assistance from government and academia to better define future development directions (Cong et al. 2024). This necessity can open up opportunities for micro, small and medium-sized enterprises (MSMEs) tasked with the collection and treatment of organic material to further develop and refine their partnerships with municipalities for their mutual benefit (Aylett, 2013). Also included in this research, were organizations that are directly involved in carbon credit ideation and trading for their knowledge of the instrument created by the Kyoto Protocol, and further expanded by the Paris Agreement (Silver, 2017).

The treatment of organic solid waste through aerobic composting is one of the cheapest technologies to treat OW, representing one of the best low-carbon technologies and is used extensively in the Netherlands (Catorza et al, 2022; Goorhuis et al., 2012). OW management MSMEs can assist municipalities in numerous areas of eco-innovation to assist sustainability transitions, and embrace innovation to answer deficits in the process of OW material treatment (Kant & Kanda, 2019).

The literature points towards a new and shifting landscape for MSMEs in this governance and the circulation of resource flows, as represented by OW material, that can be quantified and commodified for the creation of carbon credits (Silver, 2017; Moslinger et al, 2023). MSMEs that

operate in the OW management sector on the behalf of municipalities can contribute to the shift towards circularity by recognizing their value chains and contribute to its expansion with collaboration with strategic partners, in this case, the municipalities (Jonker et al, 2022; Meena & Pradhan, 2023). The Netherlands' performance in waste recycling and reuse represents an opportunity for increased financial reward linked to value of information based linked to innovative strategies introduced in national waste management practices (D'Adamo et al., 2022; Goorhuis et al., 2012). Strategies implemented by the municipalities include "pay-as-you-throw" (PAYT), also referred to as differentiated tariffs (diftar) mechanism, increased collection points for differentiated waste, and digitization to increase information (Bok & Colombijn, 2024). Such mechanisms led to international to municipal cooperation on knowledge sharing, training programs and technology sharing centered around recycling efforts and EU and Dutch national policy directives, although at times in contention with citizens ((Bok & Colombijn, 2024; D'Adamo et al., 2022).

The European Union's regulatory framework, exemplified by the Carbon Removal and Carbon Capture Facility (CRCF), outlines stringent criteria for carbon credit eligibility. Projects must fulfill quantifiability, additionality, liability, long-term storage prerequisites, as well as the transferability of carbon credits. Furthermore, there is a strong emphasis on accountability, as well as community contributions, underscoring the integral role of MSMEs in fostering socio-environmental sustainability. As illustrated in Figure 1, the implementation of the Paris Agreement in the Netherlands flows from national policies to provincial practices that, in turn, have influence to the Dutch municipal level (UNFCCC, 2015; Zaken, 2011; Elements of Dutch waste management, n.d.). This figure shows the flow from the Paris Agreement (UNFCCC, 2015)

through the Netherlands' Climate Agreement (Zaken, 2011) and National Waste Policy (Elements of Dutch waste management, n.d.) to municipal implementation strategies.

The National Waste Management Plan provides guidelines for all entities and how all waste streams should be treated, according to the Environmental Act (Ministry of Infrastructure and Water Management, 2019) to ensure the capture of all resources, and to avoid placement in landfills. The Netherlands' long-term ambition is to achieve a circular economy by 2050. It should be noted that there is no clear definition of "near zero-waste", within the National Waste Management Plan.

Governments were empowered to subsidize projects contributing to emission reduction, thus incentivizing investment in sustainable energy infrastructure (De Groote et al., 2024). However, the Paris Agreement, which allows for a bottom-up approach to the creation of carbon credits, this signaled an evolution for carbon credit sources, and by extension, the carbon market, presents an opportunity to attract investment to sustainability projects (Catorza et al, 2022; Silver, 2017).

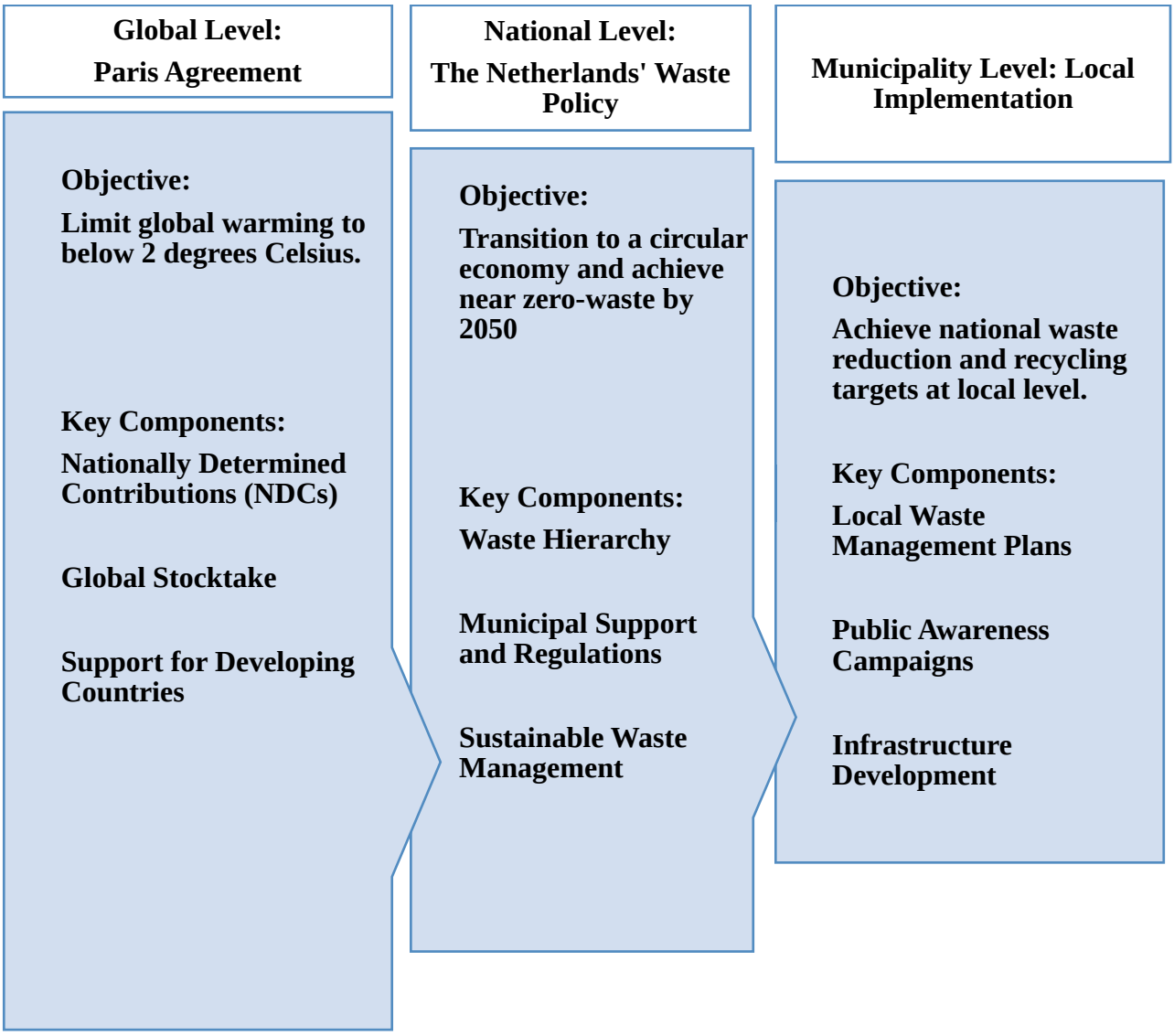
The evolution of carbon credit sources beyond traditional avenues like afforestation to include innovative methods such as seaweed cultivation and marshland conservation, with advancing technology, emerged as potent tools for enhancing carbon sequestration. The main challenge is the accreditation and validation process of the carbon credits for companies that process organic material can be prohibitive, and represent a considerable investment and should be analyzed beforehand (Catorza et al, 2022). This study wants to answer the question:

How can micro, small, medium enterprises (MSMEs) that operate in the sector of OW management and municipalities identify and create carbon credits and thus contribute to local carbon mitigation?

The aim of this research is to identify the potential of micro, small, and medium-sized enterprises (MSMEs) that handle OW material in engaging with municipalities to identify and create opportunities for carbon credit as a climate mitigation strategy (Catorza, 2022). The research gap this study aims to discover is how information asymmetry can influence decision making on the adoption of innovation for climate change strategies at the municipal level in the Netherlands. For this research the following terms are noted for either their interchangeability and/or clarification.

Given that the research question specifically asks about MSMEs, it can be assumed that the term "enterprise" refers to a business. Also, the term "OW" refers to the category of OW material. The two classes of OW material of this research will be food waste, (from households), and green waste (from households and public municipal work), which consists of cut grass, leaves, shrubbery, and branches.

