SHARING KNOWLEDGE IN AN EMERGING FIELD: THE CASE OF A KNOWLEDGE MANAGEMENT SYSTEM FOR CARBON FARMING IN THE NETHERLANDS

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Sharing Knowledge in an Emerging Field: The Case of a Knowledge Management System for Carbon Farming in the Netherlands

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Preface

This master's thesis represents an original intellectual contribution by the author, Theodosios Athanasakis.

The interviews conducted and reported in Chapters 3 to 7 were carried out in accordance with the guidelines and procedures of TU Delft (available at https://shorturl.at/dqtST). Prior to the commencement of each interview, informed verbal or signed consent was obtained from every participant, ensuring their voluntary participation and compliance with ethical standards.

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Executive Summary

In response to pressing climate change concerns, the Netherlands is actively pursuing sustainable practices within the Agriculture, Forestry, and Other Land Use (AFOLU) sector. Carbon Farming (CF), a strategy involving Carbon Dioxide (CO_2) extraction and soil carbon storage, plays a crucial role. However, limited accessible knowledge and information hinder its widespread adoption.

This study introduces a tailored Knowledge Management System (KMS) for Carbon Farming in the Netherlands. Through secondary research and stakeholder insights, this study identifies crucial information requirements, presentation preferences, and challenges.

It employs a case study approach and qualitative interviews to address the challenge of low adoption of Carbon Farming practices in the Netherlands. The primary research question explores the significance of a Carbon Farming Knowledge Management System (CFKMS) for the region of the Netherlands in disseminating knowledge and effectively addressing the most common information gaps within the sector.

The research design encompasses two primary phases: the implementation of online semi-structured interviews with diverse stakeholders to gather insights into the digitalization of knowledge for Carbon Farming practices and the collection of secondary data about challenges and drivers, established global agricultural knowledge platforms.

The study results in the proposal of a dynamic Carbon Farming Knowledge Management System (CFKMS). This system features a dynamic Knowledge Base and a user-centric design strategy, serving as a repository of current and precise information. It stimulates content generation through both financial and non-financial incentives. Complemented by functionalities like a Project-based Hub, Maps, Announcements, and Learning resources, the CFKMS emerges as a potential catalyst to foster collaboration, streamline processes, and elevate knowledge exchange within the domain of Carbon Farming.

This selection of features by the stakeholder groups has unveiled a plethora of interesting insights regarding the desired features outlined by stakeholders. Notable observations include the importance of the Knowledge Base (KB), the significance of projects, diverse presentation preferences among stakeholders, and the need for collaborative dialogue. Figure 5.1 serves as a visual representation of the results, revealing the distribution of user groups and emphasizing the role of farmers, researchers, and funders.

Furthermore, the research compared the features of CFKMS identified through interviews with those of existing KMSs. Notable findings encompass the presence of Knowledge Bases in both analyses, differences in content categories, and the unique importance of projects. The CFKMS incorporates specific functionalities to address stakeholders' needs and aligns with broader KMS requirements in agriculture.

Subsequently, the thesis delved into an in-depth analysis of challenges unveiled via interviews, the Carbon Credit process, and relevant literature. This inquiry aimed to discover the ways in which potential features of the CFKMS could potentially mitigate these challenges. The CFKMS demonstrates possible solutions to challenges related to project complexity, funding sources, user requirements, content maintenance, financial compensation, and more. This study contributes to reaching a complete solution, with the CFKMS offering valuable tools and resources to navigate these challenges effectively.

Additionally, the study underscores the enthusiastic engagement of key stakeholders, including farmers, researchers, policymakers, advisors, and funders, with the proposed CFKMS. Nonetheless, the significance of broadening the inquiry to encompass additional user categories, including brokers, Carbon Credit buyers, validators, journalists, and the general public, remains a compelling imperative.

In conclusion and as shown by the research, a significant drawback of Carbon Farming at this point is attributed to the limited availability and accessibility of information. Consequently, establishing effective communication channels and facilitating information exchange among researchers, policymakers, and farmers emerges as a pivotal necessity. It is important for policymakers and stakeholders to prioritize the provisioning of easily accessible, high-quality information to farmers concerning Carbon Farming practices (Marit Ellen Kragt et al., 2014; Evans, 2018). In this context, the creation of a comprehensive Knowledge Base (KB) holds great promise, as it can furnish valuable insights into diverse aspects of Carbon Farming practices, encompassing both success and failure stories, along with an encompassing coverage of relevant policies and regulations. This could help address the uncertainty and confusion surrounding carbon markets and selecting a carbon project suited to specific regions or practices.

The Netherlands' commitment to quality of life and its focus on Peatlands, Forestry, and Bioenergy with Carbon Capture and Storage (BECCS) necessitate efficient resource utilization. A CFKMS offers a practical path to meet these goals, aiding domestic sustainability and global Carbon Farming promotion. The advantages of this initiative can lead to greater acceptance and utilization of Carbon Farming practices throughout the Netherlands. However, the CFKMS is a stepping stone, demanding a user-centered design and a comprehensive KB. This approach streamlines processes, fosters collaboration, and enhances Carbon Farming project execution. While promising, the CFKMS should be regarded as an initial solution to strengthen coordination, knowledge sharing, and collaboration among Carbon Farming stakeholders.

Contents

List of Abbreviations

AFOLU Agriculture, Forestry, and Other Land Use. iii, 1, 2, 4, 6

BECCS Bioenergy with Carbon Capture and Storage. iv, 2, 7, 47, 53

CF Carbon Farming. iii, iv, 1–6, 14–17, 19, 21, 22, 24, 25, 28, 29, 32–35, 41, 42, 44, 46–48, 50, 53, 54

CFKMS Carbon Farming Knowledge Management System. iii, iv, 3, 4, 15, 23, 24, 27–30, 41–47, 50–54

CO_2 Carbon Dioxide. iii, 1, 2, 5–8

EU European Union. 1–3, 7, 8

GHG Greenhouse Gas. 1, 2, 4–6, 8, 14, 73

KB Knowledge Base. iii, iv, 27, 31, 39, 42, 45, 46, 52, 53

KM Knowledge Management. 2, 3, 5, 12–14, 21, 30, 36, 37, 44

KMS Knowledge Management System. iii, iv, 2–5, 13–16, 21–25, 32, 36, 39, 41–44, 48, 50, 53

LANDMARC Land Use Based Mitigation for Resilient Climate Pathways. ii, 6

LMT Land-based Management Technology. 6, 33

MOT Management of Technology. 49–51

MRV Monitoring, Reporting, and Verification. 25, 28, 29, 33

NGO Non-Governmental Organizations. 17, 75, 76

PDD Project Design Document. 9, 10, 73, 74

RKMP Rice Knowledge Management Portal. 30, 32, 44, 61, 62

SNK Stichting Nationale Koolstofmarkt (National Carbon Market Foundation). 8–10, 14, 26, 27, 41, 73, 74, 76

VCM Voluntary Carbon Market. 8, 9, 29, 34, 47, 48

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Chapter 1

Introduction

In the 21st century, climate change has become increasingly evident due to rising temperatures (Stern and Kaufmann, 2014). As a result, governments worldwide have prioritized sustainability and climate change mitigation.

To understand the causes of climate change, it is crucial to recognize the role of anthropogenic factors, particularly the increase in Greenhouse Gas (GHG) emissions (Crowley, 2000). Reducing GHG emissions has become a critical imperative (Crowley, 2000), leading to the implementation of policies and agreements like the Paris Agreement by governments, including the European Union (EU) (IPCC, 2019). Agricultural practices are among the strategies being explored to address this challenge.

Altering land management practices is seen as a viable solution to mitigate climate change (Smith et al., 2013). Farmers play a crucial role in this effort as they are at the forefront of land management and have the potential to overcome climate-related obstacles and contribute to climate targets (Smith et al., 2013).

The Agriculture, Forestry, and Other Land Use (AFOLU) ranks second in GHG emissions after the energy sector (IPCC, 2019). Land serves as a vital carbon sink, with CO_2 stored in soil and biomass. Thus, the AFOLU sector plays a crucial role in achieving the goals of the Paris Agreement by facilitating the absorption of these gases (Karki, 2021).

Moreover, soil contains significant organic carbon reservoirs, as highlighted by Reijneveld, Wensem, and Oenema (2009) in their study on soil carbon dynamics. Carbon sequestration in soils is recognized as a strategy to mitigate the adverse effects of increasing greenhouse gas emissions (Janzen, 2004).

Enhanced agricultural management enables farmers to actively participate in Carbon Farming (CF), which entails the extraction of Carbon Dioxide (CO_2) from the atmosphere and its sustainable storage as Soil Organic Carbon within the soil (P. Sharma, 2015). Carbon Farming presents a strategy to address climate change while concurrently enhancing agricultural sustainability. By employing a variety of methods, farmers can augment their land's ability to assimilate and retain CO_2 (Dumbrell, Marit E. Kragt, and Gibson, 2016).

Even though the Netherlands is a small country, it is highly developed and actively involved in mitigating GHG emissions through the AFOLU sector and Carbon Farming. Peatland Management, Forestry, and Bioenergy with Carbon Capture and Storage (BECCS) are the main areas of focus (LANDMARC, 2021). Effective management of peat soils, used for agriculture, is crucial for emission reduction and carbon sequestration (Reijneveld, Wensem, and Oenema, 2009). The country also aims to expand its forest area by 10% by 2030 through agroforestry, contributing to carbon sequestration (LANDMARC, 2021). Additionally, BECCS technology utilizes biomass for energy production while capturing and storing carbon emissions, offering potential benefits like lower climate policy costs and energy prices in the EU (Bollen and Aalbers, 2017).

In order to incentivize and facilitate the efforts of stakeholders involved in climate change mitigation, the Kyoto Protocol introduced a trading mechanism known as Carbon Credits. These credits are quantified in terms of tons of CO_2 equivalent and possess a market value like all other commodities. The generated revenue from the sale of Carbon Credits is commonly referred to as carbon finance (Gupta, 2016). This system provides financial incentives for sustainable practices and serves as a mechanism for promoting GHG emissions reduction and overall environmental sustainability.

A significant hurdle in the widespread adoption of these practices lies in the limited availability of accessible knowledge for farmers who are interested in implementing one or multiple sustainable practices into their existing land and getting their rewards, as well as that many farmers remain unaware of these beneficial practices. This challenge encompasses, among others, a lack of information and comprehension regarding the benefits associated with these practices (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014; Evans, 2018; Demeyer, 2021), as well as the intricate process of acquiring a certification and the absence of standardized methodologies (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014).

The challenge of addressing the issue of limited available information can be tackled through the implementation of knowledge-sharing techniques among the various stakeholder groups involved in this process. The dissemination of innovative knowledge has emerged as a significant area of research in management science and economics, as highlighted by Baalen, Bloemhof-Ruwaard, and Heck (2005). Given the potential for knowledge sharing to contribute to sustainable competitive advantage, it is generally beneficial for most stakeholders to engage in knowledge sharing (E. F. Cabrera and A. Cabrera, 2005).

To facilitate the successful diffusion of knowledge, it is crucial to contextualize and effectively manage it in a certain context. The concept of Knowledge Management involves various processes such as generating, capturing, acquiring, authenticating, and applying knowledge to enhance the functioning and performance of organizations (Sulaiman V et al., 2011; Kumar, Singh, et al., 2017).

Knowledge Management Systems (KMSs) serve as "a class of information systems [with the objective] to support the creation, transfer, and application of knowledge in organizations" (Alavi and Leidner, 2001, p. 1).

In the agricultural domain, but not in Carbon Farming, specific KMSs have been established to facilitate the dissemination and exchange of information among farmers, researchers, policymakers, and other relevant stakeholders (Kumar, Singh, et al., 2017; Soulignac et al., 2019; *AgroWiki* n.d.; Yadav et al., 2015). They act as centralized hubs, providing access to a plethora of materials that are suited to certain agricultural situations.

Through those, farmers have access to comprehensive advice on agricultural practices, including details on advantages, difficulties, and potential financial incentives. The portals also give farmers access to scientific studies, monitoring procedures, and data analysis tools so they may assess the potential of their property and monitor their development over time. Furthermore, the platforms encourage cooperation and promote the sharing of experiences and lessons learned among farmers, researchers, and practitioners (Kumar, Singh, et al., 2017; Soulignac et al., 2019; *AgroWiki* n.d.; Yadav et al., 2015).

Within the Carbon Farming domain, the availability of publicly accessible or known dedicated digital platforms remains absent. Looking at the previous characteristics of KMSs in other domains of agriculture, utilizing the potential of Knowledge Management through shared learning and ongoing development can be advantageous for the sector.

This culture of knowledge-sharing benefits all parties involved. Hence, it is imperative to evaluate the distinct needs and prerequisites of the Carbon Farming sector to facilitate the development of suitable digital platforms for the dissemination of knowledge.

Farmers can encourage one another in adopting successful Carbon Farming practices by exchanging success stories, creative approaches, and difficulties encountered (Kumar, Singh, et al., 2017; Baalen, Bloemhof-Ruwaard, and Heck, 2005). A recent study conducted by Fuijta et al. (2023) demonstrated the feasibility of generating spatially explicit recommendations for Carbon Farming at scales encompassing individual farms and fields. Such recommendations offer practical guidance for the implementation of Carbon Farming practices, thereby contributing to climate change mitigation efforts (Fuijta et al., 2023).

Moreover, by allowing researchers to transform scientific information into practical insights for application on the ground, this portal can close the gap between research and practice.

This thesis endeavors to delineate the goal of a Knowledge Management System for Carbon Farming within the Netherlands region. To achieve this, a combination of secondary research data and stakeholder interviews were equipped, providing firsthand insights into their specific perspectives and requirements concerning the potential Carbon Farming Knowledge Management System (CFKMS). Additionally, the interviews delved into the overarching challenges related to Carbon Markets and Carbon Credit acquisition. This research serves as a fundamental basis for the potential adoption of the KMS by farmers and for the wider dissemination of Carbon Farming practices throughout the Netherlands.

Problem Statement and Research Questions

The Netherlands, as a member of the EU, has committed to achieving zero emissions by 2050 in response to climate change, with the AFOLU sector being the second largest GHG emitter after the energy sector. However, despite the potential benefits of some agriculture practices that can reduce emissions, like Carbon Farming (CF), a lack of understanding among (Dutch) farmers and stakeholders about its benefits and procedures is hindering its adoption in the country. This lack of understanding poses a significant challenge to meeting the Netherlands' emissions targets, making it necessary to explore potential solutions to increase adoption rates in the country. To tackle this issue, this thesis aims to explore the areas of contribution of a potential implementation of a Carbon Farming Knowledge Management System (CFKMS) in the Netherlands, fostering increased adoption rates and helping the nation's initiatives in combating climate change.

Therefore, the main question that needs to be answered in this research is:

How can a specialized Knowledge Management System (KMS) focused on Carbon Farming, as an emerging carbon trading sector, disseminate knowledge and effectively address the most common information gaps within the sector?

In addition to addressing the main research question, this study seeks to provide insights into several related sub-questions that further enrich and reinforce the findings. These sub-questions encompass:

1. What are some of the most important features of a Carbon Farming Knowledge Management System (CFKMS) as identified by the interviewees?
2. How do the findings from interviewed stakeholders compare to the features of other existing agricultural KMSs worldwide?
3. What challenges, highlighted by both interviewed stakeholders and existing literature, could potentially be addressed by the proposed Carbon Farming Knowledge Management System (CFKMS)?

Chapter 2

Background Literature

The objective of this background study is to investigate current research pertaining to Carbon Farming and the digitalization of any associated knowledge. The study aims to provide an analysis of key findings and trends in the field. The review encompasses an examination of recent and pertinent literature, including academic articles, journals, books, and grey literature like blogs, white papers, and general webpages, whenever nothing else is available.

This chapter covers four main topics: Carbon Farming, Financial Incentives for Farmers, Digitalization of Knowledge, and the reasons behind the active involvement of stakeholders during this research. In Section 2.1, Carbon Farming is defined and discussed, including a definition and its associated practices, while Section 2.2 explains the incentives for farmers behind implementing Carbon Farming practices. Section 2.3 shifts the focus to the Digitalization of Knowledge, providing first a definition and some characteristics of Digitalization as a whole, and then, emphasizing the importance of Knowledge Sharing and discussing Knowledge Management. Finally, Section 2.4 analyzes the reasons for active stakeholder participation in the development of a KMS for Carbon Farming.

By the end of this chapter, readers will gain a comprehensive understanding of these topics, including their definitions, practices, and procedures, setting the foundation for the following discussion of results in Chapters 4 and 5.

2.1 Carbon Farming

2.1.1 Definition of Carbon Farming

Carbon Farming encompasses a range of environmentally friendly land use and land management practices that aim to increase carbon storage in the soil through carbon sequestration, thereby mitigating GHG emissions such as CO_2, CH_4, and N_2O in the environment (P. Sharma, 2015; Dumbrell, Marit E. Kragt, and Gibson, 2016). It presents a sustainable approach to food and product production by reducing emissions and promoting sustainable land utilization (M. Sharma et al., 2021). Through enhanced removal of CO_2 from the atmosphere and its conversion into plant material or soil organic matter, Carbon Farming can contribute to reducing people's carbon footprint and building a more sustainable future (P. Sharma, 2015).

Carbon Farming can be considered a form of LMT when it involves practices that actively remove GHGs from the atmosphere and increase carbon sequestration in the soil or contribute to social and ecological sustainability. The project "Land Use Based Mitigation for Resilient Climate Pathways (LANDMARC)[1]" defines LMT as a "deliberate action that (i) reduces the emission of GHG from land use; and/or (ii) removes GHG from the atmosphere and/or enhances land as a sink of GHG" (Karki, 2021, p. 10).

Landholders can voluntarily participate in Carbon Farming through a carbon offset scheme that rewards them economically for reducing GHG emissions. The scheme involves both sequestration, which stores carbon on land, and emissions avoidance, which prevents GHG emissions from entering the atmosphere (P. Sharma, 2015).

Additional terms used to describe similar practices include Negative Emissions Technologies and Practice, Carbon Dioxide Removal Solutions, Land-based Management Technologies, and Nature-based Solutions (Karki et al., 2023). However, this report specifically focuses on the practices falling under the scope of "Carbon Farming".

2.1.2 Practices

To promote Carbon Farming, landholders engage in nature-based activities. A report by Mcdonald et al. (2021), requested by the Committee of Environment Public Health and Food Safety, and another from Jennifer (2023) identify five key activities in the field. These activities include Managing Peatlands, Agroforestry, Maintaining and Enhancing Soil Organic Carbon on Mineral Soils, Livestock and Manure Management, and Nutrient Management on Croplands and Grasslands. Below, there is a short definition and explanation of each of the practices.

Managing Peatlands Peatlands, as defined by the IPS (n.d.), are "terrestrial wetland ecosystems in which waterlogged conditions prevent plant material from fully decomposing". When drained, peatlands release previously stored carbon along with other GHGs (Mcdonald et al., 2021). In the Netherlands, approximately 9% of the land area comprises peat soils, commonly used for agriculture. Given their significant presence, effective management of peatlands is crucial for mitigating GHG emissions and promoting carbon sequestration (Reijneveld, Wensem, and Oenema, 2009).

Agroforestry Agroforestry aims at establishing productive and sustainable land use practices by combining agriculture and forestry (Karki, 2021). This method benefits

[1]Land Use Based Mitigation for Resilient Climate Pathways (LANDMARC) is a 4-year EU-funded project that explores the potential of land-based negative emission solutions in AFOLU sectors. It is funded under the European Union Horizon 2020 research and innovation program, Grant Agreement No 869367 (LANDMARC) (Karki et al., 2023).

from the advantages of growing trees and shrubs alongside crops and/or livestock, as noted by (USDA, n.d.). Agroforestry systems, which combine forestry plants with agricultural and/or animal systems, are essential for storing carbon in soils and above-ground biomass (Mcdonald et al., 2021). In the Netherlands, agroforestry is gaining significance, as the government targets a 10% increase in forest area by 2030 and promotes the expansion of tree coverage through these practices to enhance carbon sequestration (LANDMARC, 2021).