Fig. 1. Hierarchal flow from global climate initiatives to local waste management practices in the Netherlands

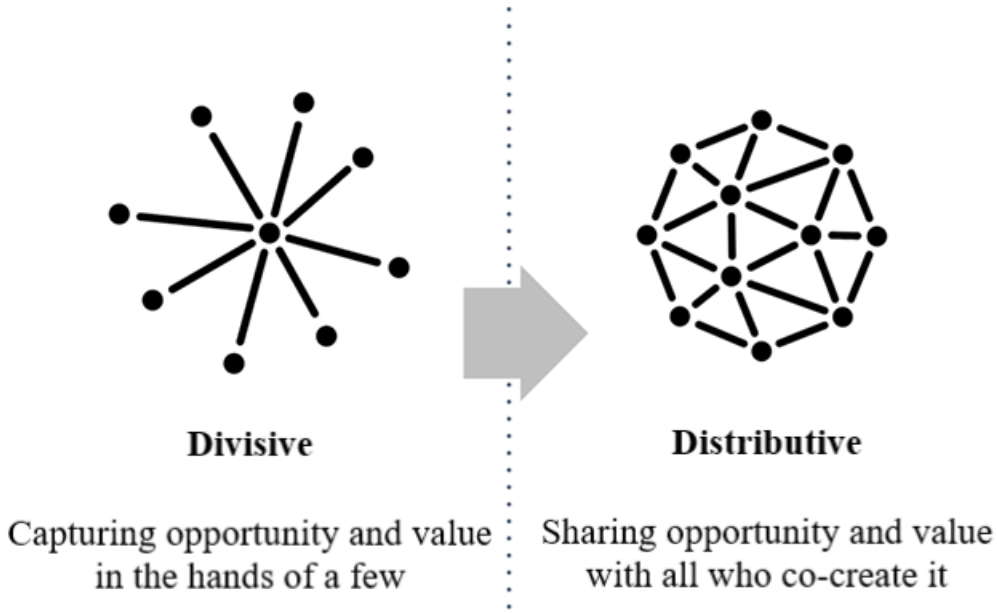


THEORETICAL FRAMEWORK

Political Ecology as a lens

Political ecology theory seeks to understand the complex relationship between political influence on decision making on climate change and the ecology, societal issues across many levels (Osborne, 2015; Silver, 2017). Political ecology theory is appropriate to explore the political and sociotechnical spheres from the perspective of the municipality and MSMEs that manage OW on its behalf (Silver, 2017; Sovacool, 2021). Political ecology offers a rich theoretical lens for understanding the intricate dynamics between information and data-driven decision making in society through politics for climate change action (Soberón et al., 2023). Grounded in the notion that ecological issues are inherently political, it can help identify the unequal distribution of environmental resources and risks among different actors (Silver, 2017; Sovacool, 2021). Political ecology explores the power relations that can shape environmental issues and connects with the Doughnut model and the shift from divisive towards distributive design for decision-making, as shown in Figure 2 (Sahan et al., 2022; Silver, 2017).

Figure 2. Divisive to distributive design



It recognizes that environmental problems are not solely the result of natural processes but are deeply intertwined with social, economic, and political factors (Sahan et al., 2022; Soberón et al., 2023; Sovacool, 2021). Moreover, integrating the theories of the liability of newness and the liability of smallness adds depth to our exploration, highlighting the challenges faced by emerging start-ups and smaller actors within socio-political and environmental contexts.

Intersectionality of Theories: Liability of Newness and Liability of Smallness

The theory of the liability of newness suggests that new organizations or movements face inherent challenges due to their lack of established relationships, resources, and legitimacy (Shepherd & Zacharakis, 2003). Applying this theory within a political ecology framework, we can examine how emerging environmental start-ups struggle to gain recognition and influence within existing power structures (Hörisch, 2015). Studies have highlighted the difficulties faced by environmental start-ups, organizations and companies in accessing funding and navigating bureaucratic processes

that want to take part in low-carbon solutions of OW management for carbon credits (Catorza, 2022; Smith, 2018; Silver, 2017).

Similarly, the theory of the liability of smallness posits that smaller actors within a system may encounter barriers to success due to their limited size and capacity (Aldrich & Auster, 1986). Within the context of political ecology, this theory sheds light on the challenges faced by smaller actors with information asymmetry (Aldrich & Auster, 1986)

By integrating political ecology theory and the concepts of the liability of newness and the liability of smallness, we can develop a framework for analyzing socio-environmental dynamics for OW management MSMEs. This approach enables us to understand the complex interplay between political power, MSMEs, and environmental change, ultimately contributing to more contextually sensitive research and policy interventions.

METHODS

Data Collection

Phase I: Literature Review. This research was initiated by a focused literature review. To research the link between organic material, carbon credits and political ecology, the primary words were utilized for the first cursory article search. The first search was conducted on Scopus using the terms “political ecology” AND “urban carbon governance.” This search produced 15 articles which, upon first reading, led to the discovery of an article that bore some initial fruit (Silver, 2017). Boundaries were placed on the time of submission of articles for articles from the year 2000. A second search was conducted by entering in the following keywords, with the AND function of SCOPUS: “compost” AND “organic material” AND “SDG”, “municipality”. These

words were chosen because one of the primary low carbon methods of treating OW through composting, which also aligns with the sustainable development goals (SDG). The key words were used in the article title, abstract, or keywords feature, as well as the date range feature of Scopus, to focus on articles from 2016, which coincides with the signing of the Paris Agreement. This second search produced 231 articles. Articles were further narrowed down by reading the abstract, and chosen subjectively to articles related to waste management practices, others by geographical representation of EU countries, including the Netherlands. This led to the selection of 49 research articles being chosen according to their relevance to answering the research question. All articles chosen were peer-reviewed articles as found on Scopus. These articles were used to develop an interview guide, write the theory, and later applied to the discussion.

Phase II: Interviews. The next part of this research was to conduct semi-structured interviews to collect primary data from selected individuals that represent various types and sizes of entities that deal in organic materials management, as well as the creation of carbon credits. The interview guide can be found in Appendix A. These interviews sought to uncover how individuals, within the stipulated organizations, partake in decision-making and priority establishment, their knowledge of carbon credits and utility in climate mitigation strategic planning, and their ambition for their organizations, as it related to carbon credits. Table 1 shows the summary of interviewees and the role in organic material management and processing, and carbon credits. Although there is no official or universally accepted definition of an MSME, for this research, I referred to the number of employees, as well as the annual turnover, which then brought all the organizations interviewed into the category of MSMEs. Commonly used definitions are 1-10 employees for micro enterprises; 10-50 employees for small enterprises; and up to 250 for medium-sized

enterprises, according to the International Labour Organization (ILO), the International Finance Corporation (IFC) and the Eurostat's Structural Business Statistics (*Definitions of MSMEs | UNESCAP*, n.d.).

Data Analysis

Grounded theory methodology was used as a systematic approach to theory development grounded in empirical data and involves the process of data collection, coding, analysis to lead to the identification of key concepts.

Audio recordings lasted an average of 45 minutes, and were transcribed (Saldaña, 2021) using a combination of Otter AI, Microsoft Teams, and Microsoft Word online. In the case of one interview, there was a technical difficulty in both the Otter AI, as well as Microsoft Teams, and no audio recording was available to transcribe. This resulted in having to make notes immediately after the interview to best capture the information communicated by the interviewee. This represents one of the limitations of this research. Transcribed interviews were coded and analyzed using Atlas.ti, with the first-order coding carried out inductively. The first order coding for the interviews was conducted in accordance with the interview guide along four second order thematic areas: role, priority, carbon credit knowledge, and ambition. The first order coding of raw qualitative data from the first interview, through familiarization of the data gathered from interview transcripts and notes associated with the interview that lacked the audio file for transcription to understand the context and content thoroughly as per the interview guide (Saldaña, 2021; Soberón et al, 2023) led to the creation of several dozen codes. As more interviews were conducted, similar codes were grouped into broader categories to assist recognition of themes or patterns that emerged from the data (Catorza, 2022; Soberón et al, 2023). New data collected was compared with existing codes and categories and refinements and adjustments codes carried out

as needed (Kant & Kanda, 2019; Saldaña, 2021; Soberón et al, 2023) until all interviews were completed**.**

Second-Order Coding connected first-order categories to existing theories or concepts (Kant & Kanda, 2019; Saldaña, 2021) to look for underlying meanings and relationships and explore relationships between categories, with the use of Atlas.ti to assist in the layout of subcategories, conditions, and relationships between the thematic areas and the literature.

Table 1

Order Summary of interviews.

Type of Organization	Size	Type of OW	Position in Organization	Expertise within Organization
Environmental Start-up	Micro	Green waste	Founder	Innovation with invasive species removal
Organic Material Processor	Small	Green waste	Head of Sustainability and Circularity	Sustainability strategy planning
Organic Material Processor	Medium	Food Waste	Head of Innovation	Innovation of recycling
Municipality	Public Sector	Green waste & Food waste	Head of Circularity & Sustainability	Circularity & Sustainability
Carbon Credit Trader	Micro	N/A	Founder	Carbon credit verification & trading
Carbon Credit Trader	Small	N/A	Founder	Carbon credit verification & trading
Carbon Credit Trader	Medium	N/A	Founder	Carbon credit verification & trading

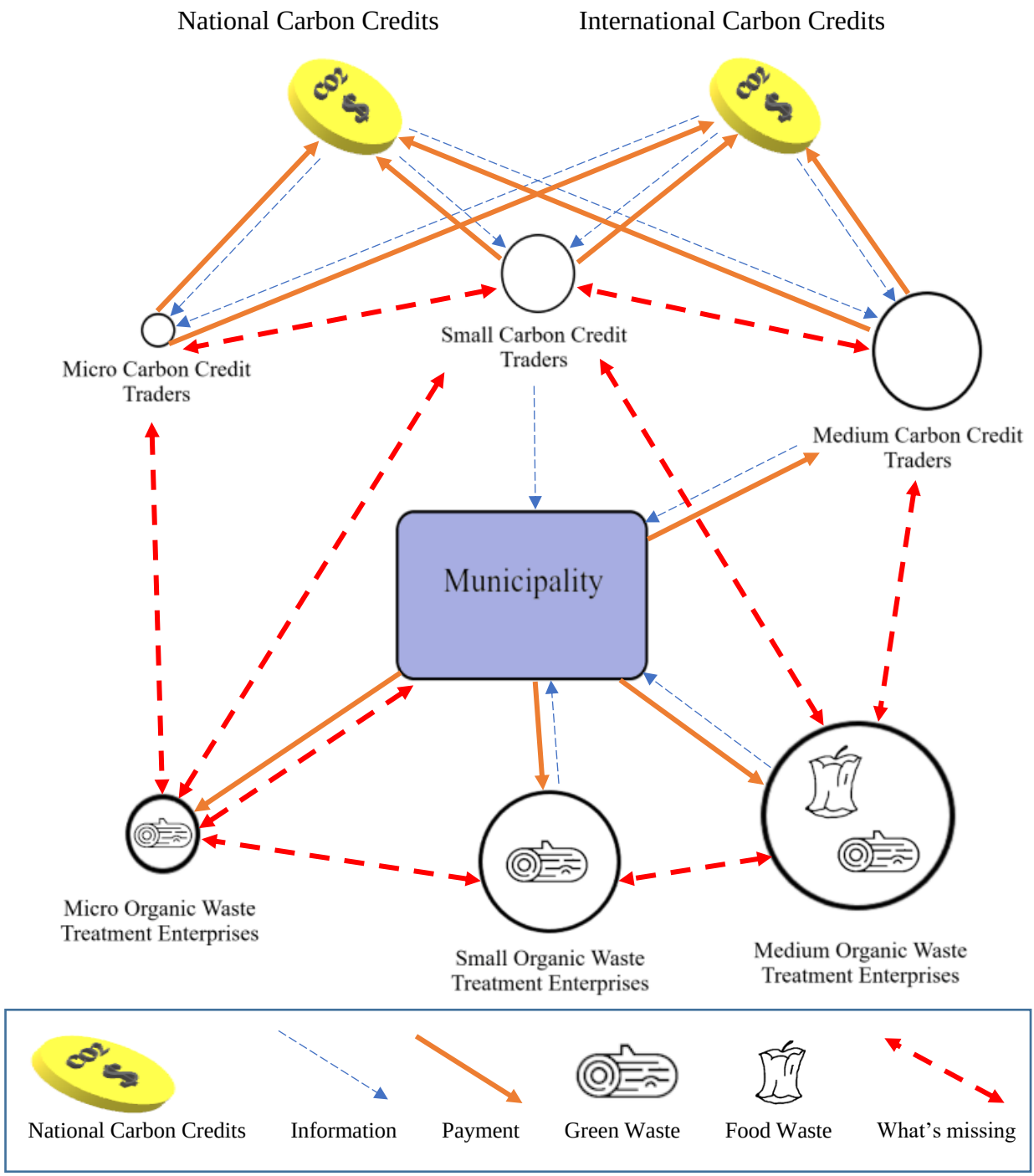


Fig. 3 Relationships of information and payment flows of MSMEs and municipalities involved with organic material handling and processing.

Fig. 4 Data structure from first order codes to second order codes to aggregate themes.

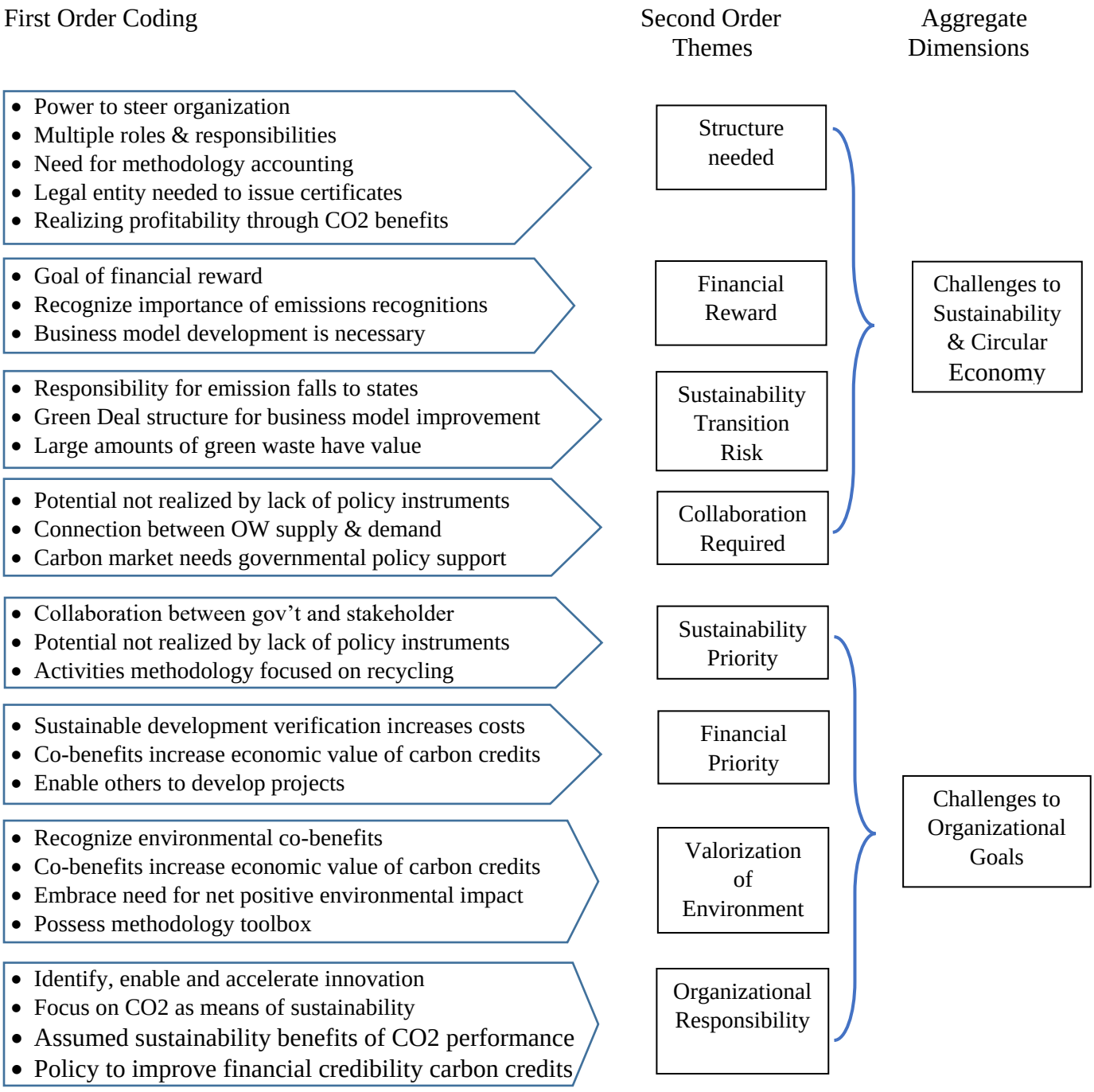
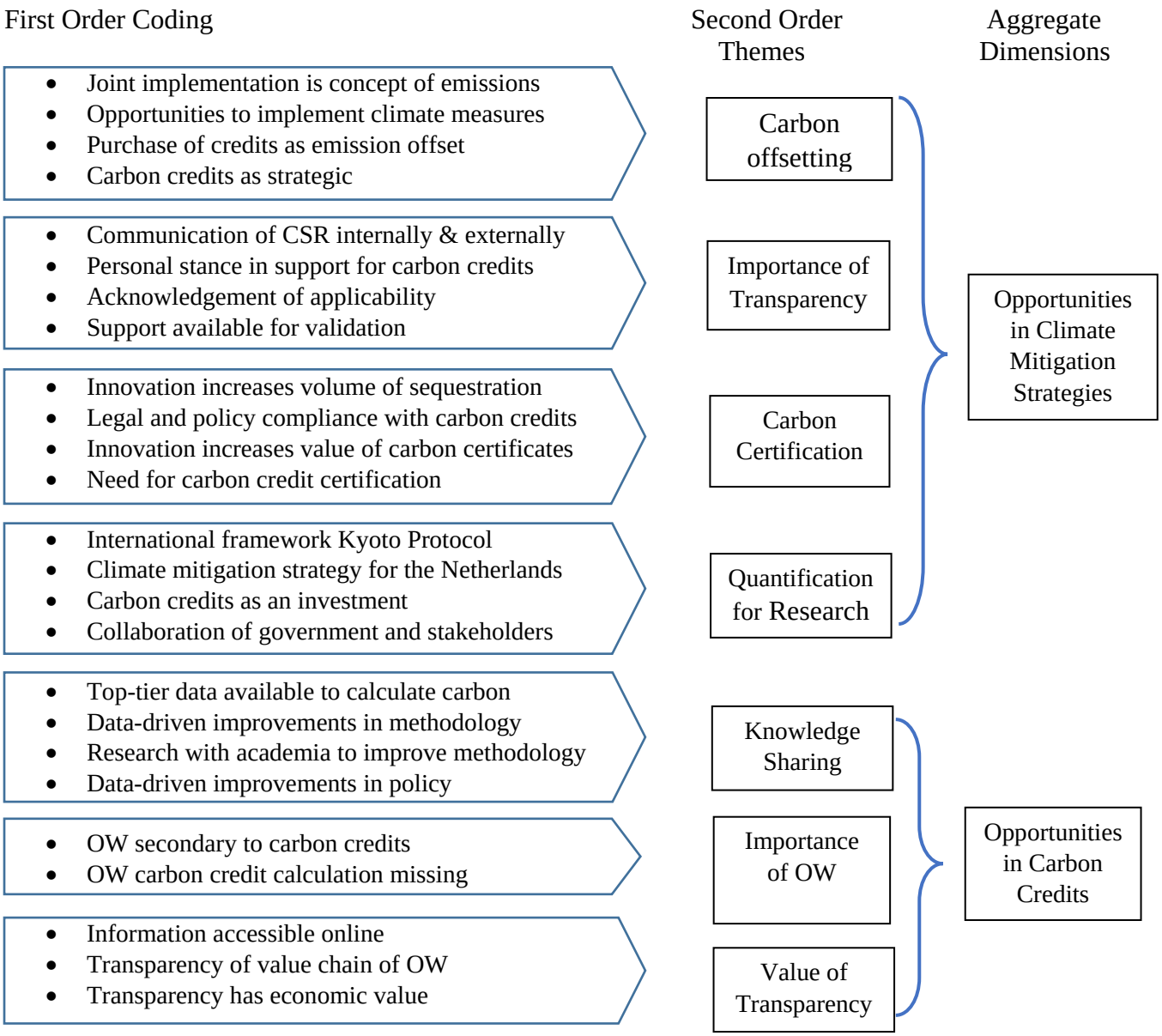