Maintaining and Enhancing Soil Organic Carbon on Mineral Soils In order to maintain and enhance Soil Organic Carbon levels, agricultural soils must achieve a balance between carbon inputs and losses (Mcdonald et al., 2021). However, there is disagreement on the relationship between the potential for agricultural land to store atmospheric CO_2 in Soil Organic Carbon pools and its ability to act as a climate change mitigation strategy (Harbo et al., 2022).

Livestock and Manure Management "Manure (also known as livestock manure) is organic matter, mostly derived from animal feces and urine, but normally also containing plant material (often straw), which has been used as bedding for animals and has absorbed the feces and urine" (Eurostat, 2020). The management of it contains the various steps adopted by respective farmers to mitigate emissions from their farming activities (Mcdonald et al., 2021).

Nutrient Management on Croplands and Grasslands Nitrogen and phosphorus are two essential nutrients that maintain human life. Excessive nutrient loading in the Earth's system, however, raises environmental issues such as regional water and air pollution and global climate change (Zhang et al., 2020). Nutrient management practices aim to mitigate N_2O emissions resulting from manure and livestock management, as well as feed measures (Spijker, 2022). Better nutrition budget quantification is necessary for sustainable nutrient management, which is a significant problem of this century (Zhang et al., 2020).

Bioenergy with Carbon Capture and Storage (BECCS) is a technology that is included in multiple categories. It involves utilizing biomass for energy generation while simultaneously capturing and storing the carbon emissions produced. The adoption of BECCS offers numerous benefits, including the reduction of climate policy costs and the potential to lower energy prices within the EU (Bollen and Aalbers, 2017).

It is important to note that the report does not aim to provide an exhaustive technical review of these practices. Instead, it focuses on highlighting the fundamental aspects of each approach.

2.2 Voluntary Carbon Market (VCM) in The Netherlands

The Kyoto Protocol and the Paris Agreement established international CO_2 emissions goals. As a result, national emissions targets and regulations have been implemented.

This has put increasing pressure on businesses to reduce their carbon footprint (Carbon Credits, n.d.). Carbon markets have emerged as a solution, divided into compliance markets and voluntary markets.

Compliance markets, such as the EU Emissions Trading System, operate under a cap-and-trade system. In this system, carbon-emitting parties are allocated carbon allowances that limit their emissions. These allowances can be traded between parties, allowing for the transfer of surplus allowances and addressing emission coverage gaps. The overall number of allowances is finite and determined through regulation, leading to scarcity and influencing the demand and price for allowances (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008).

In VCMs, participation is optional and there are no legal obligations to purchase Carbon Credits. Parties in the voluntary market choose to buy credits to offset emissions beyond their legal requirements and there is no limit on the number of voluntary credits that can be created. These credits represent reductions from climate change projects and can be used to comply with regulations, offset specific activities, or achieve carbon neutrality. The baseline-and-credit system generates credits with each new reduction or removal project, allowing for their continuous creation. These markets facilitate the trading of these credits, providing a mechanism for companies to buy and sell them (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

Carbon Credits or Certificates represent a fixed amount of carbon emission reduction and act as permission slips for emissions. Holders of these credits can retire them, making them unavailable for trading, and gain permission to generate a specific amount of CO_2 emissions. Companies that have excess credits can sell them to other companies, creating a flow of carbon revenue from buyers to regulators (Wessel and Boer, 2023; Carbon Credits, n.d.; Jennifer, 2023).

Carbon credits and associated projects can be categorized into two main types. The first comprises reductions or avoidance projects, which aim to prevent the release of GHG emissions into the atmosphere or decrease the overall amount of GHGs emitted. These projects focus on conserving natural resources and supporting the transition to renewable energies. The second category includes removal and sequestration projects, which utilize natural resources or technology to capture and store carbon or remove it from the atmosphere. Removal credits, due to their direct impact on GHG reduction, hold significant value and are often traded at a premium compared to avoidance credits. They are recognized as a powerful tool in the battle against climate change (IOSCO, 2022; Favasuli and Vandana, 2021).

In the Netherlands, the Stichting Nationale Koolstofmarkt (National Carbon Market Foundation) (SNK) plays a crucial role in supporting this voluntary market. Established in 2019, SNK includes nature-based related projects that reduce emissions or sequester carbon. It assesses plans, issues certificates, and facilitates transactions between suppliers and buyers. It originated from the Green Deal Nationale Koolstofmarkt (Green Deal National Carbon Market), a collaborative agreement signed in May 2017 by the government, companies, local initiatives, and nature and environmental organizations (Spijker, 2022; JIN, n.d.).

SNK ensures the credibility of carbon certificates, instilling market confidence that the stated emission reductions or carbon sequestration have been successfully achieved. It functions as a dedicated initiative rather than a policy instrument, ensuring that projects are certified only if they provide additional reduction or removal of emissions beyond existing policies. It has developed a set of methods called the *Rulebook* to calculate emission reductions for various project types. Project parties follow these methods when preparing project plans, which SNK validates. Once validated, projects can commence, effectively reducing emissions. Independent experts verify the achieved emission reductions, and SNK issues certificates to the project parties based on the verified results (Spijker, 2022; SNK, n.d.).

SNK operates independently, with the authority to determine the rules and methods outlined in the *Rulebook*. The board of SNK, consisting of independent members, establishes these rules and methods without external influence from third parties, the national government, or public and private entities (SNK, n.d.).

Carbon certificates issued by SNK serve as evidence that organizations voluntarily invest in emission reductions through Dutch projects. Typical buyers of SNK certificates are parties actively committed to reducing their climate impact, preferring projects in their own regions. This creates a tangible connection where people can witness the impact, such as cycling past a project during the weekend (JIN, n.d.).

2.2.1 Process of Voluntary Carbon Credit Acquisition in the Netherlands

The process of creating Carbon Credits in the VCM involves several steps. While this study primarily focuses on the Netherlands and the voluntary market, it is important to note that the overall procedure is similar across different carbon markets with variations in the regulatory bodies overseeing the process.

While the VCM encompasses a broader range of activities beyond Carbon Farming, this section aims to provide a general overview of the process based on relevant papers and web sources. For a more detailed understanding of each step and stakeholder, including visual representations and diagrams, please refer to Appendix B.

Project Planning

In the initial phase of Carbon Credit creation, project developers secure financing, undergo validation by an independent verifier, and register the project, signifying approval and eligibility for generating Carbon Credits (Broekhoff et al., 2019).

Project Design These actions include developing the project concept, selecting appropriate methodologies and standards, and engaging in consultations with stakeholders to ensure the project's compatibility with local communities. All of these activities are reported in the Project Design Document (PDD) (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

Project Validation Once the PDD is prepared, at least two experts from the Board of SNK verify the project design (GDNK, 2019).

Project Registration The project is formally registered once the SNK gives its approval, based on the PDD, validation report, and public comments (Kollmuss, Zink, and Polycarp, 2008).

Project Implementation and Management

Implemented programs are subject to monitoring and periodic verification to assess emission reductions, with resulting credits deposited into the project developer's registry account (GDNK, 2019; Broekhoff et al., 2019). It is crucial for project developers to submit all required documentation to increase the chances of approval, even if the project begins before official authorization.

Project Monitoring Project developers must create monitoring reports to document project progress and carbon reduction achieved, following PDD guidelines for approval by SNK, with monitoring frequency balanced against costs and revenues (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; GDNK, 2019).

Project Verification The project developer submits the monitoring report to the verifier, who conducts an evaluation. Based on their examination, the verifier drafts a report outlining any identified issues, which the developer addresses before the verifier creates the final verification report (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008).

Project Certification / Issuance The verification report is submitted to the SNK for certification, leading to the issuance of Certified Emission Reductions to the project participant's registry account, with credits distributed either in a one-time event or continuously throughout the project's operational phase after fee payment (GDNK, 2019; Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

Commercialization / Offset Credit Transfer / Trade After the issuance of carbon credits, project developers have the opportunity to sell them either to potential buyers or directly to end buyers, with traders playing a role in arbitrating between markets and speculating on price increases (GDNK, 2019; Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008). The sale of credits can occur at any project phase, and payment is typically received after the delivery of credits, although advance payments may be possible in some cases (Kollmuss, Zink, and Polycarp, 2008).

Credit Retirement To use a carbon credit, it must be retired following the registry's specified process. Retired credits are taken out of circulation, cannot be transferred or traded, and their retirement should be registered in the standard setter's central registry for transparency (Wessel and Boer, 2023; Broekhoff et al., 2019; IOSCO, 2022; GDNK, 2019).

2.3 Digitalization of Knowledge

2.3.1 Digitalization

To fully comprehend the concepts related to digitization, it is essential to establish clear definitions. Within the literature and business domains, there are three terms that are often used interchangeably but actually possess distinct meanings and applications (Reis et al., 2020; Danielsen, 2021).

The first term is digitization. It refers to "the process of changing from analog to digital form" (Bloomberg, 2018). This entails transforming data, documents, images, or any other analog content into digital forms that can be conveniently stored, manipulated, and accessed electronically. An illustrative example of digitization is the conversion of paper documents into Portable Document Format (PDF) files through scanning (Bloomberg, 2018).

Moving on to digitalization, the term encompasses various definitions. However, a comprehensive literature study conducted by Reis et al. (2020) concluded that digitalization is "the phenomenon of transforming analog data into a digital language (i.e. digitization), which, in turn, can improve business relationships between customers and companies, bringing added value to the whole economy and society" (Reis et al., 2020, p. 448). Thus, researchers frequently see digitalization as a sociotechnical process that includes social and human factors in addition to technical ones (Danielsen, 2021).

Lastly, digital transformation, which also has multiple interpretations, aims to achieve a unified definition. According to research, digital transformation is "a fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity [organization, business network, industry, or society] and redefine its value proposition for its stakeholders" (Gong and Ribiere, 2021, p. 10).

Among the three terms discussed, digitalization emerges as the primary focus of this analysis, given its direct relevance and potential to enhance communication and knowledge-sharing in the domain of Carbon Farming. While the terms digitization and digital transformation also hold significance in this context, their comprehensive examination falls beyond the scope of this study. Nevertheless, it is worth noting that the literature may not consistently employ precise terminology. Therefore, this report will incorporate relevant examples, even if they are not explicitly categorized under the exact term, based on the definitions provided earlier.

2.3.2 Knowledge Sharing

Knowledge sharing refers to "the provision of task information and know-how to help others and to collaborate with others to solve problems, develop new ideas, or implement policies or procedures" (Wang and Noe, 2010, p. 117). It also involves sharing task-related information and expertise to help others (Wang and Noe, 2010).

The literature on innovation and technology transfer serves as the foundation for the study of knowledge sharing (J. Cummings, 2003). This information transfer can occur via a variety of means, including textual communication, in-person interactions, networking with experts, or documenting and structuring knowledge for accessibility (J. N. Cummings, 2004).

Sharing knowledge is viewed as a dynamic learning process where businesses interact often with clients and suppliers to encourage originality and inventive imitation (J. Cummings, 2003). It is important to understand that power dynamics inside the company have an impact on knowledge sharing because it is a complex and valuable activity (Ipe, 2003). Similar to this, Baalen, Bloemhof-Ruwaard, and Heck (2005) claim that knowledge transfer within and across organizations is an ongoing process including trial and error, feedback, and mutual adjustments between knowledge sources and recipients rather than an isolated activity (Baalen, Bloemhof-Ruwaard, and Heck, 2005).

2.3.3 Knowledge Management (KM)

The classification of knowledge entails a fundamental division into two overarching categories: explicit/codified knowledge and tacit knowledge (Stover, 2004). The former encompasses information that is clearly articulated and transmitted through formal language, encompassing grammatical statements, mathematical expressions, and models. It lends itself to computer processing, electronic transmission, and storage within databases. Conversely, tacit knowledge refers to personal knowledge embedded within individual experience, encompassing intangible elements such as personal beliefs, perspectives, and value systems. Sharing tacit knowledge poses a comparatively greater challenge than sharing explicit knowledge. Nevertheless, tacit knowledge plays a pivotal role in attributing meaning to explicit knowledge and contributing to the creation of new knowledge (Sulaiman V et al., 2011).

The agricultural domain has grown increasingly intricate, necessitating farmers' access to reliable, timely, and pertinent information. In this context, farmers require access to diverse, multisource, and context-specific information (Kumar, Singh, et al., 2017; Danielsen, 2021).

Two fundamental components of KM are "knowledge" and "management". The concept of "knowledge" includes a person's attitudes, accumulated experiences, and learned abilities, which enable them to complete tasks consistently, methodically, and effectively. On the other hand, "management" refers to the activity that coordinates people's choices in order to attain goals and purposes by skillfully and effectively utilizing the resources at hand (Kumar, Singh, et al., 2017).

According to the works of Kinney (1999), KM can be defined as "the process by which an organization creates, captures, acquires, and uses knowledge to support and improve the performance of the organization" (Kinney, 1999, p. 1). The author distinguishes between two different types of KM. The first involves identifying and encoding knowledge through archiving and cataloging. The second type tries to facilitate the information transfer within the company (Kinney, 1999).

KMSs serve as “a class of information systems [with the objective] to support the creation, transfer, and application of knowledge in organizations” (Alavi and Leidner, 2001, p. 1). They are valuable tools in the conversion of tacit knowledge into explicit knowledge and vice versa. Basically, they are designed to capture, organize, store, retrieve, and share information and knowledge within an organization. Prominent instruments utilized in KM include organizational web pages and specialized portals designed for specific commodities, sectors, enterprises, or activities. Furthermore, electronic databases, audio and video recordings, and multimedia presentations are extensively employed to capture and disseminate knowledge (Kumar, Singh, et al., 2017).

2.4 Stakeholder Engagement in KMSs’ Development Process

In the context of Knowledge Management, determining the requirements for a system can be challenging due to uncertainties surrounding information needs, requesters, suppliers, and the timing and usage of information (Hahn and Subramani, 2000). Additionally, as emphasized by Riege and Lindsay (n.d.), “The better the knowledge base upon which public policies are built, the more likely they are to succeed”. This highlights the importance of not only building an accurate knowledge base but also doing so in a thoughtful and effective manner.

Firstly, engaging and empowering stakeholders and end users during the development of a KMS is crucial for its success. Research has highlighted that many KMSs’ efforts fail when they overlook the involvement of the very people who are intended to benefit from them. Project managers and developers often make assumptions that do not align with the actual needs of end users, placing excessive emphasis on technology rather than user-centric design. As a result, end users may be resistant to change until their specific requirements are addressed. By actively involving stakeholders and end users from the outset, organizations can enhance the chances of creating a KMS that truly meets their needs and delivers value (Hilger and Wahl, 2022).

In addition, the involvement of real users is essential in defining also the profile of typical system users. Without their active participation, it becomes challenging to accurately understand their needs and objectives. Traditional systems development methodologies often make the assumption that users share similar objectives and requirements, leading to a sampling of representative users for requirements gathering and user testing. However, this approach may not be sufficient in the context of KM. By actively engaging the actual users, organizations can ensure that the KMS is tailored to their specific needs, maximizing its effectiveness and usability (Hahn and Subramani, 2000).

Lastly, another crucial success factor in the adoption of a KMS is user motivation. The usage and effectiveness of a KMS heavily rely on user acceptance. A proven strategy to enhance user acceptance is by actively involving them in the process of creating the system. This involvement fosters a greater sense of motivation and commitment among users, as their input and perspectives are valued and integrated into the system. By involving users in the process of creating the system, organizations can increase user motivation and commitment, leading to higher levels of adoption and utilization of the KMS (Hahn and Subramani, 2000; Riege and Lindsay, n.d.).

Active participation of stakeholders and end users can be ensured through various strategies. Government and stakeholder partnerships play a crucial role in the development process, with the primary aim of facilitating the effective transfer of scientific and socially-based knowledge from stakeholders to governments. It is important for governments to manage diverse stakeholder views, considering expert support and addressing conflicting objectives that may arise. Enhancing stakeholder capacity is essential, as effective stakeholder participation contributes to more effective public policy outcomes. Moreover, capturing and disseminating socially constructed knowledge is particularly valuable for governments, as people serve as key knowledge repositories (Riege and Lindsay, n.d.).

2.5 Literature Summary

This review explores Carbon Farming research and its digital knowledge shift, analyzing trends. Encompassing a wide spectrum, the analysis includes Carbon Farming practices, associated incentives, basics of the digitalization of knowledge, and reasons for the active engagement of stakeholders, providing a foundation for later discussions.

Carbon Farming involves eco-friendly land management to store carbon and reduce GHG emissionss. Within this domain, specific practices include Peatland Management, Agroforestry, Maintaining and Enhancing Soil Organic Carbon on Mineral Soils, Livestock and Manure Management, and Nutrient Management.

The motivation for implementing these practices comes from incentives, namely Carbon Markets (compliance and voluntary), which emerged due to emission goals. Compliance markets have legal obligations, while voluntary markets involve purchasing Carbon Credits beyond requirements. Carbon Credits represent reductions, and SNK ensures their legitimacy in the voluntary market. The process involves project planning, implementation, monitoring, verification, certification, and credit commercialization. SNK ensures transparency and credibility in the market.

This study highlights the importance of Knowledge Sharing and Knowledge Management. These ideas help exchange useful information and expertise, encourage teamwork to solve problems, reshape how organizations work, and improve performance in challenging fields like Carbon Farming. To achieve this, they use tools like websites, databases, and multimedia presentations, which together form a Knowledge Management System (KMS) for effective sharing of both clear and hidden knowledge.

In this transitional landscape, the active involvement of stakeholders and users assumes paramount importance in the development of potent KMS. By ensuring a user-centric design, tailoring systems to individual needs, and developing user motivation, this involvement enhances the effectiveness of KMSs while fortifying decision-making support.

Chapter 3

Methodology

The research methodology used in this thesis is a case study style, which includes a thorough account of the methodology used from May to August 2023. This decision was motivated by the need to learn specific and in-depth information on a certain real-world topic that would be covered later.

The research objective satisfies all the criteria outlined by Yin (2018) for a case study. It focuses on answering the *how* or *why* questions, the researcher does not have control over the events being studied and explores a specific phenomenon, namely the development of a non-existing CFKMS in the Netherlands.

The case study that this research uncovers falls under *Type 1* (Yin, 2018), which focuses on a single case and a single unit of analysis. The research is set within the agricultural sector, delving into the various aspects and dynamics that are relevant to this specific domain. In particular, the case under examination is Carbon Farming and its implementation and practices in the Netherlands.

The unit of analysis for this study centers around the KMSs in Carbon Farming within the Netherlands. By focusing on the KMS, this thesis seeks to provide a comprehensive understanding of the purpose and potential benefits of implementing a CFKMS in the Netherlands. The aim is to enhance knowledge sharing and contribute to increased adoption rates of sustainable agricultural practices, aligning with the nation's efforts in addressing climate change.

The research process of this case study is structured around two primary steps, namely Qualitative Interview-based Study (Section 3.1) and Secondary Research (Section 3.2), and the results of them are outlined in Sections 4.1 to 4.3.

Using information gained from the aforementioned studies, all the research questions find their answers in Chapter 5. More precisely, the solution to the first sub-question is found in Section 5.1, where interview findings are combined into a Users-Features-Display diagram. Next, the second sub-question is addressed through a comparison of insights between the two studies, leading to conclusions in Section 5.2. Moreover, Section 5.3 blends the benefits and insights from the features to suggest solutions for challenges identified in both studies.