Fig. 4 Data structure from first order codes to second order codes to aggregate themes (Cont'd).



Ethical Considerations

This thesis adheres to a rigorous ethical framework designed to respect the rights, dignity, and welfare of all participants involved in accordance with guidelines set by the University of Groningen Ethics committee. All participants were provided with comprehensive information about the study's purpose, procedures, before their involvement. Informed consent was obtained verbally, and electronically, ensuring that participation was voluntary and based on a thorough understanding of the study. This process included opportunities for participants to ask questions and withdraw from the study by a stated period without any consequences. Confidentiality and anonymity of participants were strictly maintained throughout the research process. Data were anonymized, using unique identifiers instead of personal information, to protect participants' identities. All electronic data were stored on secure, password-protected devices, and physical documents were kept in locked quarters. Only the principal investigator and the research supervisor had access to the data.

This research project received approval from the Ethics Committee of University of Groningen. The Ethics Committee reviewed the study's protocol to ensure compliance with ethical standards and regulations.

Results

Challenges to Sustainability and Circular Economy

Structure needed. The organizations studied highlighted diverse structural requirements essential for effective organic material management. The organizations were a technology start-up micro-enterprise (mE) focused on combating invasive species, a small enterprise landscaping firm (SE), a medium-sized OW treatment organization (ME). Also represented in the research were three carbon credit traders. The micro-carbon credit (mCC) start-up, a small carbon credit (SCC), and medium carbon credit (MCC), and a municipality (Mu). As shown in Fig. 3, the information and payment flows in relation to the municipality (Mu) demonstrates the overall structure in which the interviewees operate. The OW MSMEs demonstrated the sufficient levels of structure that were necessary for effective operational management. However, the mE carried the heaviest responsibility as a technology start-up:

"Most of all the work needs to be with my position...inventing new methods for treating Japanese knotweed."

Financial Reward. Financial incentives were crucial for all MSMEs to sustain and grow their operations. While the tech start-up needed financial reward from its innovation for financial stability, the MCC actively pursued it to take advantage of the context of the Green Deal, and stated:

"We started with the voluntary carbon market idea in 2017 as a green deal between the Netherlands government and about 20 market stakeholders. So those were stakeholders interested in developing new measures, emission reduction activities in the market and with a goal to get the financial reward for it. For many of those measures, the business model was not solid yet, simply because those measures couldn't compete in a market against conventional technologies or conventional measures. And by adding value to the co2 benefits, you would tilt the business model from an unprofitable to profitable investment."

Sustainability transition risk. Organizations embedded in organic material management are crucial for sustainability transitions. SE not only manages OW but also promotes environmental stewardship. Engaged in a full value chain approach, SE recycles live plant material for the maintenance of landscapes, and converts OW into compost. Also, SE contributes to sustainable green space management of green spaces by addressing challenges associated with OW disposal as a commercial scale operator. SE have invested to scale their operation to receive and process organic material from the municipalities near to their compost yards. Their commitment to the comprehensive utilization of organic material underscores the pivotal role it plays in their day-to-day operations and underscores their dedication to environmental stewardship and willingness to work with the municipalities. SE believed their process of OW treatment to constitute a sustainable practice, representing a circular business model, however this was under threat from competing demands for OW:

"The biggest challenge here is not so much in diversification of the applications, but more in making sure that we get the right amount of OW stream so that we can continue producing our

compost product... Our capacity has also been extended last year, so we also have the capacity to increase volumes, but we are at the incoming site we are. We find it challenging to get sufficient waste streams in."

Collaboration required. Collaboration emerged as a key factor for successful carbon credit creation and utilization. Nature-based carbon credits are carbon credits that are specifically created using low-carbon technology. This could include tree-planting projects, or deliberate marshland flooding to reduce CO2, or OW treatment such as anaerobic or aerobic composting, as accepted by scientifically proven methodologies to verify the carbon emissions offset. Both the SCC and the MCC pointed to the use of OW material being part of the methodologies in calculating nature-based carbon credits.

Challenges with organizational goal

Sustainability priority. Technological innovation in environmental conservation is crucial for tackling invasive species and managing organic material (Ricciardi et al., 2021). The mE is dedicated to tackling invasive species and presents a unique perspective on the intersection of technology, environmental conservation, and OW treatment:

"So the governments of the whole Western world, America, Europe, they don't see that problem …when they want to rebuild, still people say, 'Japanese knotweed that's not that a big problem.'

We build a house here and after that is Japanese knotweed everywhere, so they don't see the problem."

Financial Priorities. Financial objectives and environmental stewardship are intertwined in SE operations. In the interview, the organizational ethos was delineated, to emphasize the pivotal role of climate adaptation and biodiversity within the services rendered. SE believes that sustainability is not only their license to operate but also a unique selling point and highlighted the belief in their capacity as 'greenkeepers' to offer solutions conducive to biodiversity preservation and climate change mitigation:

"We believe that as a greenkeeper that we can provide solutions for biodiversity that is going down and also solutions that help deal with climate change… I would say it's the green line in our strategy and, yeah, we are absolutely convinced that, and I'm not the only one, but also my director, that sustainability is not only our license to operate but also our unique selling point.

Valorization of environment. MSMEs recognize the environmental co-benefits of their operations. They valorize the environment and recognize the co-benefits from their operations. Here is an example from the MCC:

"We apply the no net harm principle which means that if you do a project for the sake of CO2, it should not have negative impacts on biodiversity or animal rights, etc…so that's animal protection.

So that's our 'No new harm' safety clause, but in practice, many of the projects that we do in carbon farming, carbon removal, has all kinds of co-benefits."

Organizational responsibility. Challenges in carbon credit valuation hinder broader adoption and the current market lacks adequate valuation mechanisms for CO2 sequestration from OW, thus hindering broader adoption across industries. Consequently, the SE has adopted a cautious stance, choosing to await developments in policy frameworks and market incentives before further investing in carbon credit certification. While they remain committed to sustainability, SE recognized the need for supportive policy measures to unlock the full value of carbon credits. The ME indirectly realizes carbon credits to sell to Mu through biogas production for electricity. Carbon credits are calculated and verified with methodologies that recognize the net carbon emissions reduction from this type of electricity versus electricity created from fossil-fuels. The process is laid out by ME:

The system nowadays is that they, for example, buy electricity in the market… Just from any energy supplier and they can buy certificates. From a green energy producer or solar panels or biomass or wind, an energy supplier can show… that these municipalities have bought green energy.

ME took organizational responsibility to offsetting greenhouse gas emissions and indirectly create carbon credits in its work for the Mu.

SE views circularity as its organizational responsibility through OW management.

"We have the ambition to become fully circular in 2035 and I'm responsible for the road map and the programme to realize that and part of it is also the circularity of our waste streams. But, I would say that's

why we have 4 pillars. Circularity is one of the four pillars and within that. Organic waste stream recycling is a theme. So in that sense, I'm involved in how can we make sure we close the loop. That's our ambition. We want to close the loop in the shortest way possible to do high high level waste utilization."

Opportunities in climate mitigation strategies

Carbon offsetting. Carbon offsetting is a key strategy environmental stewardship, however, mE faced challenges in mitigating direct emissions due to reliance on fossil fuels in its operation. In spite of the environmental imperative, mE's capacity to effectuate significant reductions were constrained by financial considerations. The need to maintain financial sustainability underscored the trade-offs inherent in transitioning away from fossil fuels. The mE demonstrated willingness to redirect financial resources to renewable energy solutions once they aligned with its position as a start-up and its financial stability was assured.

Importance of transparency. Transparency is crucial for achieving sustainability goals and gaining stakeholder trust. This narrative underscored SE's commitment to sustainability strategy to mitigate environmental degradation while fostering ecological resilience. Particularly noteworthy is the organization's ambitious objective to achieve net-zero emissions within its operations by 2035, supplemented by interim targets such as transitioning all leased vehicles to emission-free alternatives by 2025. Furthermore, the organization's proactive measures to electrify hand equipment exemplify a concerted effort to align operational practices with sustainability imperatives. This interview highlighted a nuanced understanding of the interconnectedness between financial viability and environmental responsibility, positioning the organization as an exemplar of sustainable business practices within its industry.

Carbon certification. As carbon certification processes are essential for validating and creating carbon credits, the MCC works directly with interested stakeholders in this process. Their role is to facilitate certification for carbon credits. This process is geared to both identification and creation of carbon certificates for carbon credits. The MCC facilitates certification to ensure transparency and credibility in carbon credits as pointed out in the following statement:

"if you buy certificates based on the project you can check the methodology document online. You can check the project plan written on the basis of that methodology. You can read the validation reports based on the project plan and… also the verification report. So then the whole value chain from an idea towards issuing of certificate has been digitally stored online as a transparent source of information."

Quantification for research. The ME highlighted the need for quantitative research to better aid climate mitigation strategies through being open to collaboration with various entities across the province:

"We have a lot of connections with companies in the province... So we tried to establish networks to have a wider vision of sustainability and also to connect companies for which we are working… from the ways that [OW] has to be recycled, we need to cooperate with other companies."

Whereas the ME is able to use its market position to seek out relationships with other companies and organizations, the mE has only recently begun to collaborate with academia:

"W*hat we want is a certificate, stamp for a company that has done the workshop… and we're now developing it with Wageningen University."*

Opportunities in carbon credits

Knowledge sharing. All of the organizations interviewed acknowledged the potential of carbon credits in incentivizing CO2 sequestration and offsetting emissions. The SE actively engages in OW management and tree planting initiatives, as well as to capture CO2 from the atmosphere. Through composting OW and producing compost products, they contribute significantly to CO2 sequestration efforts. Both the SE and both the SCC and MCC collaborate with industry partners, regulatory bodies and innovators to develop methodologies for calculating CO2 sequestration, and facilitate external audits and certification processes.

Importance of OW. The carbon credit organizations work indirectly with OW in the creation of these nature-based carbon credits. The use of OW in some of these low-carbon nature-based carbon credits was alluded to by Mu, with a preference for tree-planting projects in the Netherlands, as compared to outside of the European Union, from where it purchases carbon credits. For the SCC and MCC, the relationship with OW is in the conceptualization and creation of carbon credits through collaboration with both innovators and academia. Nevertheless, their work indirectly links to organic material, as carbon sequestration and offsetting emissions are components of their initiatives. SCC interviewee articulated:

"*It is a certificate that proves or claims that that carbon has been removed from the atmosphere. So we actually sell certificates. We're brokers, we sell the certificates, and we buy them from project developers or from carbon farmers.*

Value of transparency. The municipality presently purchases a large number of carbon credits as an offset to its activities, but stated a preference for more support for Dutch carbon credits, citing transparency as a concern. On the ideation side of carbon credits, both SCC and MCC highlighted the importance of carbon credits as a funding mechanism. Also, there was recognition of increased value of locally derived carbon credits because of transparency. Their focus was also on locally-derived carbon credits that served as a funding mechanism, and their transparency. As the SCC stated:

"Climate credits are a mechanism. It's not a currency, it's a mechanism, right? The climate credits are one of the instruments that contribute to that goal… this is just one of them. And the essence of the mechanism is that it funds small projects upfront."

The MCC offered the following on transparency:

"that information is all available on our website and then you take your decision. It's not just a piece of paper with serial numbers that you purchased. There is a story behind it. The farmer or anyone else has a clear narrative with this, and you pay for the narrative"

Discussion

This paper sought to understand the factors that influence the identification and creation of carbon credits for MSMEs and municipalities. MSMEs were chosen for this research because they represent roughly 90 percent of all businesses globally and more than 50 percent of employment (Definitions of MSMEs | UNESCAP, n.d.). They are recognized as an integral part of social development, especially in the face of the climate crisis (WTO, 2016). MSMEs could play a critical role in innovative approaches to sustainability, OW management and carbon credit creation. Municipalities were included for their importance as an arm of government and their role in effectuating the move to a circular economy in the Netherlands.

Interviewees expressed the necessity for government clarification and support, which was intriguing given the extensive National Waste Management policy in the Netherlands and its long-term goal of achieving a circular economy by 2050 (Elements of Dutch Waste Management, n.d.). The complexity of this policy may hinder micro and smaller enterprises from effectively identifying carbon credit opportunities. The Netherlands continues to develop and implement programs aimed at preventing and reducing waste through prevention, reuse, and recycling, emphasizing the need to adopt a life-cycle approach focused on resource efficiency to minimize the environmental impact of product chains and waste management.

Carbon credit traders interviewed showcased the ability to collaborate with stakeholders (such as farmers) and academia to identify and create carbon credits. They effectively navigated the information asymmetry inherent in the carbon credit creation process through this collaboration and by their deep knowledge of carbon credits, and the methodologies needed for their creation. Their efforts in valorizing OW highlight its potential as a measure of carbon sequestration and also

enhance its profile and value to the public. This is important because standards for OW separation and lower-than-expected separation rates have made it more feasible for medium enterprises to use OW for bio-energy production, via incineration. Additionally, new technologies are emerging to convert organic material into liquid carbon as a fuel source (Ahmadi et al., 2020; Ayodele et al., 2020; Ram et al., 2022), placing the future use of OW for carbon credits at risk. Transition management literature acknowledges that urban transitions are influenced by various actors operating under network governance (Ehnert, 2023; Frantzeskaki et al., 2019). Municipalities must shift from traditional roles to becoming initiators and facilitators of transition initiatives involving multiple sectors (Bok & Colombijn, 2024; Ehnert, 2023). However, structural and cultural challenges hinder their ability to collaborate effectively in network environments (Bok & Colombijn). This study highlights the role of MSMEs, as experts in OW treatment and carbon credits, in collaborating with and supporting municipalities in developing their climate strategies (Soberón et al., 2023).

Since 2004, the total recycling rate in the Netherlands has increased from 46% to 53% by 2016, with an increased volume since COVID-19 (Chioatto & Sospiro, 2023). Despite this progress, relatively cheap incineration rates and the acceptance of electricity created from contaminated OW streams represent a challenge to the utilization of OW for composting and carbon credit creation (Bok & Colombijn, 2024). Notably, the Netherlands has almost achieved the EU target for 2025 (Chioatto & Sospiro, 2023). This notwithstanding, the landscape firm (SE) still sets a robust roadmap targeting full circularity by 2035. Their strategies to reduce CO2 emissions and promote resource efficiency, and prioritization of their fleet demonstrates long-term commitment. The SE desire for 100% recycling rates across its 16 facilities, and utilization of data tracking, internally

and externally, means they understand how their services can promote climate adaptation and biodiversity (Frantzeskaki et al., 2019).

Though SE emerged as a beacon of success, through proactive measures and strategic investments they remain challenged in creating carbon credits. The information asymmetry regarding how to identify carbon credit creation opportunities seems linked to a lack of policy support to oblige purchasers of the compost and substrate products resulting from treated organic waste. Lack of knowledge on how the national government wants to move in the future has already given pause to their efforts. This demonstrates how the unwillingness to experiment on the part of government by providing policy support can delay innovation (Ehnert, 2023; Frantzeskaki et al., 2019). The technology start-up micro-enterprise (mE) faced the most formidable challenge in mitigating Scope 1 emissions due to reliance on fossil fuels as a primary energy source. Despite awareness of the environmental imperative, the organization's capacity to effect significant reductions was constrained by financial considerations, necessitating a prioritization of economic viability (Aldrich & Auster, 1986). The imperative to maintain financial sustainability underscored the nuanced trade-offs inherent in transitioning away from fossil fuels, with the organization poised to redirect resources once a viable technical solution aligning with its financial constraints becomes available (Aldrich & Auster, 1986; Catorza et al., 2023; Silver, 2017). This further highlights the importance of carbon credits as funding mechanism that could assist mEs in expanding operational capacity (Catorza et al., 2023; Silver, 2017).