Drawing on the outcomes of the previous sub-questions, the main research question about the importance of a dedicated KMS for Carbon Farming for the Netherlands in disseminating knowledge and addressing the most common information gaps within the sector is answered in Section 5.4.

3.1 Qualitative Interview-based Study

In the **first step** of the research process, a qualitative study was conducted to gather insights and data on the digitalization of knowledge for Carbon Farming practices in the Netherlands.

By employing interviews as the primary data collection method, the study allowed for an exploration of these experts' perspectives, insights, and diverse experiences expressed by each party (Yin, 2018).

To ensure the accurate reporting of the research methodology, this study follows the model proposed by Tong, Sainsbury, and Craig (2007). This model includes a comprehensive checklist that assists researchers in documenting critical aspects of the research team, study methods, study context, findings, analysis, and interpretations. By adhering to this model, the study aims to provide a detailed and transparent record of the research process.

3.1.1 Research Team and Reflexivity

Personal Characteristics

The research team consisted of a master's student who conducted the interviews. The author of this thesis served as the primary interviewer. The researcher's role and occupation provided a suitable academic foundation and context for carrying out the research. Additionally, the researcher held the status of a master's student during the study, possessing an academic background and qualifications aligned with a master's degree level.

Although the researcher did not possess previous experience in conducting interviews, the performance improved, and familiarity with the process grew with each interview. This learning effect allowed for the enhancement of skills as the study progressed.

Relationship with Participants

The interviewer ensured a neutral position by having no pre-existing direct relationship with the study participants. However, in some cases, there were indirect relations with the thesis supervisors.

At the beginning of each interview or during the initial interaction, participants were provided with information about the interviewer's background and experience. The researcher shared motivations for conducting the study, discussed reasons and interests in the research topic, and addressed any questions or concerns participants had.

To ensure clarity and transparency, participants were provided with a clear understanding of the study's purpose. The voluntary nature of participation was emphasized, confidentiality measures were explained, and participants were reassured of their right to withdraw from the study at any point. The entire process was conducted in compliance with the guidelines and procedures of TU Delft[1]. Informed verbal or signed consent was obtained from each participant before the interview commenced.

3.1.2 Study Design

Participant Selection

The study employed snowball sampling as a recruitment technique. Snowball sampling involves leveraging the knowledge and assistance of initial research participants to identify and refer additional individuals who possess pertinent expertise and insights related to the research topic (Goodman, 1961). The sampling included university researchers, employees in NGOs, policy advisors, farmers participating in CF incentives, consultants in the field of CF, co-founders of funding companies, and business owners involved in the Carbon Credit process. These individuals were selected based on their valuable expertise and experiences, ensuring a diverse range of perspectives and opinions.

The involvement of farmers in the process ensures that a system is customized to address their unique needs and challenges. This approach enhances the system's acceptance and adoption, as farmers feel valued and are more likely to engage with a solution that takes their needs and expertise into account.

A total of **7** participants were included in the study (Table 3.1). They were approached through email or LinkedIn, depending on their availability. It is worth noting that some of the approached participants did not participate in the study due to personal reasons, holiday season, or language barriers they stated.

Setting

The interviews were conducted exclusively online between June 2023 and July 2023. Face-to-face interviews were not conducted, and the online format was utilized for all interactions. This approach allowed for flexibility and convenience, as participants could engage in the interviews remotely from their respective locations. During the interviews, only the interviewer and the participants were present to ensure privacy and confidentiality.

[1]More information about the procedure on `https://shorturl.at/dqtST`

No.	Short Title	Date
1	University Researcher	19/06/2023
2	Think-Tank Researcher	28/06/2023
3	Think-Tank Researcher	28/06/2023
4	Policy Advisor/Consultant	30/06/2023
5	Policy Advisor/SNK Member	03/07/2023
6	Farmer	06/07/2023
7	Funder	21/07/2023

Table 3.1: Table of Participants

Throughout the research process, strict adherence to ethical guidelines was maintained. Informed consent was obtained from all participants, safeguarding their privacy and emphasizing their right to participate voluntarily and withdraw from the study at any time without consequences. The research was conducted in accordance with the ethical guidelines and regulations established by TU Delft, ensuring the protection of participants' rights and confidentiality.

Data Collection

To gather comprehensive and reliable data, the study employed semi-structured interviews lasting approximately one hour each. This approach provided the necessary flexibility to delve into participants' experiences, opinions, and insights while maintaining a consistent structure across interviews (Yin, 2018). An interview guide was developed specifically for this research, aligning with the objectives and questions, and consisted of a series of open-ended questions aimed at eliciting detailed and in-depth responses. Although the questions were not pre-tested due to time constraints, they were refined and improved with each subsequent interview.

With participants' consent, audio recordings were made to ensure accurate data capture, while field notes were taken concurrently to document non-verbal and contextual details. Transcription of all interviews was conducted using MS Teams, ensuring the accurate documentation of pertinent details. It is essential to emphasize that all ethical considerations were strictly followed throughout the research process, ensuring participant confidentiality and privacy.

Validation

Although repeat interviews could not be conducted due to time constraints, validation was ensured through alternative methods.

Partial data saturation was achieved in the key areas of the interviews. The interviewer summarized and restated the crucial points of the participants' answers, seeking confirmation or additional comments. This process helped validate the information and ensure a comprehensive understanding of the participants' perspectives.

Furthermore, member checking was employed as a method of verification whenever possible. A summary of the interview findings was shared with the interview participants, giving them the opportunity to review and validate the accuracy of the collected data. While not all participants provided feedback, the insights and comments received were carefully considered and integrated into the final analysis.

By implementing these comprehensive verification measures, the study aimed to enhance the credibility and trustworthiness of its findings. The validation process served as a robust foundation for drawing well-supported conclusions and deriving meaningful implications from the collected data. As a result, the research achieved a higher level of credibility and made valuable contributions to the academic world in the field of Carbon Farming.

3.1.3 Analysis and Findings

The report includes an analysis of the conducted interviews, with a specific emphasis on extracting key points that are essential to the development of the proposed model. The analysis aims to identify and highlight the significant insights derived from the interviews, which serve as the fundamental basis for the model's formulation.

Each interview was subjected to a review process, where special attention was given to extracting valuable insights, diverse perspectives, and expert experiences shared by the participants.

Data Analysis

The analysis framework employed in this study utilizes qualitative coding, "a process of systematically categorizing excerpts in your qualitative data in order to find themes and patterns" (Delve, n.d.). Selective coding, a specific approach within qualitative coding, was utilized in this thesis. Selective coding focuses on data reduction by "identifying a corpus of 'instances' of the phenomenon that you are interested in" (Braun and Clarke, 2013, p. 206).

The selection of this coding procedure was driven by the aim of promoting transparency and enhancing the validity of the study's results. By analyzing the interview data, the report aimed to uncover crucial information that can inform the development of the models and contribute to future research.

The analysis resulted in a total of **87** codes, which were further categorized into **9** sub-themes and **4** themes. Most of the themes were predetermined (deductive creation) and aligned with the interview questions and research objectives. However, some themes emerged during the interview process (inductive creation). For a detailed overview of all the themes and sub-themes, including their deductive or inductive origins, please refer to Figure 3.1.

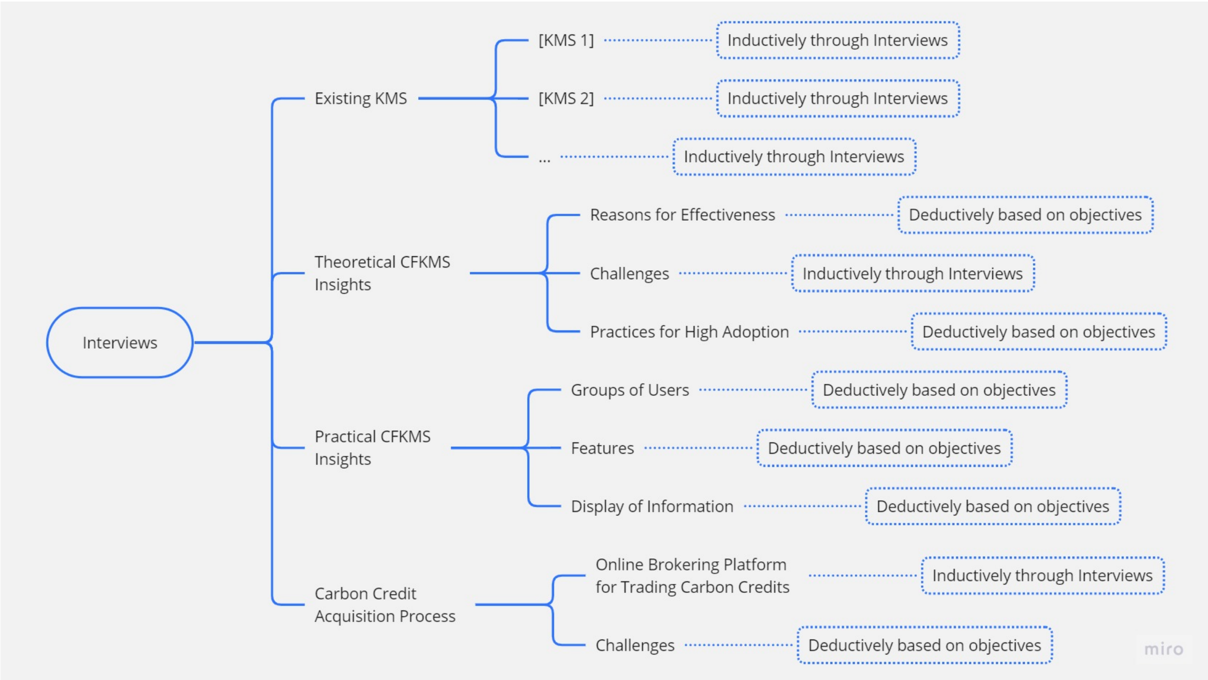

Figure 3.1: Framework of Thematic Analysis. Created using Miro [Computer software].

Reporting

While participant quotations corresponding to specific codes were not provided in accordance with guidelines from TU Delft, selected paraphrased quotations were included in the main text to offer a more interactive presentation of the results. To ensure participant anonymity, each participant was assigned a role/title, which was used wherever participant references were necessary.

All the data presented in this study were consistent with the findings derived from the interviews. The data served as supporting evidence for the identified themes and contributed to the overall understanding of the research topic.

The results were structured based on the main themes identified during the analysis. Within each theme, the different findings were presented, compared, and summarized accordingly. This approach enhanced the clarity of the major themes and facilitated the interpretation of the research findings.

When necessary, clear illustrations of the sub-themes were provided. This included descriptions of diverse cases or discussions related to minor themes that emerged during the analysis. These details contributed to a comprehensive exploration of the research topic and provided a detailed understanding of the findings.

By ensuring the reproducibility of the findings and accurately representing the participants' opinions and perspectives (while adhering to TU Delft's guidelines regarding the use of transcripts), the thesis aimed to enhance the credibility of the study.

3.2 Secondary Research

In the **second** section of the study, data collection involves six major phases presented below, namely planning, strategy, search, selection, execution, and result analysis. The results of this study are introduced in Section 4.1.

The **planning phase** entails determining the protocol and the analysis required. For this purpose, a targeted non-systematic literature search was adopted to explore the benefits and challenges related to broad topics discussed in Chapter 2, such as widespread adoption of Carbon Farming, Digitalization, Knowledge Management, and Knowledge Sharing. Additionally, a selection of KMSs utilized in the agricultural sector was examined on the internet. The study aimed to identify trends and collect data that could be compared with insights derived from the interviews, offering a comprehensive understanding of the research domain.

The **strategy** for knowledge gathering involves making choices about the online databases and resources to be used for primary research. In this study, the focus was on retrieving trends rather than conducting a systematic review and analysis. To achieve this, Google Search Engine and Google Scholar were utilized as the primary tool. However, it is important to note that the search results obtained from Google may vary among individuals due to differences in the search algorithm. This limitation should be taken into consideration when replicating the protocol from this part of the study.

The **search stage** involves conducting a keyword-based search to retrieve relevant information. For this study, the chosen keywords were selected to align with the specific objectives of each segment of the secondary investigation: Existing KMSs in Agriculture (Section 4.2), and Benefits and Challenges (Section 4.3). For the former, phrases such as "Knowledge Management System Agriculture" and "Knowledge Management Agriculture" were employed. For the latter, keywords such as "Carbon Farming Barriers", "Carbon Farming Challenges to Wide Adoption", "Digitalization Benefits", "Knowledge Management Challenges", "Knowledge Sharing Benefits", and "Knowledge Sharing Barriers" emerged as the most pertinent choices.

As this research diverges from a systematic literature review, the omission of all the exact terms streamlines the explanation, highlighting the overarching process rather than specific details. Nonetheless, this approach comes with a limitation — the potential challenge of replicating the study due to the absence of all the precise terms. It is crucial to acknowledge that for a broader scope encompassing a wider array of webpages and academic papers falling under this category, an expanded search could have incorporated supplementary digital libraries, additional terms, and synonyms.

During the study's **selection phase**, certain exclusion criteria were applied to refine the results and focus on the most relevant ones. The following criteria were used:

- Webpages written in languages other than English and could not be translated were excluded.
- Papers written in languages other than English were excluded.

- Master's and doctoral dissertations were excluded.
- Webpages and papers that were not directly related to one of the aforementioned categories were excluded.

The aim of this step was to identify literature that offers significant contributions to the agricultural sector. When there was uncertainty about the relevance of a webpage or paper, additional investigation was carried out. This involved conducting a further study on the webpage or downloading the full text of the paper. In such cases, specific sections, such as the introduction and conclusions, were carefully examined to evaluate the suitability and relevance of the literature for the study.

Subsequently, the **execution phase** involved conducting the search in the selected web sources and evaluating the retrieved studies according to the predetermined inclusion and exclusion criteria. Since the objective of the study was to identify trends rather than comprehensively cover all available sources, the search was stopped after reviewing the first few relevant results per keyword, which typically contains the most relevant findings. Additionally, the identified resources were thoroughly examined to identify any additional relevant sources or related papers.

Lastly, in the **final phase**, the results and conclusions of the study are presented. Each webpage and paper was examined. Furthermore, the analysis includes also an extensive summary of each category. This summary plays a crucial role in drawing conclusions and establishing the basis for the development of the new KMS specifically tailored for Carbon Farming in the Netherlands.

Chapter 4

Results

This chapter is organized into three sections. First, Section 4.1 presents the results from the interviews and the thematic analysis. Next, Section 4.2 consolidates the content lists of six existing KMSs in the field of agriculture, with the aim of revealing the most important features that such systems contain in real-world scenarios. Lastly, Section 4.3 examines benefits and challenges from literature. A comprehensive interpretation of results follows in Chapter 5.

4.1 Interview Research Results

In this section, the interview results are presented and structured according to the conducted thematic analysis. Illustrative tables containing the findings can be found in Appendix C. Additionally, a visual representation of the thematic analysis with the identified themes and sub-themes is provided in Figure 3.1.

The analysis of the results is structured around four fundamental themes, each contributing to a comprehensive understanding of the research findings:

Existing KMS This theme explores the utilization of existing KMSs by participants, both currently and previously. It sheds light on their experiences with such systems.

Theoretical CFKMS Insights Delving into the theoretical aspects, this theme focuses on gathering soft knowledge insights regarding the potential CFKMS. This includes reasons for effectiveness, challenges, and practices for high adoption of the system from the relevant stakeholders.

Practical CFKMS Insights In this theme, practical insights about the CFKMS are gathered. This involves extracting information about potential users, desired contents, and preferred modes of presentation for the CFKMS.

Carbon Credit Acquisition Process Insights Addressing the broader context, this theme offers insights into the Carbon Credit Acquisition Process. It provides valuable information about the larger framework within which the CFKMS operates.

4.1.1 Existing Knowledge Management Systems (KMSs)

The first topic discussed during the interviews revolved around exploring the experiences of existing KMSs in different sectors of agriculture to gain insight into what a KMS entails according to participants. Notably, five out of seven participants in the study had prior experience with one or more KMSs. However, it is important to note that one participant possessed experience in other sectors, which led to the exclusion of further discussion on this aspect during the interview. The diversity of these systems is evident; nonetheless, they share some common characteristics. The comprehensive list of identified systems and their respective features, as identified through the interviews, can be found in Table C.1.

The first group of features is connected with project management. These systems provide a unified platform for efficient project management, facilitate shared file management among team members, and enable seamless communication and collaboration.

Moreover, certain features are closely related to climate change and agricultural systems. They function as valuable databases for climate change mitigation efforts, collect and analyze water and chlorophyll data in agriculture, manage farming and banking data for agricultural support, and optimize gas production processes using production data.

The last group of features encompasses data tracking, monitoring, and registries. These aspects involve recording, capturing, and tracking project details, including location, stakeholders, project duration, funding sources, and emission reductions. Additionally, these systems offer methodology documents for Carbon Farming and other relevant information. Lastly, some systems serve as calculation tools for peatlands, simplifying monitoring and effectively managing vast databases.

4.1.2 Theoretical CFKMS Insights

The second theme of the conversations focused on theoretical insights into a potential CFKMS and the aspects that interviewees found interesting concerning effectiveness, challenges, and adoption practices for the system.

Reasons for Effectiveness

The stakeholders involved in the research identified several reasons for the effectiveness of a potential CFKMS (Table C.2). These reasons can be categorized into three groups: "Data Management", "Collaboration and Impact", and "Cost Optimization".

Regarding **Data Management**, the implementation of a Knowledge Management System for Carbon Farming has the potential to substantially enhance the availability of validation data (*Think-Tank Researcher*) and facilitate a comprehensive knowledge integration (*Think-Tank Researcher*, *Farmer*). By combining diverse knowledge sources, it can create a robust and all-encompassing information pool. Moreover, this pool of information will be transparent (*Think-Tank Researcher*) and incorporate objective insights (*Advisor/SNK Member*), thereby enhancing its overall effectiveness. Furthermore, such a system can assist policymakers in formulating more accurate and knowledge-driven policies (*Farmer*), while also optimizing the way other stakeholders access and utilize these policies (*Advisor/SNK Member*).

Concerning **Collaboration and Impact**, there appears to be a notable demand for the system (*Funder*). This is evident from the plethora of potential applications it could offer (*Think-Tank Researcher*) and the anticipated social impact it may generate once made accessible (*Think-Tank Researcher*, *Farmer*). Specifically, stakeholders are looking forward to the benefits of a multi-stakeholder collaborative knowledge-sharing platform (*Think-Tank Researcher*, *Farmer*) that could provide much-needed support to Farmers (*Advisor/SNK Member*) in various aspects and practices of Carbon Farming that are currently lacking.

Lastly, the anticipated **Cost Optimization** resulting from the system's implementation will effectively offset the initial setup expenses. This optimization will effectively reduce pertinent information, transaction, and Monitoring, Reporting, and Verification costs, while concurrently expanding the potential projects that can emerge once the system is fully operational (*Advisor/SNK Member*).

Challenges

On the other hand, there exist several challenges that the directors of this action must consider, as listed in Table C.3. These challenges primarily are associated with the "Scale and Complexity" of the task, the complicated aspects of "System Development", and the necessary "System Adaptation" to evolving circumstances and demands.

One of the primary concerns revolves around the **Scale and Complexity** of the project. This aspect involves the challenge of defining an appropriate scale (*Think-Tank Researcher*, *Advisor/Consultant*), as it is difficult to establish clear and consistent boundaries and adhere to them consistently. Moreover, given the nature of such a project, it necessitates dealing with complex and dynamic targets, along with continuously evolving definitions that prove to be highly challenging to address comprehensively (*Advisor/Consultant*).

Another significant challenge arises in the context of **System Development**. The implementation of the system entails considerable expenses (*Advisor/SNK Member*), and, as emphasized by the majority of the interviewees, a plethora of perspectives must be taken into account to ensure the final product proves beneficial to all stakeholders involved (*Think-Tank Researcher*, *Advisor/Consultant*, *Farmer*). Furthermore, many of the existing processes rely heavily on paper and telephone-based methods (*Advisor/SNK Member*), which presents a demanding obstacle in terms of seamless integration into a digital system. Lastly, it is crucial to avoid replicating the system as another digital manual (*Think-Tank Researcher*); instead, the users are seeking comprehensive enhancements beyond traditional functionalities.

Lastly, **System Adaptation** represents the final identified concern. The adoption of an a priori design approach pursued in this thesis has been met with some skepticism by certain interviewees (*Advisor/Consultant*, *Funder*) who perceive potential difficulties in adapting it to future needs. Consequently, the system should be designed to offer a robust foundation for accommodating dynamic policy and structural changes, facilitating efficient adaptive transitions to address future stakeholder demands (*Advisor/Consultant*). Moreover, the directors must strategize approaches to demonetize the knowledge, ensuring its accessibility and availability to all interested parties (*Farmer*).

Practices for High Adoption

However, even with attention to all the aforementioned challenges, the success of the system and active participation from relevant stakeholders remains uncertain. It involves not only the addition of new information but also the utilization of the provided practices, as can be seen in Table C.4. To fortify the prospects of success, interviewees highlighted three key areas for intervention, namely enhancing the “Attractiveness” of the system, providing appropriate “Incentives and Support” to the users, and fostering the “Involvement of Policy Instruments”.

Enhancing the system’s **Attractiveness** may entail numerous actions. One aspect that emerged as of utmost importance for almost all interviewees and was emphasized multiple times during the discussions was the criticality of hyperlocal and high-quality information (*University Researcher*, *Think-Tank Researcher*, *Advisor/SNK Member*, *Farmer*, *Funder*). Irrelevant or inaccurate information might lead users to abandon the system eventually. Therefore, incorporating adaptive features to accommodate the latest updates can help address this concern (*Advisor/Consultant*). Lastly, assessing market demand (*University Researcher*) and providing an accessible and available product for all in need (*University Researcher*) will significantly increase the likelihood of success.

Another approach to foster active participation is by providing **Incentives and Support** to all users based on their position. Financial incentives (especially to Farmers) for newly uploaded information are considered the primary method by many interviewees (*University Researcher*, *Think-Tank Researcher*, *Funder*). Additionally, these individuals propose non-financial incentives, such as promoting potential life improvements, promises of funding, enhanced reputation, increased motivation, and more (*Think-Tank Researcher*, *Funder*). However, equally important is the need to provide training and ongoing support to users engaging with the system (*Advisor/Consultant*).

The final method concerns the **Involvement of Policy Instruments**. This encompasses policy intervention (*Think-Tank Researcher*) and the force by SNK (*Advisor/SNK Member*). Intervention proves crucial since many individuals initially exhibit a reluctance and prefer an initial action by someone else before committing to using the platform (*Advisor/SNK Member*). Alternatively, more gentle approaches like utilizing social media for promotion (*Farmer*) and fostering knowledge-sharing promotion (*University Researcher*, *Farmer*) may also be employed. Lastly, some stakeholders propose that if the government can ensure a scalable system, it is likely to be embraced by a wider audience (*Think-Tank Researcher*).

4.1.3 Practical CFKMS Insights

Following the theoretical insights, a more targeted and specific discussion centered on three key aspects: **WHO** will use the system, **WHAT** it will encompass, and **HOW** it will be presented to the users. While the responses varied considerably, certain dominant themes emerged across all the interviews.

Groups of Users

The stakeholders participating in the study self-identified as potential users of the system, and the study also recognized several other groups of stakeholders. Among the 7 participants, the stakeholder groups identified as users are presented in Table C.5, and the summary of these is as follows:

- **Farmers(/Landowners/Developers)** were mentioned by 6 out of 7 participants.
- **Researchers** were mentioned by 5 out of 7 participants.
- **Government/Policymakers** were mentioned by 5 out of 7 participants.
- **Funders/Donors** were mentioned by 3 out of 7 participants.
- The **General Public** was mentioned by 2 out of 7 participants.
- **Businesses/Buyers** were mentioned by 2 out of 7 participants.
- **Journalists** were mentioned by 1 out of 7 participants.
- **SNK** was mentioned by 1 out of 7 participants.
- **Validators** were mentioned by 1 out of 7 participants.

Features

While it is generally beneficial for a system to have a wide range of features, some specific features and capabilities are crucial for the potential CFKMS. This section outlines these essential features without delving into their respective stakeholders. For further details, please refer to the Table C.6.

First and foremost, as the primary goal is the dissemination of knowledge and information, the potential CFKMS requires a comprehensive **Knowledge Base (KB)**. According to the participants, this KB should incorporate the following components:

- Metrics (*University Researcher*, *Think-Tank Researcher*, *Farmer*)
- Contextual Applications (*University Researcher*, *Think-Tank Researcher*, *Advisor/Consultant*, *Advisor/SNK Member*, *Funder*) - providing information for specific Carbon Farming practices in particular areas.
- Success and Replicable Stories (*University Researcher*, *Think-Tank Researcher*, *Farmer*, *Funder*)
- Failure Stories (*University Researcher*, *Funder*)
- Soft Knowledge Insights (*Think-Tank Researcher*, *Advisor/Consultant*, *Funder*) - encompassing information on public acceptance, business models, policies, regulations, and more.
- Financial Streams (*Think-Tank Researcher*, *Funder*) - including funding methods or information about the Carbon Markets.
- Financial Tools (*Think-Tank Researcher*)

During the interviews, stakeholders expressed a desire for a comprehensive **Project Hub** that includes all Carbon Farming projects. This Project-based Hub would incorporate vital features such as MRV, communication channels, project status, profiles, and active project listings (*Think-Tank Researcher*, *Farmer*, *Funder*). Additionally, participants emphasized the importance of Digital Guided Procedures, including PDD-related documents and automated monitoring, to streamline processes and enhance efficiency (*Think-Tank Researcher*, *Advisor/Consultant*, *Advisor/SNK Member*, *Farmer*, *Funder*). Furthermore, stakeholders recognized the significance of addressing the Market Demand through integrated features to assess and respond to evolving needs effectively (*Think-Tank Researcher*).

Lastly, some participants mentioned the inclusion of additional services in the CFKMS. These services include **Earth Observation** (*Think-Tank Researcher*, *Advisor/SNK Member*) for valuable data insights. Additionally, there was a suggestion for a **Learning Environment** that offers practical agricultural education, technology integration, and more (*Think-Tank Researcher*, *Farmer*). Moreover, stakeholders highlighted the importance of **Announcements** for actions (*Farmer*) to keep users informed about relevant updates and opportunities.

Display of Information

While the initial plan for the interviews did not specifically focus on the way of displaying information, the research collected a sufficient amount of information during the interviews and through follow-up questions from some of the interviewees, particularly for some of the most important user groups based on the results, as shown in Table C.7.

The results revealed that there is no one-size-fits-all approach to displaying information effectively. Various formats, such as videos, diagrams, and images, were found to aid in providing a clear impression of a project (*Think-Tank Researcher*, *Funder*). However, for farmers and funders seeking to access and comprehend general knowledge, financial streams, and regulations, text, tables, charts, and publications were identified as essential (*Farmer*, *Funder*). Moreover, while proven educational systems can be beneficial for current and future farmers, they also expressed a need for interactive on-site experiences to enhance their learning process (*Farmer*). The diversity in preferences and requirements underscores the importance of offering a flexible and adaptable information presentation approach in the potential CFKMS.

4.1.4 Extra Points of Interest

During the interviews, two additional topics emerged from some of the interviewees. While these topics may not have a direct correlation to a potential CFKMS, they offer valuable insights that necessitate further investigation in future research.

Online Brokering Platform for Trading Carbon Credits

The first topic pertains to a parallel digitalization project, involving the creation of an external online brokering platform for Carbon Credit trading (Table C.8). This proposed platform was proposed by the *Advisor/SNK Member* interviewed during this research. Essentially, it would serve as a centralized hub or marketplace for all carbon certificates, encompassing those held by farmers in the Voluntary Carbon Market (VCM). Potential buyers would have the capability to search for specific certificates and conduct trades through this platform. According to the interviewee, such a platform is essential if Carbon Farming culture and practices are to be scaled up and achieve mainstream recognition.

Challenges of the Carbon Credit Acquisition Process

Another significant issue serves as a valuable indicator of the challenges faced in the VCM of the Netherlands. The extensive list of challenges is illustrated in Table C.9.

First and foremost, the problem begins even before entering a market due to the unclear requirements of every Carbon Market and the need to select the most suitable one for a specific project (*Advisor/Consultant*). Additionally, some interviewees view the Carbon Market as excessively layered (*Think-Tank Researcher*), resulting in an exclusive (concerning the market as a whole but also in terms of carbon prices), an expensive, and non-standardized process that discourages many potential participants (*Think-Tank Researcher*, *Funder*).

The issue of cost was identified by several interviewees across multiple phases of the procedure. It was noted in the expensive, complex, and pivotal planning of Project Design (*Think-Tank Researcher*, *Advisor/SNK Member*, *Funder*), as well as in the costly and time-consuming MRV (*Advisor/SNK Member*, *Farmer*). Lastly, there was a call for better integration of monitoring and research efforts (*Funder*).

4.2 Existing Knowledge Management Systems in Agriculture

Information technology has long been regarded as an invaluable tool by public organizations in several sectors to tackle the myriad challenges they encounter (Danielsen, 2021). This analysis explores a range of initiatives in agriculture that exemplify the successful implementation of Knowledge Management technology in overcoming obstacles regarding information sharing among key stakeholders.

Numerous comparable tools catering to agricultural needs are available. A selection of such tools is analyzed in this thesis and a more extensive analysis of every system can be found in Appendix A.

Based on the analysis of the webpages, Table 4.1 presents an overview of their contents. It is important to note that the categorization in the table is subjective and aimed at providing a universal perspective, considering the different names and categorizations used across the webpages. The following steps were followed to structure the categorization:

1. **Extraction of main categories** from each of the included webpages from the corresponding home page to gain every content page from each webpage.
2. **Exclusion of the Rice Knowledge Management Portal (RKMP) webpage**, as it differs significantly from the others. During the discussion process (Section 5.2), this unique approach of RKMP has been considered to assess its potential usefulness for the CFKMS project. The results of the interviews provided valuable insights into whether adopting a similar stakeholder-oriented structure could benefit the CFKMS platform and its users.
3. **Grouping and simplification of terms from each webpage**. The aim was to simplify the findings and retain only universal terms applicable to any system. Many categories and sub-categories fell under the umbrella of the Knowledge Base, which contains information on various topics, such as technologies, crops, or related information. Hence, the term "Knowledge Base" was chosen. However, certain categories such as *Publications*, *Success Stories*, *Catalogs/Practices*, *Tools*, and *Programs and Schemes* are presented separately as they form specific broader sections within the Knowledge Base.
4. **Combination of similar categories based on their meaning**. This final grouping of results revealed **15** categories and **5** sub-categories for the term "Knowledge Base".

Combining insights from the different platforms reveals several key points for analysis. Most of the listed webpages share common features, such as a "Home Page" serving as the platform's entry point, an "About Page" providing essential details about the platform or organization, a "Contact Page" for inquiries and support, and a "Login/Signup Page" for personalized experiences and contributions.

Feature	TNAU	Farmer's Portal	GECO	Agrowiki	Agropedia
Home	X	X	X	X	X
About	X	X	X	X	
Contact / Team	X		X	X	
Login / Signup		X	X	X	X
Knowledge Base / Models	X	X	X	X	
- Publications	X				
- Success Stories	X			X	
- Catalogs / Practices				X	X
- Tools				X	
- Programs and Schemes		X			
Search	X		X	X	X
News				X	X
Events	X			X	X
Association	X				
Interactions (Forum/Blog/FAQs)			X		
Learning				X	
Assistance					X
Map View		X			
Weather		X			
Marketplace				X	

Table 4.1: Comparison of Contents of Existing KMS in Agriculture

The "Knowledge Base (KB)" is a central component of these platforms, offering a comprehensive collection of information in various formats. Users can search, access, and contribute to the content, creating a dynamic and collaborative knowledge-sharing environment. The KB in these systems typically include "Publications", providing access to research papers, articles, and academic content, "Success Stories" showcase real-world examples of positive outcomes and innovative practices, while "Catalogs", "Practices", "Tools", and "Programs and Schemes" offer practical insights into different approaches and techniques used in the sector.

The "Search" functionality within many of the platforms allows users to quickly find specific content, saving time and effort in navigating through various sections. This feature is particularly helpful for inexperienced users who may find the platform overwhelming.

Some platforms go beyond the core features and include "News", "Events", "Association", "Forums", "Blogs", and "Frequently Asked Questions" pages. These additional elements keep users informed about upcoming events, conferences, workshops, and news, offering opportunities for networking, learning, and community engagement.

Other capabilities found in these platforms include "Learning" options, such as courses and webinars, as well as "Assistance" through phone calls or other forms of support, "Map View", "Weather", and "Marketplace". These resources aim to enhance users' understanding of the available knowledge and help them implement it effectively.

As previously mentioned, the exclusion of the RKMP webpage from the analysis is due to its significant differences compared to the other platforms. However, it is important to note that RKMP has a distinct organization tailored to specific stakeholder needs. It features separate tabs for researchers, extension professionals, farmers, the public, and more. These tabs facilitate global access, sharing, and discussions among rice researchers, provide location-specific rice knowledge for extension professionals, enable farmers to access and discuss local rice knowledge in their languages, and offer information on rice for the general public.

Last but not least, it is important to keep in mind that many of the features presented differ from KMS to KMS as they are tailored to the unique requirements of users and stakeholders within each platform.

4.3 Benefits and Challenges

4.3.1 Challenges and Barriers of Carbon Farming to Wide Adoption

Numerous challenges have been identified throughout the years that make it difficult for farmers to adopt Carbon Farming practices and for the approach to be widely implemented. These challenges and barriers can be classified into five main factors: socio-cultural, technological, economic, institutional, and ethical. The following challenges represent significant barriers identified by multiple regions across Europe and Australia.

Socio-cultural factors

Socio-cultural factors play a crucial role in the adoption of Carbon Farming practices. Farmers may be hesitant to adopt these practices due to a lack of information and understanding about their benefits (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014; Evans, 2018; Demeyer, 2021). The incompatibility of these practices with current farm management strategies can also deter farmers from adopting them (Marit Ellen Kragt et al., 2014). Additionally, farmers may have personal interests and concerns about the impact of Carbon Farming practices on their yields, productivity, and profitability (M. Sharma et al., 2021).

Furthermore, landholder socio-demographics, social norms, attitudes, and cultural affiliation to a traditional production system and low social acceptance can significantly impact the adoption of Carbon Farming practices (Karki, 2021; Evans, 2018). The provision of social, cultural, and environmental co-benefits can play an important role in increasing the adoption of these practices (Evans, 2018). Lastly, the consequences for the re-sale of properties that have tree plantations and the dissenting opinions about the sale of products from tree plantations are also important socio-cultural factors that can impact adoption (M. Sharma et al., 2021; Marit E. Kragt, Dumbrell, and Blackmore, 2017).

Technological factors

One major barrier to the adoption of Carbon Farming practices is the lack of required technologies (Marit E. Kragt, Dumbrell, and Blackmore, 2017). This includes the lack of approved methodologies (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014), the perceived complexity of LMTs for farmers and landowners (Karki, 2021), as well as the complexity of obtaining certification as an accredited carbon offset provider (Marit Ellen Kragt et al., 2014). Karki (2021) found that implementing LMTs can require significant changes to current farming practices, and many landowners may not have the knowledge or resources to adopt these practices effectively.

Another technological factor that can impact the success of tree planting efforts is the risk of seedling or tree death (Evans, 2018). Additionally, farm size and characteristics can play a role in the adoption of Carbon Farming practices, as it may be more difficult to integrate tree plantings into existing land uses on smaller farms (Evans, 2018).

Finally, the lack of development of efficient Monitoring, Reporting, and Verification (MRV) systems, as well as large uncertainties about the benefits of LMTs (Karki, 2021) is a crucial factor. These uncertainties can make it difficult for farmers and landowners to understand the potential impacts of Carbon Farming practices and may discourage adoption (M. Sharma et al., 2021)

Economic factors

There are several economic factors that hinder the adoption of Carbon Farming practices (Demeyer, 2021). Firstly, there are high costs associated with implementing these practices, including capital investment costs, establishment and management costs, labor requirements, and expensive machinery needed for some practices (Karki, 2021; Marit E. Kragt, Dumbrell, and Blackmore, 2017; Evans, 2018). Additionally, there is a large initial investment with a long transition period for some practices (Karki, 2021).

Moreover, there are uncertainties surrounding carbon prices, market prices for carbon and other commodities, and future government policy settings, which create further barriers to adoption (Marit Ellen Kragt et al., 2014; Evans, 2018). Farmers may be hesitant to adopt Carbon Farming practices due to the lack of financial incentives associated with participation in the Carbon Farming Initiative in Australia and the uncertainty of future carbon prices (Marit E. Kragt, Dumbrell, and Blackmore, 2017).

In addition to economic barriers, there are also financial consequences of participation, including the possibility of reduced income due to insufficient management (Karki, 2021) and a transitional period with higher production costs and lower income when adopting some practices (Karki, 2021). Farmers may also have difficulty obtaining financial assistance from banks or other sources (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014; Evans, 2018).

Finally, it is expensive to deploy Carbon Farming practices at scale, particularly in developing countries, which can limit their adoption (Karki, 2021).

Institutional factors

Institutional factors are major barriers to the adoption of Carbon Farming. Policy and political uncertainties are among the primary challenges (Demeyer, 2021). There is too much policy uncertainty regarding Carbon Farming, which can hinder farmers from adopting it (Marit E. Kragt, Dumbrell, and Blackmore, 2017). There is also a lack of policy support mechanisms for machinery and credit, and to set explicit incentives and regulations for large-scale implementation, which are crucial for the successful adoption of Carbon Farming (Karki, 2021).

Political uncertainties pose also significant challenges to the adoption of Carbon Farming. Changes in government and policy priorities can create uncertainties and inconsistencies in the regulatory framework, making it difficult for farmers to plan and invest in Carbon Farming practices (M. Sharma et al., 2021; Marit Ellen Kragt et al., 2014; Marit E. Kragt, Dumbrell, and Blackmore, 2017). Furthermore, political instability can affect the acceptance and implementation of Carbon Farming initiatives, as it may lead to inconsistent support and policies in the long term (M. Sharma et al., 2021). Additionally, uncertainty about political developments in carbon policies further adds to the complexity, making it challenging for farmers to anticipate future policy changes and their impact on Carbon Farming practices (Marit Ellen Kragt et al., 2014; Evans, 2018).

In addition to these factors, there are also other institutional factors that hinder the adoption of Carbon Farming. For example, long commitment periods and too much paperwork involved can discourage farmers from adopting Carbon Farming (Marit E. Kragt, Dumbrell, and Blackmore, 2017). Furthermore, the lack of standards and protocols to measure carbon sequestration, as well as the expensive procedures involved, can be additional barriers to the adoption of Carbon Farming (Karki, 2021; Marit Ellen Kragt et al., 2014).

Finally, uncertainty about buyers in the Voluntary Carbon Market (VCM) is another factor that hinders the adoption of Carbon Farming (Marit Ellen Kragt et al., 2014).

Ethical factors

The ethical challenges hindering adoption include the impracticality of the 100-year permanence period, uncertainty over future government policy settings and market prices for carbon and other commodities, and conflicting targets of policymakers and farmers (M. Sharma et al., 2021; Marit E. Kragt, Dumbrell, and Blackmore, 2017; Evans, 2018). Moreover, the perceived reward for farmers with a history of poor land management practices and uncertain yield benefits can act as disincentives to adoption (Marit Ellen Kragt et al., 2014; Marit E. Kragt, Dumbrell, and Blackmore, 2017).