Effective waste management in the Netherlands proved that cooperation is vital as the Waste Management Council formed in 1990, facilitated the collaboration among the three tiers of government (national, provincial, and municipal) and create a coherent and cooperative approach

to the waste management problems of the time (Elements of Dutch Waste Management, n.d.). This cooperative approach should be revisited today and facilitated by increased information exchange of OW quantities. Collaboration through technology, such as remote sensing, data analytics, and blockchain, can enhance the accuracy and traceability of carbon credits (Frantzeskaki et al., 2019). These technologies can help monitor and verify carbon sequestration activities in real time (Frantzeskaki et al., 2019; Tozer et al., 2022; Tozer et al., 2023).

New research incorporating these technologies could highlight opportunities for a working distributive model that addresses social inequality in Dutch municipalities (Frantzeskaki et al., 2019). Increased data gathering could lead to new insights and methodologies for calculating carbon sequestration opportunities, benefiting MSMEs and municipalities in their climate mitigation strategies (Ehnert, 2023; Frantzeskaki et al., 2019). This political agenda-setting has brought political ecology theory to the fore, offering a lens to view how OW is valorized and acted upon at the municipal level with relevance for the future utilization of carbon credits as a climate mitigation strategy. Where separation has stalled in favor of biomethane electricity production, a political decision needs to be made on balancing the high energy and resource dependency in the Netherlands with sustainable climate mitigation strategies (Tomić & Schneider, 2017).

The aforementioned Waste Management Council no longer exists since 2016, having been deemed unnecessary as a political necessity upon achieving its primary goals (Elements of Dutch Waste Management, n.d.). The government's present policy approach to OW management is limited to reducing landfills and organic food waste, as highlighted in the National Waste Policy. Recent valorization of OW has limited its usage to energy-from-waste initiatives to reduce methane emissions from the landfilling of OW (Ahmadi et al., 2020; Elements of Dutch Waste

Management, n.d.). This shift may have been in response to stalling waste separation rates in municipalities, therefore the government should refocus its policy to push for higher rates of OW separation from households, restaurants, and hospitality sectors (Frantzeskaki et al., 2019; Tomić & Schneider, 2017).

From this research, it was pointed that there are several methodologies to measure the amount of CO2 sequestered related to OW. These methodologies provide scientific basis for the quantity of CO2 sequestered, but some may need updating. Academia has historically played a role in developing and updating these methodologies, but I would suggest periodic updates on a scheduled basis. This could represent new opportunities for MSMEs, municipalities, and academia to create legitimacy for carbon credits as a climate mitigation strategy. The legitimacy of carbon credits has been questioned since the Verra scandal of 2023. The scandal of "phantom credits" was exposed by a media investigation by the Guardian, Die Zeit, and SourceMaterial, and was due to quantification flaws in carbon credit certification (Conti & Seele, 2024).

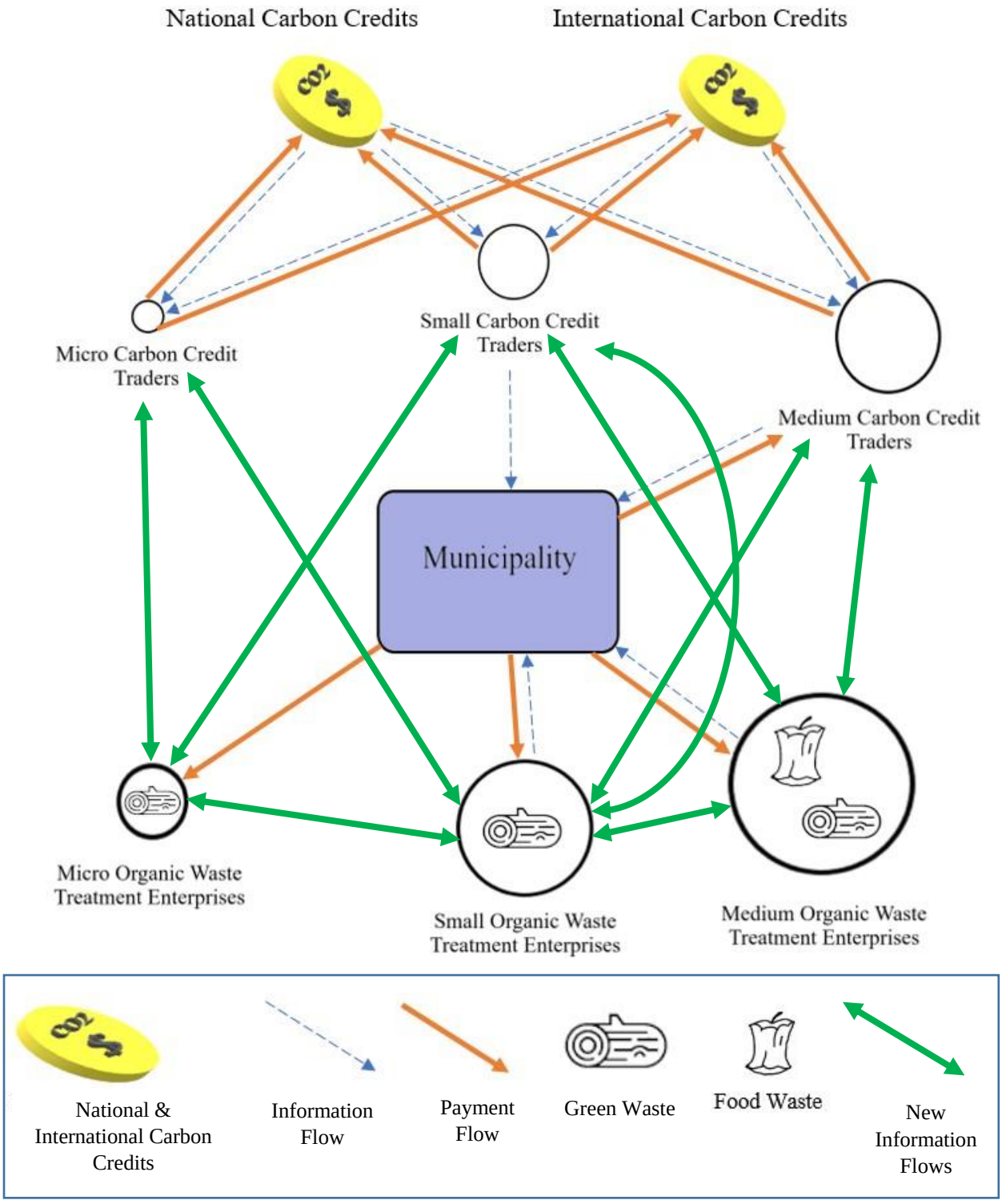
The findings from this research underscore the divergent trajectories pursued by MSMEs as they grapple with the imperative to reduce their emissions, while balancing environmental stewardship and economic viability. On the one hand SE offered a blueprint for effective emission reduction strategies through to 2035, while on the other, mE faced financial and environmental challenges due to its reliance on fossil fuels. What is not factored is the CO2 savings to the municipality when it does not have to replace infrastructure affected by invasive species. Ultimately, a deeper understanding of the complexities surrounding emission reduction would balance efforts of micro-enterprises, and emphasize the need for context-specific solutions tailored to the unique challenges

and opportunities encountered by individual organizations and municipalities in creating climate mitigation strategies (Ehnert, 2023; Frantzeskaki et al., 2019; Tozer et al., 2022).

This research sought to identify pathways for MSMEs engaged in the handling and processing of organic material to create carbon credits for climate mitigation strategies. Drawing insights from various sources, including interviews and literature review, the findings underscore several crucial aspects imperative for MSMEs in navigating the complexities of carbon credit identification and creation, as afforded under the Paris Agreement. MSMEs could prioritize fair wages, gender equality, and community engagement to augment the societal value of carbon offset projects while fostering biodiversity and environmental stewardship, key components of sustainable development agendas (Bok & Colombijn, 2024; Ehnert, 2023; Frantzeskaki et al., 2019). The findings highlight a multifaceted landscape wherein MSMEs can leverage carbon credits as catalysts for sustainable development to influence the meso-level as represented by the municipalities (Catorza et al., 2023; Chioatto & Sospiro, 2023; Hörisch, 2015; Hughes et al., 2020; Silver, 2017). By adhering to regulatory standards, embracing innovation, and fostering socio-economic inclusivity, these enterprises are poised to spearhead transformative climate action, moving towards a greener and more equitable future (Chioatto & Sospiro, 2023; Hughes et al., 2020).