Land use change could alter food prices and compromise food security in certain areas. Land availability and competition with other land uses pose additional challenges to Carbon Farming (Karki, 2021). There is also an issue of equitable benefit sharing and social conflicts that need to be addressed, along with the issue of land grabbing (Karki, 2021). Finally, planting with a diversity of native trees and shrubs in place of fast-growing monocultures can deliver social and biodiversity co-benefits alongside carbon abatement and complementary land uses (Evans, 2018).

Digital platforms have emerged as a popular medium for communication and knowledge-sharing. However, such tools are currently lacking in the Carbon Farming sector. Therefore, it becomes necessary to assess the specific needs and requirements of the sector to develop appropriate digital platforms for knowledge dissemination. This assessment will enable a better understanding of the potential offerings and pave the way for developing tailored solutions.

4.3.2 Drivers and Benefits of Digitalization

There are many reasons and advantages for a corporation or organization to digitalize all or some of its activities. These advantages encompass both the end-users and the respective companies or organizations, as evidenced by research findings (Danielsen, 2021; Parviainen et al., 2022; Turel, Qahri-Saremi, and Vaghefi, 2021; Mishra and Deichmann, 2016). Given time limitations, this section selectively references the works of these authors.

According to them, digitalization significantly improves business process efficiency, providing higher quality, consistency, and productivity. Businesses are able to see their operations and results in real-time by utilizing digital tools and technology; this allows them to act quickly and with knowledge. Because they have access to current information and tools, this not only improves decision-making but also helps employees feel more satisfied at work (Parviainen et al., 2022).

Additionally, digitalization results in better compliance and recovery capabilities, assisting organizations in better aligning with regulatory requirements and recovering from any disruptions (Parviainen et al., 2022). Furthermore, it encourages easier connectivity, communication, and information sharing within and beyond the organization, which promotes greater cooperation and knowledge sharing (Danielsen, 2021; Turel, Qahri-Saremi, and Vaghefi, 2021; Mishra and Deichmann, 2016), and as a result, organizations benefit from increased convenience and increased growth potential (Mishra and Deichmann, 2016). Moreover, digitalization boosts economic growth since companies may use technology to improve operations and look into new revenue streams (Mishra and Deichmann, 2016; Turel, Qahri-Saremi, and Vaghefi, 2021).

Improved response time and client service are also prominent benefits of digitalization. Organizations can leverage digital tools to provide faster response times and deliver superior client service experiences (Mishra and Deichmann, 2016; Parviainen et al., 2022). However, it's important to note that while digitalization offers complexity reduction and possibilities for new ways of doing business, achieving these benefits can be challenging (Danielsen, 2021; Parviainen et al., 2022). Organizations must navigate the complexities and adapt their processes and workflows accordingly.

Moreover, digitalization presents opportunities for cost reduction in the long term, as automated processes and streamlined operations can lead to savings in resources and expenses (Danielsen, 2021). However, organizations must also address the challenges associated with privacy and security to ensure the integrity and protection of digital assets (Danielsen, 2021). Finally, digitalization contributes to overall quality improvement, enabling organizations to deliver products and services of higher standards (Danielsen, 2021).

In summary, digitalization brings numerous advantages to organizations, including internal efficiency, external opportunities, and disruptive change (Parviainen et al., 2022). By embracing digitalization, organizations can leverage these benefits to thrive in an increasingly digital and interconnected world.

4.3.3 Challenges of Knowledge Management (KM)

KM in agriculture faces several challenges that must be addressed to promote sustainable growth and empower farmers. Several studies have identified key areas that require attention and improvement.

An important factor contributing to the poor efficacy in promoting information exchange through KMSs is the lack of attention to the interpersonal context and personal traits that affect this process within the sector (Voelpel, Dous, and Davenport, 2005).

According to Kumar, Singh, et al. (2017), ensuring easy accessibility of relevant information to all stakeholders is crucial. This can be achieved by developing a strong system linkage for faster dissemination of technologies and information (Kumar, Singh, et al., 2017). However, it is important to avoid duplicates and incorrect information through user contributions (Yadav et al., 2015).

Timely and accurate knowledge is essential for farmers' empowerment and decision-making (Kumar, Singh, et al., 2017; Danielsen, 2021). Providing cost-effective information to farmers, especially small and marginal farmers, can significantly benefit their agricultural practices (Kumar, Singh, et al., 2017). However, scope-related project challenges such as complexity, costs, and resistance need to be addressed in KMSs (Danielsen, 2021; Chalmeta and Grangel, 2008).

Implementation challenges in agricultural KM mainly revolve around technological issues (Yadav et al., 2015; Soulignac et al., 2019). These challenges include developing knowledge models and mobile use patterns (Yadav et al., 2015) and managing unrealistic expectations (Danielsen, 2021). The frequent change of personnel in key positions and the lack of infrastructural support pose additional hurdles (Yadav et al., 2015; Danielsen, 2021). Furthermore, ethical and policy issues, as well as privacy and security regulations, need to be considered (Danielsen, 2021). Lastly, its implementation calls for particular corporate culture and practices, human resources policy, and change management (Chalmeta and Grangel, 2008).

Overall, KM in agriculture is a socio-technical process that requires staying connected with users to understand their responses to the deployed technology (Yadav et al., 2015; Soulignac et al., 2019). This understanding is crucial for determining the efficiency of KM tools in addressing the complex challenges faced in agriculture (Soulignac et al., 2019).

4.3.4 Drivers and Barriers for Knowledge Sharing

The successful implementation of knowledge sharing within an organization can be attributed to several factors. One crucial aspect is the recognition that effective Knowledge Management (KM) relies on the interconnectedness and collaboration among individuals within the organization (Ipe, 2003).

According to Stenmark (2000), individuals are unlikely to share knowledge unless they have a strong personal motivation to do so (Stenmark, 2000). In addition, Baalen, Bloemhof-Ruwaard, and Heck (2005) argue that people who have significant knowledge may be reluctant to share it for a variety of reasons. These reasons include a lack of sufficient rewards or incentives, preserving a privileged or superior position, tensions about losing ownership or control, and a lack of time to discuss novel methods (Baalen, Bloemhof-Ruwaard, and Heck, 2005). This shows that intrinsic elements, including individual interest, a sense of accomplishment, or acknowledgment, are important in promoting knowledge-sharing behavior.

According to Wang and Noe (2010)'s article, organizational culture has come to be recognized as a key impediment to the efficient production, sharing, and application of knowledge inside organizations. Processes for exchanging information can also be integrated into larger organizational networks (Wang and Noe, 2010). Individuals' interpersonal connections and relationships within these social networks are essential for promoting knowledge sharing and raising the standard of information provided (J. N. Cummings, 2004). As a result, knowledge-sharing programs within an organization may be supported or hindered by the dominant cultural norms, values, and beliefs.

The presence of management support for knowledge-sharing has been found to have a positive correlation with employees' perceptions of a knowledge-sharing culture, including factors such as employee trust and the willingness of experts to assist others (Wang and Noe, 2010). Organizations that establish a culture of openness and trust, high-bandwidth communication, equality, justice, and support and uphold strong knowledge-sharing rules create a setting that is favorable to the efficient sharing of information (E. F. Cabrera and A. Cabrera, 2005).

However, only the presence of management support does not seem effective on its own. A lack of incentives has been suggested to be a major barrier to knowledge sharing across cultures (Wang and Noe, 2010). Thus, incentive programs rewarding effective knowledge sharing and emphasizing intrinsic rewards is an effective way for achieving the goal (E. F. Cabrera and A. Cabrera, 2005; Ipe, 2003).

While management support is important, research suggests that it may not be sufficient on its own to promote effective knowledge sharing. In addition to management support, the presence of incentives has been identified as a critical factor in facilitating knowledge sharing across different cultural contexts (Wang and Noe, 2010). An efficient strategy for fostering knowledge sharing within organizations is to implement incentive programs that reward and recognize individuals for their contributions to knowledge sharing while also placing an emphasis on intrinsic motivators like self-fulfillment and a sense of accomplishment (E. F. Cabrera and A. Cabrera, 2005; Ipe, 2003).

Finally, substantial collaborative training programs, as well as formal and informal activities, can be successful in fostering knowledge exchange, according to E. F. Cabrera and A. Cabrera (2005). These programs seek to promote participant self-efficacy, collaborative abilities, and knowledge expression and communication. Knowledge sharing can also be facilitated by the deployment of carefully selected, user-friendly information technology that complements the company culture and strengthens current social networks (E. F. Cabrera and A. Cabrera, 2005).

Chapter 5

Discussion

This chapter aims to interpret the results through four main objectives. First, in Section 5.1, the study illustrates, in one combined scheme, the groups of users, features of the system, and the way of displaying these features. Second, in Section 5.2, it compares the results of the features obtained from the interviews with the findings from the secondary data gathered from existing KMSs. Third, in Section 5.3, it explores whether the system features identified by the participants can address the identified challenges both from the interviews and the literature. Finally, in Section 5.4, it explores the significance of the system in the context of the Netherlands.

5.1 Integrated Users-Features-Display Approach

Section 4.1.3 presents all the information discussed during the interviews with various stakeholders. This section aims to consolidate this knowledge into a unified diagram that illustrates the identified features, the corresponding group of users for each feature, and, where available, the different modes of presentation of these features to the respective users. The diagram is provided in Figure 5.1.

The primary components of the diagram encompass the comprehensive Knowledge Base (KB), comprising distinct sub-categories such as Metrics, Contextual Applications, Success and Replicable Stories, Failure Stories, Soft Knowledge Insights, Financial Streams, and Financial Tools. Additionally, the diagram features a Project Hub integrating Project Details, User Profiles, Communication Channels, Digital Guided Procedures, and Market Demand. Furthermore, it encompasses Earth Observation, a Learning Environment, and an Announcements section.

One notable observation is the substantial contribution of the Knowledge Base (KB). As expected, the KB plays a central role in a KMS, serving as the primary means of disseminating knowledge effectively.

Figure 5.1: Integrated Users-Features-Display Approach. Created using Miro [Computer software].

Another notable observation is the significant attention given by all stakeholders to the projects. Based on the purpose of the identified projects, the study has categorized them into four groups: “Contextual Application”, which includes theoretical or practical projects ready to be implemented based on an area and practice; “Success and Replicable Stories”, which encompass projects that have been successfully implemented and can be replicated with some restrictions; “Failure Stories”, consisting of experiences that failed but provide valuable lessons for relevant stakeholders on what to avoid; and the “Project-based Hub”, which serves as a communication hub between all the relevant stakeholders corresponding to the existing active Carbon Farming projects. These categories highlight the importance of projects and their varied impact in engaging stakeholders effectively within the CFKMS.

Additionally, it is noteworthy to observe the diverse preferences of different stakeholders regarding the presentation of projects. While a blend of videos, diagrams, and images holds broad appeal, the interviews revealed interesting insights. Although not explicitly mentioned by all stakeholder groups, the farmer and funder emphasized the significance of the traditional form of text, tables, and charts. They find these formats beneficial for searching specific information about a project, as they offer easier access compared to visual representations (*Farmer*, *Funder*). This insight highlights the importance of addressing various information preferences among stakeholders to ensure an inclusive and user-friendly CFKMS.

Upon examining the diagram, one can observe that certain groups of users are distributed throughout the system, and their presence can be justified for various reasons. Farmers/landowners/developers and researchers emerge as the primary users and key stakeholders of the system. They play a crucial role in updating the content and retrieving essential information for their projects, whether in the field or in the lab. Consequently, their needs are more extensive, making them prominent stakeholders. Another group of users that actively engages with the system includes funders/donors. They utilize the system to search for potential projects, review them, and establish seamless communication and coordination with other relevant stakeholders, thereby eliminating the need for traditional phone calls. The government/policymakers and SNK are also integrated into the system, as they rely on it to update current policies and make data-based decisions based on the stored knowledge in the KMS, as requested by the farmer during the interviews (*Farmer*).

However, there is an interesting aspect behind the non-explicit mention of other stakeholders in the feature diagram — their absence in the conversation. Throughout the interviews, participants mostly focused on their own needs and desires from the system, with less emphasis on understanding the perspectives of others. As a result, non-interviewed stakeholder groups are absent from the features. This observation highlights the importance of fostering collaborative dialogue among stakeholders to ensure a more comprehensive and inclusive Carbon Farming Knowledge Management System that caters to the needs of all relevant parties.

Moreover, the diagram does not explicitly indicate a category for policies and regulations, which happens to be one of the most desired features by more than half of the study participants. However, one participant sheds light on this aspect by stating that policies and regulations fall under the umbrella of the social science component of the KMS. This category encompasses not only policies and regulations but also elements like public acceptance, business models, and other "soft" knowledge. The term "soft" is used to denote that this type of knowledge is subject to constant change and requires frequent reviews, never remaining static (*Advisor/Consultant*). As a result, all the mentioned sub-categories, including policies and regulations, are part of the "Soft Knowledge Insights" feature of the system. This insight clarifies the positioning of policies and regulations within the CFKMS and highlights their significance as part of the dynamic and evolving soft knowledge repository.

Last but not least, it is important to acknowledge that the sample used in the study may not fully represent all potential stakeholders, and diversity might exist even within each identified group. As a result, the findings and conclusions drawn from the study should be interpreted as a starting point. Further research and exploration of the system's functionalities and user requirements are essential to gain a more comprehensive understanding and make informed decisions for the development of the CFKMS.

5.2 Feature Comparison: Interviews vs. Existing KMSs

After summarizing and discussing the capabilities of the CFKMS, it is essential to compare them with the findings from the secondary research in Section 4.2. This comparison aims to determine if the needs of the Carbon Farming market align with the overall needs of the agriculture industry, at least based on the data collected from the interviews and the secondary research of existing KMSs in agriculture. Table 5.1 provides a visual representation of this comparison, with each row representing a feature of the system. Features listed on the same row indicate the presence of the same feature in both analyses. This comparative analysis helps assess the compatibility and relevance of the CFKMS features within the broader context of the agriculture industry's KMS requirements.

The first notable and expected aspect is the presence of a "Knowledge Base" in both analyses. Such a feature serves as the cornerstone of a KMS, and it would be unusual for either analysis not to include one. However, there are slight differences in the contents of the KMSs in the two studies. Both include success stories and tools, as well as applications and practices, with minor variations in the terminology. Notably, the absence of publications in the Carbon Farming Knowledge Management System can be attributed to the fact that research publications often contain a wide range of insights and information that may span across different functionalities of the system. Including them as a separate capability within the CFKMS might lead to redundancy of the provided information.

On the other hand, the existing KMSs do not incorporate information about financial streams, possibly because they primarily focus on non-financial aspects. Moreover, it is important to mention that the identified KMSs from the secondary research do not include features related to failure stories and soft knowledge insights. The participants of

Interviews	Existing
	Home
	About
	Search
Knowledge Base	Knowledge Base / Models
	- Publications
- Metrics	
- Contextual Applications	- Catalogs / Practices - Programs and Schemes
- Success and Replicable Stories	- Success Stories
- Failure Stories	
- Soft Knowledge Insights	
- Financial Steams	
- Financial Tools	- Tools
Project Hub	
- Project Details	
- User Profiles	Login / Signup Contact / Team
- Communication Channels	Interactions (Forum/Blog/FAQs) Association
- Digital Guided Procedure	Assistance
- Market Demand	
Earth Observation	Map View Weather
Learning Environment	Learning
Announcements	News Events
	Marketplace

Table 5.1: Feature Comparison: Interviews vs. Existing KMSs

the study highlighted this potential absence, indicating that such data is not available in existing KMSs in the agriculture industry (*University Researcher*, *Advisor/Consultant*, *Funder*).

The "Project Hub" functionality in the CFKMS appears to encompass several capabilities found in other systems. It combines elements such as user profiles (login page and contact), communication channels (interactions and association), and digitally guided procedures (assistance) to create a comprehensive platform for project-related activities. Notably, the absence of project details and market demand in the secondary research results could be attributed to the limited availability of specific active project information in the KMSs that were analyzed.

Additionally, there are some other functionalities in the CFKMS that have equivalents in existing KMSs, such as maps, learning resources, and announcements.

However, the CFKMS does not include static pages like home, about, and search, as the focus was primarily on dynamic functionalities that cater to the specific needs of the stakeholders.

One of the unique features found in one of the existing identified KMS is a marketplace. While this can be compared to the "Online Brokering Platform for Trading Carbon Credits" discussed in Section 4.1.4, it was suggested as a separate system rather than being integrated into the CFKMS. This highlights the potential for collaboration and interoperability between different systems to enhance the overall effectiveness of Knowledge Management in the context of Carbon Farming.

In Section 4.2, there was an unresolved question and a debate on whether the strategy of RKMP to categorize its contents based on the stakeholder would be beneficial for a system like CFKMS. The study's results demonstrated that most of the portal's features would be similar for every group of users, with some even sharing the same way of displaying information. Additionally, even in cases where certain stakeholders were not explicitly mentioned, the features might still be useful for them. As a result, based on the data acquired and knowledge extracted, it appears that such an approach would introduce unnecessary complexity in design and cost without effectively solving potential user experience problems.

It is important to acknowledge that the sample used in the study may not fully represent all existing KMSs, and the CFKMS is still at a theoretical level. As a result, the findings and conclusions drawn from the study should be interpreted as a starting point. Further research and exploration of the user interface are essential to gain a more comprehensive understanding and make informed decisions for the development of the CFKMS.

5.3 CFKMS and Addressed Challenges

This section aims to address the alignment between the identified features of the CFKMS and the challenges raised by the study participants. It explores whether the features have the potential to tackle the challenges identified by both the participants and the literature. By examining this correlation, valuable insights can be gained into how the CFKMS may effectively address the specific concerns of the stakeholders, and identify potential areas for further improvements or enhancements.

5.3.1 CFKMS Challenges

To tackle the issue of scale and complexity mentioned by the participants, a strategic approach would be, to begin with a focused implementation of one or two **pilot functionalities** of the CFKMS. By doing so, it allows for a smoother and more manageable introduction of the system to the public. Additionally, to address the challenge of complex and evolving content, a practical solution would be to implement a **history-tracking mechanism**, which can keep users informed of any changes or updates through the announcement page of the portal, ensuring they stay up-to-date with the latest information.

The development of the portal poses a significant challenge, and there is no simple solution to address it. The associated costs can be a major drawback, but potential **funding sources**, such as national and European funds, as well as private sector involvement when needed, can pave the way for the realization of the CFKMS. Moreover, to ensure that the system effectively meets the needs of its diverse user groups, conducting **further research on their specific requirements**, navigation preferences, and information presentation preferences is crucial. This deeper understanding will enable the design and implementation of a more user-centric and impactful CFKMS.

Ensuring the continuous updating and maintenance of the system is indeed a significant challenge. To address this, a dedicated team of **well-specialized individuals** should be responsible for **inspecting and curating the uploaded content**. Conducting **user surveys** and gathering feedback on their satisfaction will also be essential for identifying areas of improvement. It is crucial to adopt a user-centric approach throughout the design and development process, continually incorporating user feedback to meet their evolving needs.

Regarding the fear of monetizing the uploaded knowledge, **financial compensation** is often necessary, as discussed in Section 4.1.2. This compensation can incentivize users to actively participate and contribute to the platform. Implementing a **sustainable financial model** that supports the system's operation and encourages stakeholders to share valuable knowledge will be critical for the long-term success of the CFKMS.

5.3.2 Carbon Credit Process Challenges

The proposed CFKMS demonstrates its ability to address several challenges that participants encountered during the Carbon Credit process.

Notably, the system's **Project Hub** functionality can effectively tackle the complexities associated with multi-layered, expensive, difficult, and time-consuming project design and other processes, provided that active participation is guaranteed. By providing a centralized platform, the CFKMS facilitates coordination and collaboration among farmers, researchers, funders, and policymakers, streamlining communication and project management. Stakeholders involved in active projects can access real-time updates, communicate seamlessly, and benefit from the system's digitally guided procedure, eliminating the need for traditional and time-consuming phone calls or emails (*Farmer*). Moreover, the **Knowledge Base** serves as a valuable resource, allowing users to access additional information whenever required, providing a convenient and available knowledge repository accessible through every internet-enabled device.

While the CFKMS addresses various challenges, two key aspects that require additional attention are the correct selection of the appropriate Carbon Market for a project and the integration of monitoring and research efforts. For the former challenge, a **stepwise system** that guides users through a series of questions to input area-specific details could be a potential solution. This system would calculate and provide accurate recommendations for the most suitable Carbon Market to apply to. As for the latter, researchers can utilize the CFKMS's Knowledge Base to **extract monitoring data and analyze it** to derive valuable insights and information. However, it's important to note that the CFKMS itself may not directly offer a comprehensive solution for these challenges. Instead, it can serve as a valuable resource for stakeholders by providing relevant information and supporting their decision-making processes through the Knowledge Base.

Overall, the proposed CFKMS can certainly provide valuable tools and resources to help stakeholders navigate the Carbon Credit process more effectively, eventually aiming for the full automatization of the process.

5.3.3 Wide Adoption Challenges from Literature

The scope of this thesis primarily focuses on addressing sociocultural factors related to knowledge sharing and management within the context of Carbon Farming. While other challenges exist, they are beyond the scope of this research. This section explores how the CFKMS can potentially address some of these challenges.

Many of the "socio-cultural and technological challenges" stem from a lack of available and accessible information. Thus, effective communication and information-sharing among researchers, policymakers, and farmers are crucial. Policymakers and stakeholders should prioritize providing farmers with accessible and high-quality information regarding Carbon Farming practices (Marit Ellen Kragt et al., 2014; Evans, 2018). By providing a comprehensive Knowledge Base, the portal can offer valuable insights into Carbon Farming practices, success and failure stories, policies, and regulations. This could help address the uncertainty and confusion surrounding carbon markets and selecting a carbon project for a specific area or practice.

In terms of "economic factors", it is essential to address farmers' individual interests and concerns while demonstrating the potential profitability of adopting Carbon Farming practices (M. Sharma et al., 2021). The system can significantly reduce expenses related to information exchange and streamline the process of finding funders for farmers or developers through the Project Hub, thereby optimizing the financial aspects of Carbon Farming initiatives.

As for "institutional and ethical factors", CFKMS can play a role in resolving the challenge of data-driven policy decisions. By providing data-backed insights and analysis, policymakers can make more informed decisions (*Farmer*), leading to the formulation of more accurate and certain policies that encourage the wider adoption of Carbon Farming practices.

5.4 Significance of CFKMS for the Netherlands

After considering the points mentioned earlier, the potential benefits of a CFKMS become apparent. However, a lingering question pertains to its significance in the Netherlands.

The answer to this query emerges when one closely examines the alignment between the reasons for digitalization and the present challenges of the nation, while also considering the desired features highlighted by the interviewed stakeholders.

This tool represents a significant stride towards achieving broad acceptance and engagement among crucial stakeholders. This spectrum encompasses farmers and researchers, who should be the forefront proponents, to funders and policymakers, who have the potential to sustain this movement. As the interviews demonstrate, there exists an eagerness among all parties to embrace such practices. Nonetheless, a gap exists in terms of information dissemination and fostering connections among relevant entities, hindering the realization of these initiatives and the consequent visibility of the VCM.

A CFKMS has the potential to address the concerns of various stakeholder groups, particularly in terms of improving key aspects such as efficiency, cost-effectiveness, and quality, which are crucial indicators of successful initiatives.

In terms of efficiency, a CFKMS could streamline processes through digitalization, consolidating project information in a centralized platform, eliminating the need to search across multiple sources. This digital approach could also improve communication by offering real-time services, replacing traditional methods like emails and phone calls, thus potentially reducing response times.

Moreover, the implementation of such a system could lead to cost savings, as the widespread availability of reliable, free knowledge would eliminate the reliance on costly, monetized information sources. The interviews highlighted the urgent demand for information and the high associated costs, making Carbon Farming project implementation challenging without financial support. A knowledge-sharing platform like the proposed CFKMS could stimulate economic growth by fostering collaboration and providing equal access to accurate information.

Lastly, the overall quality of initiatives may see improvement, as the system would offer detailed step-by-step guidance, reducing complexity and enhancing overall Carbon Farming project execution.

Given the Netherlands' relatively compact geographical size and its unwavering dedication to maintaining an exceptional quality of life for its inhabitants, the necessity to harness and optimize every accessible resource becomes particularly evident. This commitment is underscored by the nation's strategic alignment with the pivotal areas of Peatlands, Forestry, and BECCS as focal points in its forward-looking agenda for the year 2030. In this context, the introduction and operation of a specialized CFKMS emerges as a promising and practical pathway to advance these multifaceted ambitions and can result in fostering greater acceptance and utilization of Carbon Farming practices across the Netherlands.

This unique and tailored KMS possesses the capability to generate a diverse range of impacts, extending well beyond the confines of national borders. Not only does it have the potential to make a substantial contribution to the realization of the Netherlands' internal sustainability objectives, but it also serves as a guiding light for the global dissemination of Carbon Farming practices. By forging ahead and establishing such a platform for the VCM, the Netherlands not only reinforces its domestic sustainability efforts outside of the regulated compliance market but also pioneers a transformative role in internationally promoting and adopting Carbon Farming practices, thereby carving a path toward a more ecologically balanced and carbon-neutral future on a global scale.

Chapter 6

Limitations and Relevance with MSc MOT

This chapter offers an examination of the study's limitations (Section 6.1). By defining the scope of the research, the study seeks to achieve a careful balance between depth and breadth, ensuring a rigorous analysis within practical boundaries. Moreover, the chapter highlights the importance of this research within the context of the Management of Technology (MOT) master program (Section 6.2).

6.1 Limitations

Despite the extensive methodology implemented in this case study, it is essential to acknowledge and address certain limitations that may have influenced the research outcomes and their interpretations. The limitations of this study include:

Interview Sample Size The study's small sample size of 7 participants, influenced by time and resource constraints, restricts the generalizability of findings and underscores the importance of broader participant representation in future research.

Knowledge Management Systems Sample Size The study's limited sample size of 6 webpages, influenced by time constraints, underscores the potential for future research to address this limitation by expanding the scope of systems, digital libraries, and search terms.

Secondary Research Approach The study acknowledges the potential variability in search results from Google due to its algorithm, underscoring the need for consideration when replicating the study's protocol.

"What You See Is All There Is" Bias (WYSIATI) (Kahneman, 2013) Participants' previous exposure to specific software designs might have influenced their subsequent judgments and limited their ability to provide additional insights or suggestions for new designs.

Geographical Generalizability Findings from this Netherlands-focused case study may not generalize to other regions due to differing contextual factors and the applicability of digitalization models.

Context Generalizability Findings from this case study may have limited generalizability to other agricultural contexts or broader settings due to distinct factors influencing digitalization models.

Researcher Bias The researcher's biases and limited prior knowledge might have influenced the research process, despite efforts to enhance reflexivity and minimize bias.

Reliance on Self-Report The study used self-report interviews, which could be influenced by recall bias and social desirability bias, although efforts were made to mitigate these limitations by creating a supportive interview environment.

While these limitations were acknowledged, efforts were made to mitigate their potential impact through transparency in reporting, methodological rigor, and careful interpretation of the findings.

6.2 Relevance with MSc Management of Technology

The research presented in this thesis aligns well with the core principles and objectives of the Management of Technology (MOT) master program. The MOT curriculum seeks to give students the skills and expertise required to handle various technological challenges in a wide range of industries. The thesis' relevance to the program's curriculum is identified by examining the following principles.

Interdisciplinary Nature The MOT program values an interdisciplinary approach to solving technological challenges. This thesis fits well with this approach as it addresses the intersection of technology, agriculture, and climate change. The proposed Carbon Farming Knowledge Management System aims to bridge technology and agricultural practices to promote Carbon Farming (CF) adoption. This aligns with the MOT program's goal of preparing professionals to handle complex technology-driven challenges.

Technology Management The thesis centers on the implementation of a KMS, a key aspect of technology management. In the MOT program, students learn to manage and leverage technology for organizational goals. By proposing a CFKMS to promote sustainable farming practices, this thesis exemplifies the use of technology management to address environmental and agricultural challenges effectively.

Innovation and Entrepreneurship The CFKMS exploration entails designing an innovative solution to enhance the adoption of carbon farming practices. The MOT program emphasizes innovation and entrepreneurship, and this thesis aligns with these principles by exploring how technology and knowledge dissemination can drive the adoption of environmentally friendly practices in agriculture.

Sustainability and Social Impact The MOT program focuses on sustainable business practices and the social impact of technology. This thesis directly addresses the challenge of meeting emissions targets in the Netherlands to combat climate change. By promoting the adoption of carbon farming practices, the proposed CFKMS can contribute significantly to sustainability efforts and have a positive social impact by mitigating climate change effects.

Research and Data-Driven Decision-Making The thesis reflects a strong emphasis on research and data-driven decision-making, which are key components of the MOT program. By investigating the components and contents of a CFKMS and gathering perspectives from stakeholders, the thesis follows a rigorous research approach that aligns with the program's emphasis on evidence-based decision-making.

Other Relevant Courses The proposed CFKMS involves using digital technologies for knowledge dissemination and management. This aligns with courses in the MOT program, such as *Digital Business Process Management*, *Emerging and Breakthrough Technologies*, and *Inter- and Intra-Organizational Decision Making*. These courses teach students how to leverage technology to improve business processes, adapt to emerging trends, and engage stakeholders within and between organizations and stakeholders. The incorporation of digital technologies in the CFKMS aligns with the core objectives of these courses.

In conclusion, this thesis seamlessly integrates within the Management of Technology master program. It shares common ground with the program's focus on technology management, innovation, sustainability, research, data-driven decision-making, and stakeholder engagement.

Chapter 7

Conclusions and Recommendations

In this final phase of the study, different perspectives, thorough analysis, and careful interpretation come together to fully understand the topic. This concluding chapter summarizes the main findings from the research journey, provides recommendations, and directly addresses the research question. Each paragraph provides a conclusion, a recommendation, and an answer to a specific part of the research study questions.

Looking at the first part of the first research sub-question concerning user groups for the potential CFKMS, it is clear that farmers/landowners/developers and researchers would be major beneficiaries of the system. In addition, policymakers, advisors, and funders expressed appreciation and enthusiasm for this initiative during the interviews. Nonetheless, it is important to acknowledge a constraint within this study: the limited participation of individuals from the aforementioned categories, coupled with the absence of certain user groups such as brokers, carbon credit buyers, validators, journalists, and the general public. Further research should consider including these stakeholders to gather insights and perspectives on the topic before moving to the implementation design.

Turning attention to the second half of the first research sub-question and the elements that make up the envisioned CFKMS, the Knowledge Base (KB) takes center stage as a primary vehicle for disseminating knowledge effectively, along with a Project-based Hub, Maps, Announcements, and Learning environments. Ensuring the provision of current and precise data is paramount, enabling users to access valuable and accurate information. A viable approach could involve offering incentives, both financial and non-financial, to content creators, supported by a dedicated team responsible for monitoring and maintaining the uploaded content.

Another important aspect of the potential CFKMS is the different types of projects that stakeholders want to include. These project categories help different groups work together, share knowledge, and coordinate effectively. This creates a positive environment for new and sustainable ideas. When developing the portal, it is a good idea to clearly separate these project types and provide accurate information for each of them.

Moreover, an essential aspect of the potential CFKMS is relevant to the inclusive design catering to diverse user group preferences. While the study revealed overlapping preferences among various stakeholder groups, it remains important to acknowledge their unique requirements and engage in a comprehensive exploration before embarking on the implementation and dissemination of knowledge. Neglecting this step could make the system challenging to navigate for certain users, potentially diminishing its utility.

Moving on to the second sub-question, the study reveals a significant alignment between the content and design principles of these existing KMSs and the envisioned platform for Carbon Farming. The findings of the secondary research highlight that existing Knowledge Management Systems (KMSs) in the agricultural domain share common foundational elements. Components such as a Knowledge Base (KB), search functionality, news sections, event listings, forums, blogs, and Frequently Asked Questions (FAQs) are consistently present in these systems. These KMSs, spanning diverse agricultural sectors globally, serve as valuable reference points for designing a potential KMSs tailored to Carbon Farming in the Netherlands.

However, while these insights provide a solid starting point, further investigation into the specific needs of Carbon Farming stakeholders in the Netherlands is essential to create a context-sensitive platform. This entails expanding the sample size of the existing KMSs, incorporating diverse sources, and implementing standardized search methodologies to ensure the reliability of outcomes while accounting for potential algorithmic variations.

Concerning the third sub-question examining how the identified features of the CFKMS align with challenges from participants and the literature, the propositions are numerous for a successful implementation. Phased implementation, funding exploration, user-centric design, dedicated maintenance, and a sustainable incentives model are proposed to address challenges specific to the CFKMS. While the system aids in managing project complexities within the Carbon Credit process, challenges in Carbon Market selection and monitoring persist. Furthermore, the CFKMS effectively addresses some of the socio-cultural, technological, economic, institutional, and ethical challenges outlined in the literature. Overall, the CFKMS demonstrates the potential to significantly enhance Carbon Farming endeavors.

Taking into account all the aforementioned aspects, the study can now provide a comprehensive answer to the central research question, resulting in the preceding analyses specific to the Netherlands' context.

Synthesizing the preceding findings allows us to conclude the significance of the proposed system. The envisioned CFKMS should embody a user-centric interface and design, catering to the needs of diverse stakeholder groups. Anchored by an accessible KB encompassing a spectrum of project types, the system should offer a centralized platform poised to streamline processes, reduce complexities, and promote communication, collaboration, and effective Carbon Farming project implementation. The CFKMS is though a starting point and should be treated as a promising solution that can significantly enhance collaboration, knowledge-sharing, and coordination among stakeholders involved in Carbon Farming initiatives. This can lead to fostering greater acceptance and utilization of Carbon Farming practices across the Netherlands.

Given the Netherlands' compact size and its commitment to maintaining a high quality of life, it becomes imperative to leverage every available resource. Notably, the strategic focus on Peatlands, Forestry, and BECCS attests to the nation's vision for

2030. The implementation of a CFKMS emerges as a viable avenue to advance these objectives. This distinct system holds the potential not only to contribute significantly to the nation's internal goals but also to showcase Carbon Farming practices on a global scale. By establishing such a platform, the Netherlands could not only bolster its domestic initiatives but also play a pioneering role in disseminating Carbon Farming practices worldwide.

Bibliography

Agropedia (n.d.). URL: http://agropedia.iitk.ac.in/.

AgroWiki (n.d.). URL: https://uhbdp.org/en/.

Alavi, Maryam and Dorothy E. Leidner (Mar. 2001). “Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues”. In: *MIS Quarterly* 25.1, p. 107. ISSN: 02767783. DOI: 10.2307/3250961. URL: https://www.jstor.org/stable/3250961?origin=crossref.

Baalen, Peter van, Jacqueline Bloemhof-Ruwaard, and Eric van Heck (June 2005). “Knowledge Sharing in an Emerging Network of Practice:” in: *European Management Journal* 23.3, pp. 300–314. ISSN: 02632373. DOI: 10.1016/j.emj.2005.04.008. URL: https://linkinghub.elsevier.com/retrieve/pii/S0263237305000484.

Bloomberg, Jason (Apr. 2018). “Digitization, Digitalization, And Digital Transformation: Confuse Them At Your Peril”. In: *Forbes*. URL: https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril/#78e677fd2f2c.

Bollen, J and R Aalbers (2017). “Biomass-energy with carbon capture and storage should be used immediately”. In: *CPB Netherlands Bureau for Economic Policy Analysis*.

Braun, Virginia and Victoria (Associate Professor in Sexuality Studies) Clarke (2013). “Successful Qualitative Research : A Practical Guide for Beginners”. In: *Successful Qualitative Research*, pp. 1–400.

Broekhoff, Derik et al. (2019). “Securing Climate Benefit: A Guide to Using Carbon Offsets”. In: *Stockholm Environment Institute & Greenhouse Gas Management Institute*. URL: https://www.offsetguide.org/pdf-download/.

Cabrera, Elizabeth F. and Angel Cabrera (May 2005). “Fostering knowledge sharing through people management practices”. In: *The International Journal of Human Resource Management* 16.5, pp. 720–735. ISSN: 0958-5192. DOI: 10.1080/09585190500083020. URL: https://www.tandfonline.com/doi/full/10.1080/09585190500083020.

Carbon Credits (n.d.). *The Ultimate Guide to Understanding Carbon Credits*. URL: https://carboncredits.com/the-ultimate-guide-to-understanding-carbon-credits/.

Chalmeta, Ricardo and Reyes Grangel (Mar. 2008). “Methodology for the implementation of knowledge management systems”. In: *Journal of the American Society for Information Science and Technology* 59.5, pp. 742–755. ISSN: 15322882. DOI: 10.1002/asi.20785. URL: https://onlinelibrary.wiley.com/doi/10.1002/asi.20785.

Crowley, Thomas J. (July 2000). "Causes of Climate Change Over the Past 1000 Years". In: *Science* 289.5477, pp. 270–277. ISSN: 0036-8075. DOI: 10.1126/science.289.5477.270. URL: https://www.science.org/doi/10.1126/science.289.5477.270.

Cummings, Jeffrey (2003). *Knowledge Sharing : A Review of the Literature*. URL: http://hdl.handle.net/10986/19060.

Cummings, Jonathon N. (Mar. 2004). "Work Groups, Structural Diversity, and Knowledge Sharing in a Global Organization". In: *Management Science* 50.3, pp. 352–364. ISSN: 0025-1909. DOI: 10.1287/mnsc.1030.0134. URL: https://pubsonline.informs.org/doi/10.1287/mnsc.1030.0134.

Danielsen, Frank (June 2021). "Benefits and Challenges of Digitalization: An Expert Study on Norwegian Public Organizations". In: *DG.O2021: The 22nd Annual International Conference on Digital Government Research*. New York, NY, USA: ACM, pp. 317–326. ISBN: 9781450384926. DOI: 10.1145/3463677.3463703. URL: https://dl.acm.org/doi/10.1145/3463677.3463703.

Delve (n.d.). *Essential Guide to Coding Qualitative Data*. URL: https://delvetool.com/guide.

Demeyer, Anna (June 2021). *Incentivising carbon farming; policy recommendations from the Carbon Farming project White paper*. Tech. rep.

Dumbrell, Nikki P., Marit E. Kragt, and Fiona L. Gibson (July 2016). "What carbon farming activities are farmers likely to adopt? A best–worst scaling survey". In: *Land Use Policy* 54, pp. 29–37. ISSN: 02648377. DOI: 10.1016/j.landusepol.2016.02.002. URL: https://linkinghub.elsevier.com/retrieve/pii/S0264837716000181.

Eurostat (2020). *Glossary:Manure - Statistics Explained*. URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Manure&oldid=476892.

Evans, Megan C (June 2018). "Effective incentives for reforestation: lessons from Australia's carbon farming policies". In: *Current Opinion in Environmental Sustainability* 32, pp. 38–45. ISSN: 18773435. DOI: 10.1016/j.cosust.2018.04.002. URL: https://linkinghub.elsevier.com/retrieve/pii/S1877343517301604.

Farmer Portal (n.d.). URL: https://www.farmer.gov.in/.