Part of a more equitable future could be the establishment of digital platforms for information exchange about OW between academia, government, MSMEs, and other stakeholders to facilitate knowledge sharing and collaboration (Chioatto & Sospiro, 2023; Hughes et al., 2020). Figure 5 shows a re-imagined distributive design of funding and information flows of MSMEs and municipalities involved with organic material handling and processing.

Fig. 5 Distributive design for information and payment flows between MSMEs and municipalities involved with organic material handling and processing, and the creation of carbon credits



Hosting workshops, webinars, and conferences to disseminate best practices and innovative solutions could benefit both academia and municipalities (Chioatto & Sospiro, 2023; Ehnert, 2023; Frantzeskaki et al., 2019; Hughes et al., 2020). Identifying carbon credits involves several critical steps for MSMEs and municipalities, therefore a clearer understanding of national and international policies regarding carbon credits, the specific criteria for OW treatment, and the potential for carbon sequestration (Chioatto & Sospiro, 2023). Collaborating with academic institutions to conduct scientific research can provide the necessary data to quantify carbon sequestration accurately (Chioatto & Sospiro, 2023). Engaging stakeholders, including farmers, waste management companies, and government agencies, can help identify new opportunities for carbon credit creation.

Limitations of this research include the small sample size and the omission of citizens as stakeholders, a key element of political theory. Also, due to a technical issue, an audio recording was not available for one of the key contributors. Future research should incorporate citizen participation to highlight more opportunities for a distributive model that could also address social inequality in Dutch municipalities (Bockarjova et al., 2022). Increased data gathering could lead to new insights and methodologies for calculating carbon sequestration opportunities, benefiting MSMEs and municipalities in their climate mitigation strategies (Bockarjova et al., 2022; Catorza et al., 2023; Sahan et al., 2022; Soberón et al., 2023; Tozer et al., 2022).

Conclusion

MSMEs and municipalities can play a pivotal role in the identification, creation and utilizing carbon credits through innovative approaches to data gathering and increased information exchange amongst all the relevant stakeholders. Overcoming information asymmetry and enhancing collaboration between stakeholders are essential for maximizing the potential of carbon credits as part of a comprehensive climate mitigation strategy. In addition, profound societal implications could be realized with knowledge sharing to increase OW separation rates.

References

Ahmadi, L., Kannangara, M., & Bensebaa, F. 2020. Cost-effectiveness of small scale biomass supply chain and bioenergy production systems in carbon credit markets: A life cycle perspective. ***Sustainable Energy Technologies and Assessments***, *37*.

Aldrich, H., & Auster, E. R. 1986. Even dwarfs started small: Liabilities of age and size and their strategic implications. ***Research in Organizational Behavior***, 8: 165–198.

Amjad, M. S., McCleeary, D., Nagaraj, S., & Diaz-Elsayed, N. 2023. ***Integrating Carbon Credits with Life Cycle Costing for Economic Sustainability in SMEs***. 116: 672–677.

Aylett, A. 2013. Networked urban climate governance: Neighborhood-scale residential solar energy systems and the example of Solarize Portland. ***Environment and Planning C: Government and Policy***, 31(5): 858–875.

Ayodele, T. R., Alao, M. A., & Ogunjuyigbe, A. S. O. 2020. Effect of collection efficiency and oxidation factor on greenhouse gas emission and life cycle cost of landfill distributed energy generation. ***Sustainable Cities and Society***, 52, 101821.

Bockarjova, M., Botzen, W. J. W., Bulkeley, H. A., & Toxopeus, H. 2022. Estimating the social value of nature-based solutions in European cities. ***Scientific Reports***, 12(1).

Bok, J., & Colombijn, F. 2024. Modest governance as a condition for separating benevolent from malevolent recycling practices in the Netherlands. ***DECISION***.

Bulkeley, H., & Betsill, M. M. 2005. Rethinking sustainable cities: Multilevel governance and the "urban" politics of climate change. ***Environmental Politics***, 14(1): 42–63.

Catorza, C. F., Elk, A. G. H. P. V., & Passos, L. H. S. 2022. Potential of carbon credits generation from OW composting of large generators: An alternative to the final disposal in sanitary landfills. ***Revista Brasileira de Ciências Ambientais (RBCIAMB)***, 57(2), Article 2.

Chioatto, E., & Sospiro, P. 2023. Transition from waste management to circular economy: The European Union roadmap. ***Environment, Development and Sustainability***, 25(1): 249–276.

Cong, R., Fujiyama, A., & Matsumoto, T. 2024. An optimal scheme assists the municipalities in Fukuoka, Japan in achieving their goal of 100% renewable energy supply and future decarbonization. ***Energy Nexus***, 13.

Conti, L. G., & Seele, P. 2024. Upsetting offsetting? Nathan the Wise's Ring Parable and three reasons why not to adopt the carbon offsetting logic to biodiversity. ***Ambio***, 53(5):697–701.

D'Adamo, I., Mazzanti, M., Morone, P., & Rosa, P. 2022. Assessing the relation between waste management policies and circular economy goals. ***Waste Management***, 154: 27–35.

De Groote, O., Gautier, A., & Verboven, F. 2024. The political economy of financing climate policy—Evidence from the solar PV subsidy programs. ***Resource and Energy Economics***, *77*.

Definitions of MSMEs | UNESCAP. (n.d.). Retrieved June 1, 2024, from https://msmepolicy.unescap.org/definitions-msmes

Demiralay, S., Gencer, H. G., & Bayraci, S. 2022. Carbon credit futures as an emerging asset: Hedging, diversification and downside risks. ***Energy Economics***, *113*.

Ehnert, F. 2023. Review of research into urban experimentation in the fields of sustainability transitions and environmental governance. ***European Planning Studies***, 31(1): 76–102.

Elements of Dutch waste management. (n.d.). Rijkswaterstaat Environment. Retrieved May 30, 2024, from https://rwsenvironment.eu/subjects/from-waste-resources/elements-dutch-waste/

Frantzeskaki, N., McPhearson, T., Collier, M. J., Kendal, D., Bulkeley, H., Dumitru, A., Walsh, C., Noble, K., Van Wyk, E., Ordóñez, C., Oke, C., & Pintér, L. 2019. Nature-based solutions for urban climate change adaptation: Linking science, policy, and practice communities for evidence-based decision-making. ***BioScience***, 69(6): 455–466.

Goorhuis, M., Reus, P., Nieuwenhuis, E., Spanbroek, N., Sol, M., & van Rijn, J. 2012. New developments in waste management in the Netherlands. ***Waste Management & Research***, 30(9_suppl): 67–77.

Götze, V., & Hartmann, T. 2021. Why municipalities grow: The influence of fiscal incentives on municipal land policies in Germany and the Netherlands. ***Land Use Policy***: 109.

Gupta, H., & Rakshit, D. 2023. Assessing the demand for carbon credits from the most polluting and hard-to-abate sectors in India. ***Journal of Cleaner Production***: 425.

Hörisch, J. 2015. The Role of Sustainable Entrepreneurship in Sustainability Transitions: A Conceptual Synthesis against the Background of the Multi-Level Perspective. ***Administrative Sciences,*** 5(4): Article 4.

Hughes, S., Giest, S., & Tozer, L. 2020. Accountability and data-driven urban climate governance. ***Nature Climate Change***, 10(12): 1085–1090.

Islam, Md. M. 2022. Distributive justice in global climate finance – Recipients' climate vulnerability and the allocation of climate funds. ***Global Environmental Change***, 73: 102475.

Jonker, J., Faber, N. and Haaker, T., 2022. Circular Business Models. ***A Study to Classify Existing and Emerging Forms of Value Retention and Creation***.

Kant, M., & Kanda, W. 2019. Innovation intermediaries: What does it take to survive over time? ***Journal of Cleaner Production***, 229: 911–930.

Kuyper, J., Schroeder, H., & Linnér, B.-O. 2018. The Evolution of the UNFCCC. ***Annual Review of Environment and Resources***, *43*(1): 343–368.

López-Sánchez, A., Silva-Gálvez, A. L., González-López, M. E., Díaz-Vázquez, D., Orozco-Nunnelly, D. A., Novoa-Leiva, I., González-Valdez, J., Casillas-García, L. F., & Gradilla-Hernández, M. S. 2023. Valorization of livestock waste through combined anaerobic digestion and microalgae-based treatment in México: A techno-economic analysis for distributed biogas generation, animal feed production, and carbon credits trading. ***Environmental Technology & Innovation***, 32: 103321.

Maalouf, A., & El-Fadel, M. 2020. A novel software for optimizing emissions and carbon credit from solid waste and wastewater management. ***Science of The Total Environment***, 714: 136736.

Maldet, M., Loschan, C., Schwabeneder, D., Lettner, G., & Auer, H. 2023. Business models for local energy market and circular economy establishment in municipalities: A case study in an Austrian municipality. ***Heliyon***, 9(10).

Meena, R. S., & Pradhan, G. 2023. Industrial garbage-derived biocompost enhances soil organic carbon fractions, CO2 biosequestration, potential carbon credits and sustainability index in a rice-wheat ecosystem. ***Environmental Research***, 235: 116525.