Favasuli, Silvia and Sebastian Vandana (June 2021). *Voluntary carbon markets: how they work, how they're priced and who's involved*. URL: https://www.spglobal.com/commodityinsights/en/market-insights/blogs/energy-transition/061021-voluntary-carbon-markets-pricing-participants-trading-corsia-credits.

Fuijta, Yuki et al. (Feb. 2023). "Quantifying the potential of agricultural soils to store carbon. A data-driven approach illustrated for the Netherlands." In: *EGU23*. DOI: 10.5194/egusphere-egu23-12830. URL: https://meetingorganizer.copernicus.org/EGU23/EGU23-12830.html.

GDNK (Sept. 2019). "Van projectplan tot uitgifte van certificaten". In: *Green Deal Nationale Koolstofmarkt*.

Gong, Cheng and Vincent Ribiere (Apr. 2021). "Developing a unified definition of digital transformation". In: *Technovation* 102, p. 102217. ISSN: 01664972. DOI: 10.1016/j.technovation.2020.102217. URL: https://linkinghub.elsevier.com/retrieve/pii/S0166497220300894.

Goodman, Leo A. (Mar. 1961). "Snowball Sampling". In: *The Annals of Mathematical Statistics* 32.1, pp. 148–170. ISSN: 0003-4851. DOI: 10.1214/aoms/1177705148. URL: http://projecteuclid.org/euclid.aoms/1177705148.

Guichard, L. et al. (2015). "AgroPEPS, a collaborative web tool of knowledge management to Share, Practice, Inform on sustainable cropping systems". In: DOI: 10.3/JQUERY-UI.JS. URL: https://agris.fao.org/agris-search/search.do?recordID=FR2021010120.

Gupta, Anil (Jan. 2016). "Climate Change and Kyoto Protocol". In: *Handbook of Environmental and Sustainable Finance*. Elsevier, pp. 3–23. DOI: 10.1016/B978-0-12-803615-0.00001-7. URL: https://linkinghub.elsevier.com/retrieve/pii/B9780128036150000017.

Hahn, Jungpil and Mani Subramani (Dec. 2000). "A Framework of Knowledge Management Systems: Issues and Challenges for Theory and Practice". In: *ICIS 2000 Proceedings*. URL: https://aisel.aisnet.org/icis2000/28.

Harbo, Laura Sofie et al. (Sept. 2022). "Estimating organic carbon stocks of mineral soils in Denmark: Impact of bulk density and content of rock fragments". In: *Geoderma Regional* 30, e00560. ISSN: 23520094. DOI: 10.1016/j.geodrs.2022.e00560. URL: https://linkinghub.elsevier.com/retrieve/pii/S2352009422000803.

Hilger, Joseph and Zachary Wahl (2022). "Common KMS Project Challenges and Mistakes". In: *Making Knowledge Management Clickable*, pp. 241–245. DOI: 10.1007/978-3-030-92385-3{_}17. URL: https://link.springer.com/chapter/10.1007/978-3-030-92385-3_17.

IOSCO (2022). "Voluntary Carbon Markets". URL: www.iosco.org.

IPCC (2019). "Climate Change and Land: An IPCC Special Report". In: URL: https://www.ipcc.ch/site/assets/uploads/2019/08/Fullreport-1.pdf.

Ipe, Minu (Dec. 2003). "Knowledge Sharing in Organizations: A Conceptual Framework". In: *Human Resource Development Review* 2.4, pp. 337–359. ISSN: 1534-4843. DOI: 10.1177/1534484303257985. URL: http://journals.sagepub.com/doi/10.1177/1534484303257985.

IPS (n.d.). *What are peatlands? - International Peatland Society*. URL: https://peatlands.org/peatlands/what-are-peatlands/.

Janzen, H H (2004). "Carbon cycling in earth systems-a soil science perspective". In: *Ecosystems and Environment* 104, pp. 399–417. DOI: 10.1016/j.agee.2004.01.040.

Jennifer (Feb. 2023). *Carbon Credits Farming (Everything You Need To Know)*. URL: https://carboncredits.com/carbon-credits-farming-everything-you-need-to-know/.

JIN (n.d.). *Stichting Nationale Koolstofmarkt*. URL: https://jin.ngo/14-projects/225-stichting-nationale-koolstofmarkt.

Kahneman, D (2013). *Think Fast and Slow*.

Karki, Lokendra (2021). "D6.1: Assessment of regional/continental market potential of LMTs (WP 6) - Internal Deliverable".

Karki, Lokendra et al. (July 2023). "Potentials and barriers to land-based mitigation technologies and practices (LMTs) - a review". In: *Environmental Research Letters*. ISSN: 1748-9326. DOI: 10.1088/1748-9326/ACE91F. URL: https://iopscience.iop.org/article/10.1088/1748-9326/ace91f%20https://iopscience.iop.org/article/10.1088/1748-9326/ace91f/meta.

Kinney, Thomas (Jan. 1999). "Knowledge Management, Intellectual Capital and Adult Learning". In: *Adult Learning* 10.2, pp. 2–3. ISSN: 1045-1595. DOI: 10.1177/104515959901000201. URL: http://journals.sagepub.com/doi/10.1177/104515959901000201.

Kollmuss, Anja, Helge Zink, and Clifford Polycarp (2008). "Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards". In: *WWF Germany*.

Kragt, Marit E., Nikki P. Dumbrell, and Louise Blackmore (July 2017). "Motivations and barriers for Western Australian broad-acre farmers to adopt carbon farming". In: *Environmental Science & Policy* 73, pp. 115–123. ISSN: 14629011. DOI: 10.1016/j.envsci.2017.04.009. URL: https://linkinghub.elsevier.com/retrieve/pii/S1462901116307894.

Kragt, Marit Ellen et al. (Dec. 2014). "What are the barriers to adopting carbon farming practices?" In: DOI: 10.22004/AG.ECON.195776. URL: https://ageconsearch.umn.edu/record/195776.

Kumar, Sunil, V. Sangeetha, et al. (2017). "Perceived Utility and Users' Satisfaction about Information Provided by Rice Knowledge Management Portal (RKMP)". In: *Journal of Global Communication* 10.2, p. 122. ISSN: 0974-0600. DOI: 10.5958/0976-2442.2017.00021.0. URL: http://www.indianjournals.com/ijor.aspx?target=ijor:jgc&volume=10&issue=2&article=011.

Kumar, Sunil, Rahul Singh, et al. (2017). "Knowledge Management in Agriculture: A Critical Analysis". In: 5, pp. 19–26. ISSN: 2321-8851. URL: https://ssrn.com/abstract=3090942.

LANDMARC (2021). *Land-Based Mitigation Technologies for the Netherlands*. URL: https://www.landmarc2020.eu/netherlands-peat-soils-agroforestry/land-based-mitigation-technologies-for-the-netherlands.

Mcdonald, Hugh et al. (Nov. 2021). "Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards". In: *European Parliament*.

Miro (n.d.). *Miro*. URL: https://miro.com/app/dashboard/.

Mishra, D. and U. Deichmann (July 2016). "World Development Report, 2016: digital dividends". In: *Choice Reviews Online* 53.11, pp. 53–4889. ISSN: 0009-4978. DOI: 10.5860/CHOICE.196952. URL: http://choicereviews.org/review/10.5860/CHOICE.196952.

Paia Team (July 2021). *Carbon Offsets and Credits, Explained*. URL: https://paiaconsulting.com.sg/carbon-offsets-and-credits-explained/.

Parviainen, Päivi et al. (Feb. 2022). "Tackling the digitalization challenge: how to benefit from digitalization in practice". In: *International Journal of Information Systems and Project Management* 5.1, pp. 63–77. ISSN: 2182-7788. DOI: 10.12821/ijispm050104. URL: https://revistas.uminho.pt/index.php/ijispm/article/view/3856.

Reijneveld, A., J. van Wensem, and O. Oenema (Sept. 2009). "Soil organic carbon contents of agricultural land in the Netherlands between 1984 and 2004". In: *Geoderma* 152.3-4, pp. 231–238. ISSN: 0016-7061. DOI: 10.1016/J.GEODERMA.2009.06.007.

Reis, João et al. (2020). "Digitalization: A Literature Review and Research Agenda". In: Springer, Cham, pp. 443–456. DOI: 10.1007/978-3-030-43616-2{_}47. URL: http://link.springer.com/10.1007/978-3-030-43616-2_47.

Rice Knowledge Management Portal (n.d.). URL: http://www.riceportal.in/about-rkmp.

Riege, Andreas and Nicholas Lindsay (n.d.). "Knowledge management in the public sector: stakeholder partnerships in the public policy development". In: (). DOI: 10.1108/13673270610670830. URL: www.oecd.org.

Sharma, Meenakshi et al. (Oct. 2021). "Carbon Farming: Prospects and Challenges". In: *Sustainability* 13.19, p. 11122. ISSN: 2071-1050. DOI: 10.3390/su131911122. URL: https://www.mdpi.com/2071-1050/13/19/11122.

Sharma, Prabhakar (Oct. 2015). “Nanomaterials from Food Packaging and Commercial Products into Ecological and Soil Environment”. In: *Current Science* 109.7, pp. 1223–1224. ISSN: 0011-3891. DOI: 10 . 1038 / ncomms. URL: https://www.i-scholar.in/index.php/CURS/article/view/92122.

Smith, Pete et al. (Aug. 2013). “How much land-based greenhouse gas mitigation can be achieved without compromising food security and environmental goals?” In: *Global Change Biology* 19.8, pp. 2285–2302. ISSN: 13541013. DOI: 10.1111/gcb.12160. URL: https://onlinelibrary.wiley.com/doi/10.1111/gcb.12160.

SNK (n.d.). *Stichting Nationale Koolstofmarkt*. URL: https://nationaleco2markt.nl/.

Soulignac, Vincent et al. (July 2019). “GECO, the French Web-based application for knowledge management in agroecology”. In: *Computers and Electronics in Agriculture* 162, pp. 1050–1056. ISSN: 01681699. DOI: 10.1016/j.compag.2017.10.028. URL: https://linkinghub.elsevier.com/retrieve/pii/S0168169917300492.

Spijker, Eise (2022). *D2.5: Guidance report for potential role of carbon offsetting schemes and Paris Agreement (WP 2) - Internal Deliverable*. Tech. rep. LANDMARC.

Stenmark, Dick (Dec. 2000). “Leveraging Tacit Organizational Knowledge”. In: *Journal of Management Information Systems* 17.3, pp. 9–24. ISSN: 0742-1222. DOI: 10.1080/07421222.2000.11045655. URL: https://www.tandfonline.com/doi/full/10.1080/07421222.2000.11045655.

Stern, David I. and Robert K. Kaufmann (Jan. 2014). “Anthropogenic and natural causes of climate change”. In: *Climatic Change* 122.1-2, pp. 257–269. ISSN: 0165-0009. DOI: 10.1007/s10584-013-1007-x. URL: http://link.springer.com/10.1007/s10584-013-1007-x.

Stover, Mark (June 2004). “Making tacit knowledge explicit: the Ready Reference Database as codified knowledge”. In: *Reference Services Review* 32.2, pp. 164–173. ISSN: 0090-7324. DOI: 10.1108/00907320410537685. URL: https://www.emerald.com/insight/content/doi/10.1108/00907320410537685/full/html.

Sulaiman V, Rasheed et al. (May 2011). “Tacit knowledge and innovation capacity: evidence from the Indian livestock sector”. In: *Knowledge Management for Development Journal* 7.1, pp. 32–44. ISSN: 1947-4199. DOI: 10 . 1080 / 19474199 . 2011 . 593855. URL: http://www.tandfonline.com/doi/abs/10.1080/19474199.2011.593855.

Tong, Allison, Peter Sainsbury, and Jonathan Craig (Dec. 2007). “Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups”. In: *International Journal for Quality in Health Care* 19.6, pp. 349–357. ISSN: 1353-4505. DOI: 10.1093/INTQHC/MZM042. URL: https://dx.doi.org/10.1093/intqhc/mzm042.

Turel, Ofir, Hamed Qahri-Saremi, and Isaac Vaghefi (Apr. 2021). “Special Issue: Dark Sides of Digitalization”. In: *International Journal of Electronic Commerce* 25.2, pp. 127–135. ISSN: 1086-4415. DOI: 10.1080/10864415.2021.1887694. URL: https://www.tandfonline.com/doi/full/10.1080/10864415.2021.1887694.

USDA (n.d.). *Agroforestry Practices | USDA National Agroforestry Center*. URL: https://www.fs.usda.gov/nac/practices/index.shtml.

Voelpel, Sven C., Malte Dous, and Thomas H. Davenport (May 2005). “Five steps to creating a global knowledge-sharing system: Siemens’ ShareNet”. In: *Academy of Management Perspectives* 19.2, pp. 9–23. ISSN: 1558-9080. DOI: 10 . 5465 / ame . 2005 . 16962590. URL: http://journals.aom.org/doi/10.5465/ame.2005.16962590.

Wang, Sheng and Raymond A. Noe (June 2010). “Knowledge sharing: A review and directions for future research”. In: *Human Resource Management Review* 20.2, pp. 115–131. ISSN: 10534822. DOI: 10.1016/j.hrmr.2009.10.001. URL: https://linkinghub.elsevier.com/retrieve/pii/S1053482209000904.

Wessel, Gerko and Remco de Boer (2023). “Voluntary Carbon Markets: Supervisory issues”. In: *The Dutch Authority for the Financial Markets*. URL: https://www.afm.nl/~/profmedia/files/rapporten/2023/occasional-paper-handel-in-co2.pdf.

Yadav, K. et al. (2015). “ICTs in knowledge management: the case of the Agropedia platform for Indian agriculture”. In: *Knowledge Management for Development Journal*.

Yin, Robert K. (2018). “Case Study Research Design and Applications”. In: *The Canadian Journal of Program Evaluation*, p. 319.

Zhang, X. et al. (Mar. 2020). “Quantifying Nutrient Budgets for Sustainable Nutrient Management”. In: *Global Biogeochemical Cycles* 34.3, e2018GB006060. ISSN: 0886-6236. DOI: 10.1029/2018GB006060. URL: https://onlinelibrary.wiley.com/doi/10.1029/2018GB006060.

Appendix A

Selection of Existing KMSs in Agriculture

A.1 Rice Knowledge Management Portal (RKMP)

The Rice Knowledge Management Portal (RKMP) project was initiated in 2009 and sponsored by the National Agricultural Innovation Project under the Indian Council of Agricultural Research. The main objective of the project was to develop and maintain the RKMP as a platform to strengthen research, extension services, farmers, private subsystems, partnerships, and networks in the rice sector. The RKMP serves as a comprehensive Knowledge Management platform that facilitates the flow of rice knowledge and information through the use of the latest Information and Communication Technology tools (Kumar, Singh, et al., 2017).

The RKMP project aimed to address the challenges in the rice sector by providing an information highway for sharing rice knowledge. It serves as a one-stop platform for authentic, validated, relevant, and contextual information related to rice. The primary focus of the project was to enhance the dissemination of rice knowledge and information, contributing to the overall development of rice production in the country. By equipping stakeholders with the necessary skills and expertise, the project aimed to maximize the utilization of the RKMP as a valuable resource in the rice sector (Kumar, Singh, et al., 2017).

The primary vision of the RKMP, as stated on the portal, is to cater to a diverse group of stakeholders and contribute to enhanced planning processes aimed at achieving increased productivity and production of rice (*Rice Knowledge Management Portal* n.d.).

According to research conducted by Kumar, Sangeetha, et al. (2017), which aimed to examine the perceived usefulness and satisfaction of stakeholders regarding the RKMP system, the results were overwhelmingly positive. The effectiveness of the information provided by RKMP was found to vary in terms of its usefulness for different groups, including farmers, scientists, and extension personnel. However, the findings strongly indicate that these stakeholders perceive RKMP as a valuable resource for accessing rice-related information. While RKMP is generally accepted by all stakeholders, it is particularly favored by scientists, followed by extension personnel and farmers. This preference can be attributed to factors such as technological features, user-friendliness, usability, and the perceived benefits of the technology. Among the aspects evaluated, the adequacy of content, the ability to address queries, and the timeliness of information were identified as the most satisfying factors related to RKMP (Kumar, Sangeetha, et al., 2017).

The aforementioned portal, accessible via the webpage http://www.riceportal.in/, continues to remain operational, providing valuable information to all pertinent stakeholders. Figure A.1 depicts a visual representation of the homepage, showcasing its current status.

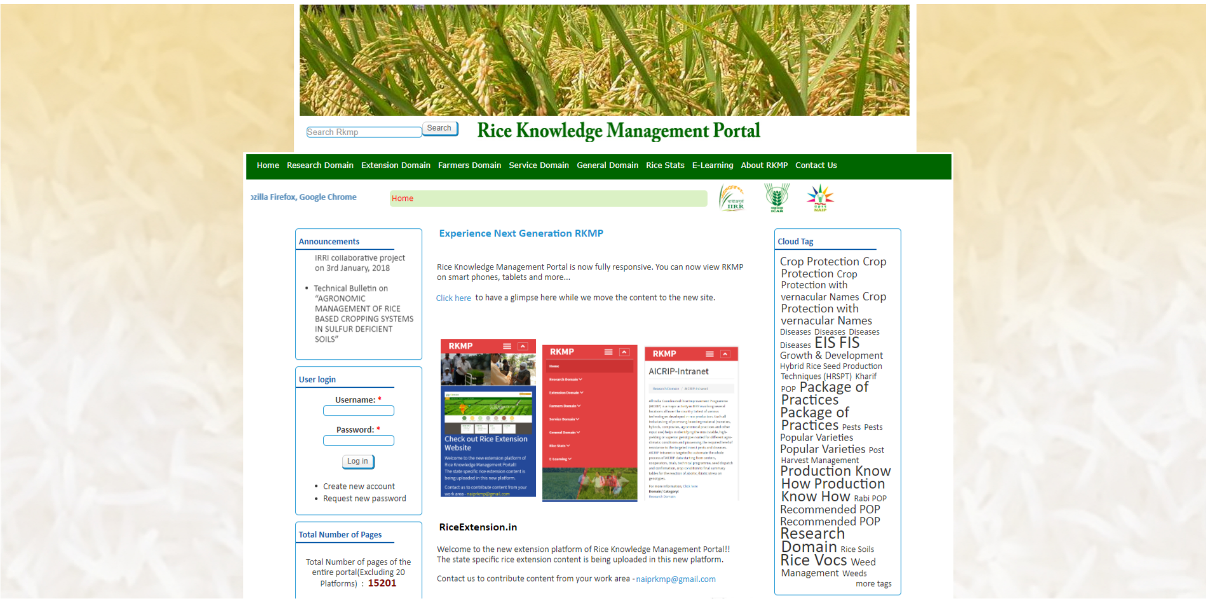

Figure A.1: Snapshot of the homepage of the RKMP. Retrieved from http://www.riceportal.in/ on 22 May 2023.

The contents of the portal are meticulously structured to cater to the specific needs and preferences of the webpage visitors, according to their perspective.

A.2 Tamil Nadu Agricultural University Agri-tech portal

The Tamil Nadu Agricultural University Agritech portal was established in 2009 by the Tamil Nadu Agricultural University. Its primary audience includes farmers, scientists, and other stakeholders involved in agriculture and related sectors such as animal husbandry, sericulture, and fisheries. The main objective of this portal is to provide customized farm advice tailored to the specific needs of farmers, rather than offering general or generic information. It aims to address the challenges and issues faced by farmers while serving as a comprehensive source of information for various categories of stakeholders (Kumar, Singh, et al., 2017).

The portal offers a wide range of information, both Tamil and English, including crop-related data, government schemes, programs for farmers, and publications. Noteworthy features of the portal include Multi Video Conferencing, Dynamic Market Information, Domestic and Export Market Intelligence Cell, Automatic Weather Network, and Instant Agro-Advisory System, among others (Kumar, Singh, et al., 2017).