Möslinger, M., Ulpiani, G., & Vetters, N. 2023. Circular economy and waste management to empower a climate-neutral urban future. ***Journal of Cleaner Production***, 421.

Osborne, T. 2015. Tradeoffs in carbon commodification: A political ecology of common property forest governance. ***Geoforum***, 67: 64–77.

Ram, M., Osorio-Aravena, J. C., Aghahosseini, A., Bogdanov, D., & Breyer, C. 2022. Job creation during a climate compliant global energy transition across the power, heat, transport, and desalination sectors by 2050. ***Energy***, 238.

Ricciardi, A., Iacarella, J. C., Aldridge, D. C., Blackburn, T. M., Carlton, J. T., Catford, J. A., Dick, J. T. A., Hulme, P. E., Jeschke, J. M., Liebhold, A. M., Lockwood, J. L., Macisaac, H. J., Meyerson, L. A., Pyšek, P., Richardson, D. M., Ruiz, G. M., Simberloff, D., Vilà, M., & Wardle, D. A. 2021. Four priority areas to advance invasion science in the face of rapid environmental change. ***Environmental Reviews***, 29(2): 119–141.

Ricciardi, G., Ellena, M., Barbato, G., Giugliano, G., Schiano, P., Leporati, S., Traina, C., & Mercogliano, P. 2023. Climate change adaptation cycle for pilot projects development in small municipalities: The northwestern Italian regions case study. ***City and Environment Interactions,*** *17*.

Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., & Meinshausen, M. 2016. Paris Agreement climate proposals need a boost to keep warming well below 2 °C. ***Nature***, 534(7609): 631–639.

Sahan, E., Winden, W., Deal, K., van den Buuse, D., & Ruiz, C. 2022. ***What Doughnut Economics means for business: Creating enterprises that are regenerative and distributive by design.*** Executive summary**.**

Saldaña, J., 2021. Coding Techniques for Quantitative and Mixed Data, in: The Routledge Reviewer's Guide to Mixed Methods Analysis. Routledge.

Shepherd, D.A. and Zacharakis, A., 2003. A new venture's cognitive legitimacy: An assessment by customers. ***Journal of Small Business Management***, *41*(2), pp.148-167.

Show, K. Y., & Lee, D. J. 2008. Carbon credit and emission trading: Anaerobic wastewater treatment. ***Journal of the Chinese Institute of Chemical Engineers***, 39(6): 557–562.

Silver, J. 2017. The climate crisis, carbon capital and urbanisation: An urban political ecology of low-carbon restructuring in Mbale. ***Environment and Planning A***, 49(7): 1477–1499.

Soberón, M., Ezquerra-Lázaro, I., Sánchez-Chaparro, T., Moreno-Serna, J., Dóci, G., & Kordas, O. 2023. Supporting municipalities to develop collaboration capability to facilitate urban transitions and sustainability: Role of transition intermediaries in Madrid. ***Journal of Cleaner Production***, 426: 138964.

Sovacool, B. K. 2021. Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. ***Energy Research and Social Science***: *73*.

Su, T., Meng, L., Wang, K., & Wu, J. 2023. The role of green credit in carbon neutrality: Evidence from the breakthrough technological innovation of renewable energy firms. ***Environmental Impact Assessment Review***, 101: 107135.

Tomić, T., & Schneider, D. R. 2017. Municipal solid waste system analysis through energy consumption and return approach. ***Journal of Environmental Management***, 203: 973–987.

Tozer, L., Bulkeley, H., Kiss, B., Luque-Ayala, A., Palgan, Y. V., McCormick, K., & Wamsler, C. 2023. Nature for Resilience? The Politics of Governing Urban Nature. ***Annals of the American Association of Geographers***, 113(3): 599–615.

Tozer, L., Bulkeley, H., & Xie, L. 2022. Transnational Governance and the Urban Politics of Nature-Based Solutions for Climate Change. ***Global Environmental Politics***, 22(3): 81–103.

The Paris Agreement | UNFCCC [WWW Document], n.d. URL https://unfccc.int/process-and-meetings/the-paris-agreement.

WTO, 2016. World Trade Report 2016. Levelling the trading field for SMEs. https://www.wto.org/english/res_e/publications_e/wtr16_e.htm.

Zaken, M. van A., 2011. ***Environmental Management Act - Environment*** - Government.nl

APPENDICES

Appendix A: Information Sheet

TITLE OF THE STUDY: OW Management and Carbon Credits as Climate Change Mitigation Strategies in Dutch Municipalities: Challenges and Opportunities

Dear

Thank you for your interest in participating in this research. This letter explains what the research entails and how the research will be conducted. Please take time to read the following information carefully. If any information is not clear kindly ask questions using the contact details of the researchers provided at the end of this letter.

WHAT THIS STUDY IS ABOUT? The costs related to fees and other investments required in the accreditation and validation process of the carbon credits for companies that process organic material can be prohibitive, and represent a considerable investment and should be analyzed beforehand. This study wants to answer the question: How SMEs that operate in the sector of OW management on the behalf of municipalities identify and create carbon credits and thus contribute to local carbon mitigation and reduction? This research is not sponsored or funded.

WHAT DOES PARTICIPATION INVOLVE? Participation will involve an in-depth, semi-structured interview, ranging from 30 to 60 minutes, including the time investment for the participant. The interviews will be carried out separately to ensure confidentiality of information disclosed. Audio recordings of the interviews will be transcribed.

DO YOU HAVE TO PARTICIPATE? Participation in this is strictly voluntary, and participants can choose to withdraw from the study from the 10th of May and choose not to answer questions without consequences or providing reasons.

ARE THERE ANY RISKS IN PARTICIPATING? There are no potential risks of participating in this research. All data will be handled in accordance with the University of Groningen ethics guidelines.

ARE THERE ANY BENEFITS IN PARTICIPATING? There will be no direct benefits from the research conducted, but this research may contribute to further knowledge on the research topics and be informative for future innovation in the approach to OW management.

HOW WILL INFORMATION YOU PROVIDE BE RECORDED,STORED AND PROTECTED? To ensure confidentiality, anonymization will be utilized to safeguard all participants. All data will be stored on the researcher's computer until the research submission. Then, according to GDPR rules of the University, the final findings and research presentation shall be stored, for open-source access for future use.

WHAT WILL HAPPEN TO THE RESULTS OF THE STUDY? The results of this study will be the submission for the Sustainable Entrepreneurship Project master's thesis, and will lead to the creation and presentation of an output poster. This poster will feature the major findings of the research and will be presented to our peers and faculty of the University of Groningen.

ETHICAL APPROVAL

This research study has obtained ethical approval from the Campus Fryslân Ethics Committee. As a researcher, all relevant ethical standards of the University of Groningen will be upheld.

INFORMED CONSENT FORM

Please sign the informed consent form prior to participation in this research. However, please note that you can withdraw by the 10th of May from participating during the interview process.

WHO SHOULD YOU CONTACT FOR FURTHER INFORMATION?

Name: George Gill Contact

email: g.a.gill@student.rug.nl

Appendix B: Informed Consent Form

Title study: OW Management and Carbon Credits as Climate Change Mitigation Strategies in Dutch Municipalities: Challenges and Opportunities

Name participant:

Assessment

● I have read the information sheet and was able to ask any additional question to the researcher.

● I understand I may ask questions about the study at any time.

● I understand I have the right to withdraw from the study by the 13th of May without giving a reason.

● I understand that at any time I can refuse to answer any question without any consequences.

● I understand that I will not benefit directly from participating in this research.

Confidentiality and Data Use

● I understand that none of my individual information will be disclosed to anyone outside the study team and my name will not be published.

● I understand that the information provided will be used only for this research and publications directly related to this research project.

● I understand that data (consent forms, recordings, interview transcripts) will be retained on the Y-drive of the University of Groningen server for 5 years, in correspondence with the university GDPR legislation.

Future involvement

● I wish to receive a copy of the scientific output of the project: **Yes / No**

● I consent to be re-contacted for participating in future studies: **Yes / No**

● Having read and understood all the above, I agree to participate in the research study: **Yes / No**

Date

Signature

Appendix C: Interview Guide with Themes

Relevance of Role to OW

1) What is your position within the organization?
2) What do you do professionally in OW management? How long?
3) What kind of OW does your organization manage?

Determine Priority

4) How does your company address sustainability and circular economy?
5) Is sustainability a priority for your company/the organization?
6) What are your organization's strategies related to climate change mitigation?

Carbon Credits

7) What do you know about carbon credits?
8) Are you working within your organization to recognize any opportunities with carbon credits?
9) Would you develop a climate change strategy that embraces carbon credits? If yes, how? If not, why?

Ambition

10) What do you do with your OW material? How are you using it as a new material for new products?
11) What products do you offer related to OW?
12) Do you offer digitization and service tracking internally? Do you offer that to customers?

Appendix D: Transcripts Examples (via hyperlink)

SEP Interview 1-Transcript

SEP Interview 3-Transcript

SEP Interview 5-Transcript

SEP Interview 7-Transcript