The previously mentioned portal, which can be accessed through the webpage https://agritech.tnau.ac.in/, remains functional, continuing to provide invaluable information to all relevant stakeholders. Its homepage, as depicted in Figure A.2, visually represents the current state of the portal, highlighting its ongoing operations and significance.

Figure A.2: Snapshot of the homepage of the Tamil Nadu Agricultural University Agritech portal. Retrieved from https://agritech.tnau.ac.in/ on 22 May 2023.

The contents of the page are structured depending on the context around it.

A.3 Farmers' Portal India

In addition, the Ministry of Agriculture from the Government of India introduced a dedicated farmer's portal in November 2015, aimed at providing essential information to farmers. Within the Farmers' Portal, farmers have access to relevant information concerning their specific location, including their village, block, district, or state. This information is available in various formats such as text, Short Message Service (SMS), email, and audio/video, presented in the language that farmers understand. To facilitate navigation, the Home page of the portal features a Map of India, enabling farmers to easily access information at different levels. Moreover, a Feedback module has been developed to enable farmers to ask specific queries and provide valuable feedback regarding the portal (*Farmer Portal* n.d.). A visual representation of the portal can be observed in Figure A.3.

Figure A.3: Snapshot of the homepage of the Farmers' Portal of India. Retrieved from https://www.farmer.gov.in/ on 1 June 2023.

The contents of this portal are focused on the different procedures with many more underneath each link.

A.4 GECO

GECO is a collaborative Knowledge Management web-based application dedicated to agroecological transition in France (Soulignac et al., 2019). It is described as an improved version of Agro-PEPS, another web-based application for Knowledge Management in agroecology (Guichard et al., 2015).

GECO aims to facilitate the management and transfer of knowledge in the field of agroecology. It utilizes methodological tools developed by a French Knowledge Management group, allowing for the transfer of both explicit and tacit knowledge within organizations. The application is designed to enable farmers and other stakeholders to formalize, share, and discuss knowledge related to agroecology. By providing a platform for knowledge exchange, GECO contributes to the broader agroecology community (Soulignac et al., 2019).

According to the author of this report, although GECO is still in active utilization, it is perceived as relatively challenging to locate and access. Access to GECO is facilitated through the following link: https://geco.ecophytopic.fr/. To provide a visual depiction of the portal, Figure A.4 has been included below as an illustrative representation.

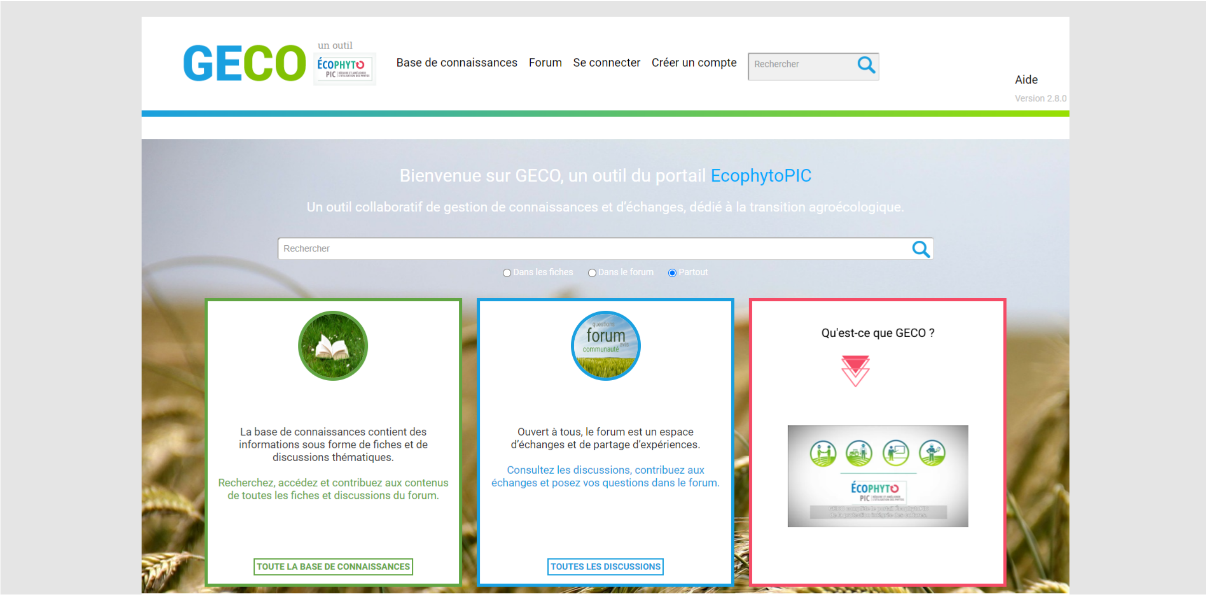

Figure A.4: Snapshot of the homepage of the GECO portal.
Retrieved from https://geco.ecophytopic.fr/ on 22 May 2023.

The webpage consists of two primary domains, namely the Knowledge Base and the Forum. These domains encompass various pages, each serving a specific purpose.

A.5 AgroWiki

AgroWiki (https://uhbdp.org/en/) is a Ukrainian initiative aimed at fostering the growth of fruit and vegetable cultivation in the business sector. Referred to as the Ukrainian Fruit and Vegetable Business Development Project, it receives financial support from the Ministry of International Affairs of Canada. AgroWiki's primary objective is to grant horticultural growers unrestricted access to knowledge while simultaneously boosting the profitability of small and medium-scale fruit and vegetable producers and other stakeholders in the market (*AgroWiki* n.d.).

For illustrative purposes, an accompanying visual representation of the portal has been included as Figure A.5, displayed below.

The website features a user-friendly interface, incorporating various tools and sections to enhance user experience and facilitate access to information.

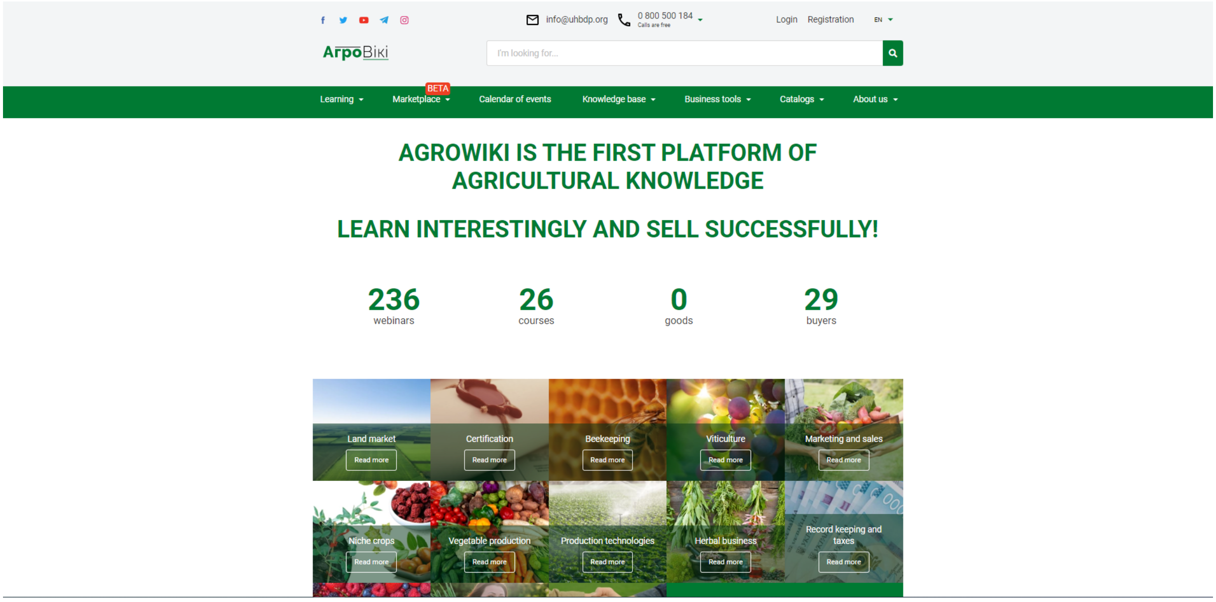

Figure A.5: Snapshot of the homepage of the AgroWiki portal.
Retrieved from https://uhbdp.org/en/ on 22 May 2023.

A.6 Agropedia

The Agropedia project, titled "Re-designing the farmer-extension-agricultural research/education continuum in India with Information and Communication Technology-Mediated Knowledge Management", was initiated to address challenges in the agricultural sector in India and provide a national entry point for agriculture-related information. It was established in 2009 with support from the World Bank and the Indian Council of Agricultural Research (Kumar, Singh, et al., 2017).

The project's objectives include developing a comprehensive agricultural repository, creating a digital ecosystem for knowledge circulation, deploying extension services for agricultural development, and facilitating knowledge exchange among experts. Agropedia aims to drive progress in the agricultural sector and promote sustainable farming practices (*Agropedia* n.d.).

Agropedia's knowledge base is divided into two categories. The first is Certified Content, which is the content that is now available and offers agricultural advice on what should and shouldn't be done when growing nine different crops, text and voice messages sent to registered farmers, and a calendar of crops organized by month. The consortium partners who created this resource. Semantic search capabilities are employed to facilitate the effective retrieval of information within the certified content. Agro-wiki, Agro-blog, and Questions and Answers (Q&As) Forum make up the second category, Contributed content. Various communication channels, such as text and voice messaging, are utilized to share this knowledge. The primary objective of the Contributed Content section is to foster collaboration and knowledge exchange among diverse stakeholders (*Agropedia* n.d.; Yadav et al., 2015).

Platforms like Agropedia, according to Yadav et al. (2015), can facilitate the creation and dissemination of pertinent content for policymakers, industry, retailers, and researchers. The same authors agree that even though Agropedia addressed some of the problems, much more work must be done in order to fully benefit from this endeavor (Yadav et al., 2015). Please note that the Agropedia project is currently inactive, but its webpage with archived information can still be accessed at http://agropedia.iitk.ac.in/. A snapshot of the homepage can be observed in Figure A.6.

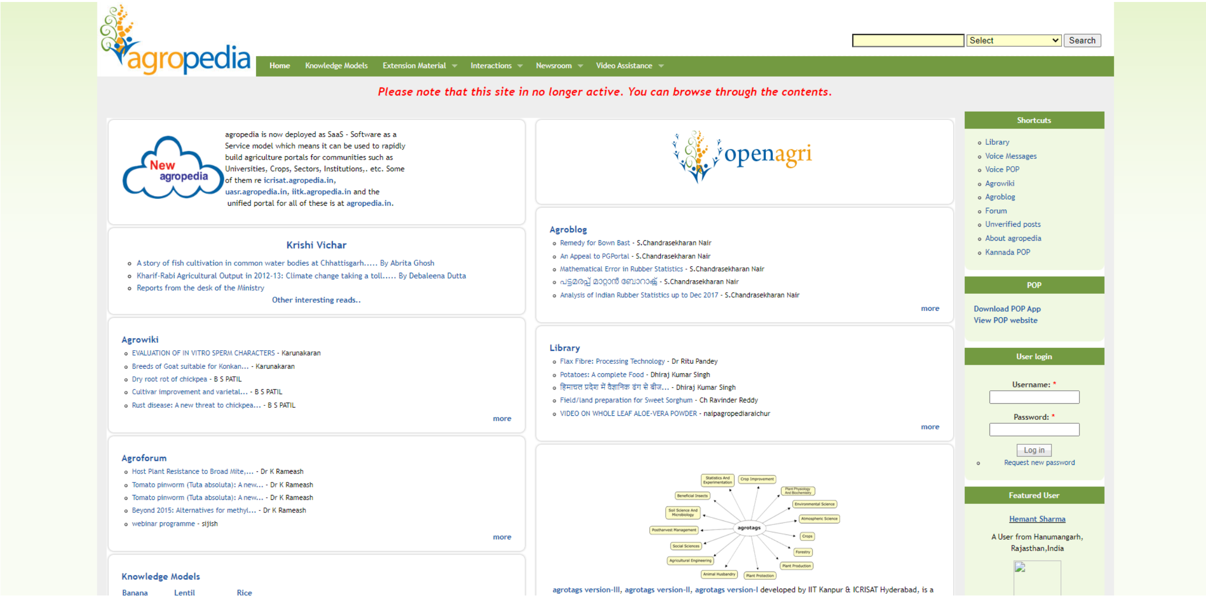

Figure A.6: Snapshot of the homepage of the Agropedia portal.
Retrieved from http://agropedia.iitk.ac.in/ on 22 May 2023.

The development of Agropedia encompassed two distinct phases. Initially, the focus was on establishing a foundational platform to fulfill the system's objectives. However, the mere aggregation and digitization of content from various sources were deemed insufficient to effectively assist Indian farmers, who often face illiteracy and limited access to computers and the Internet. Subsequently, the second phase was dedicated to enhancing the platform by updating existing content, incorporating new information, and disseminating knowledge directly to farmers through voice messages. This approach aimed to ensure widespread knowledge dissemination beyond the realm of knowledge partners (Yadav et al., 2015). Although the webpage is currently deprecated, it previously operated under the Software as a Service model, which allowed for the quick creation of agriculture portals tailored to certain communities, such as universities, Crops, Sectors, Institutions, etc. (*Agropedia* n.d.).

Appendix B

Carbon Credit Process

This appendix presents a more detailed understanding of each step and stakeholder, including visual representations and diagrams illustrating the key concepts and processes discussed in Section 2.2.1.

B.1 Original Source Diagrams

These diagrams have been selected from the respective sources to serve as visual aids in understanding the Carbon Credit Process. Each diagram is accompanied by a caption and proper citation, acknowledging the original source. The diagrams offer a clear and concise overview of the stages and components within the Carbon Credit Process.

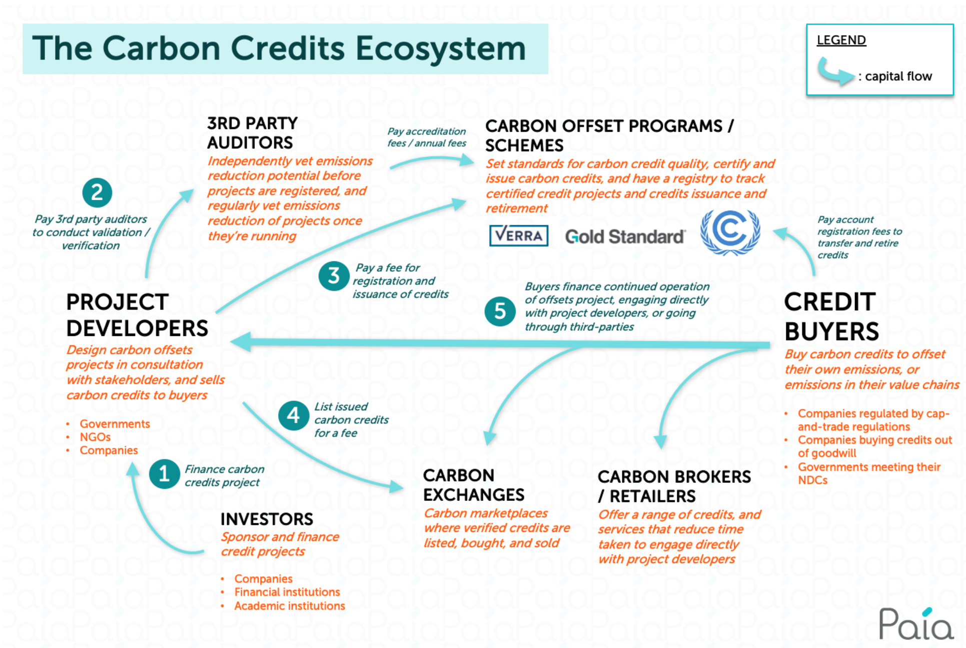

Figure B.1: The Carbon Credit Ecosystem. Originally used by Paia Team (2021) and reproduced by IOSCO (2022).

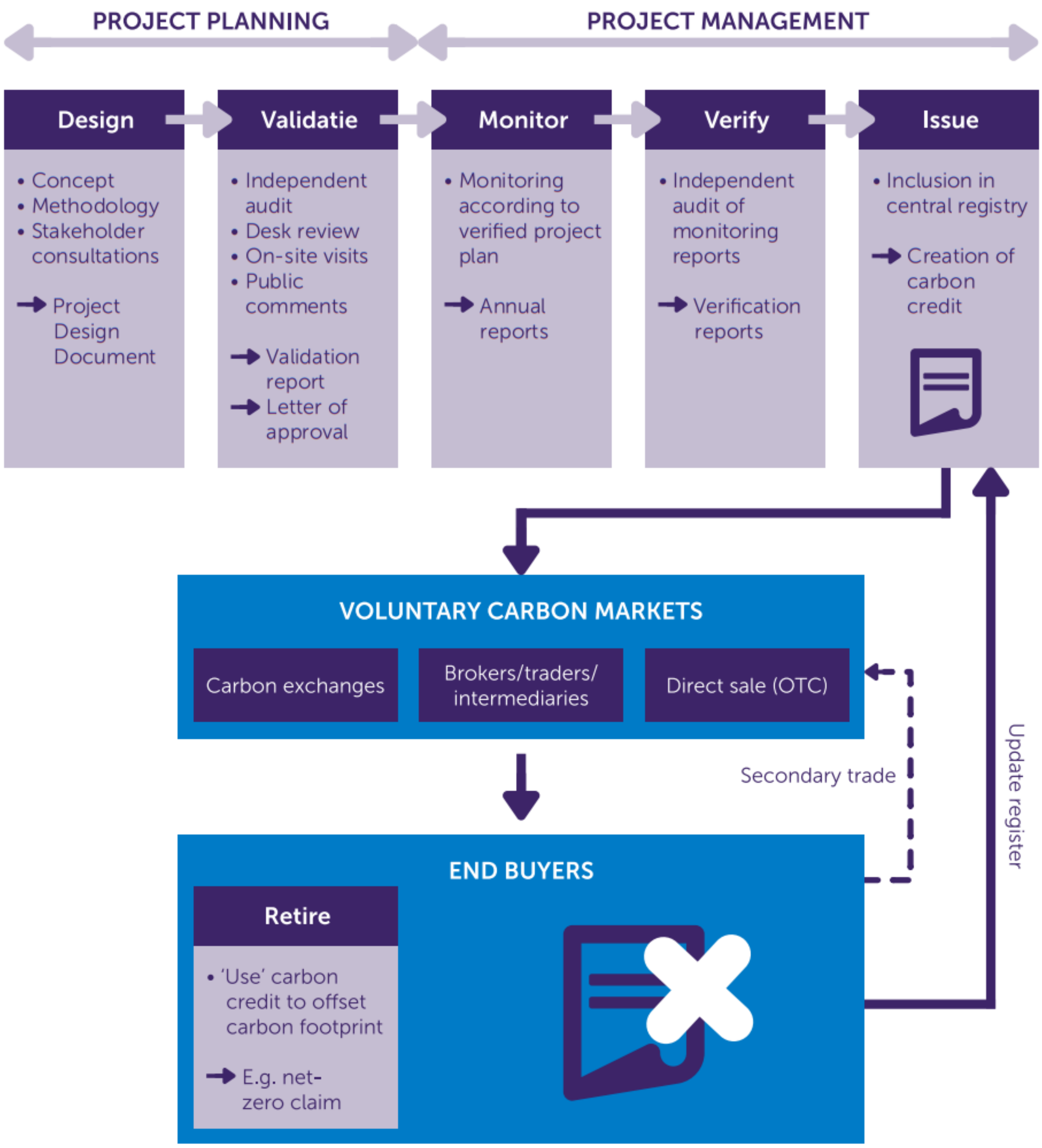

Figure B.2: Overview of the voluntary carbon credits mechanism. Originally used by Wessel and Boer (2023).

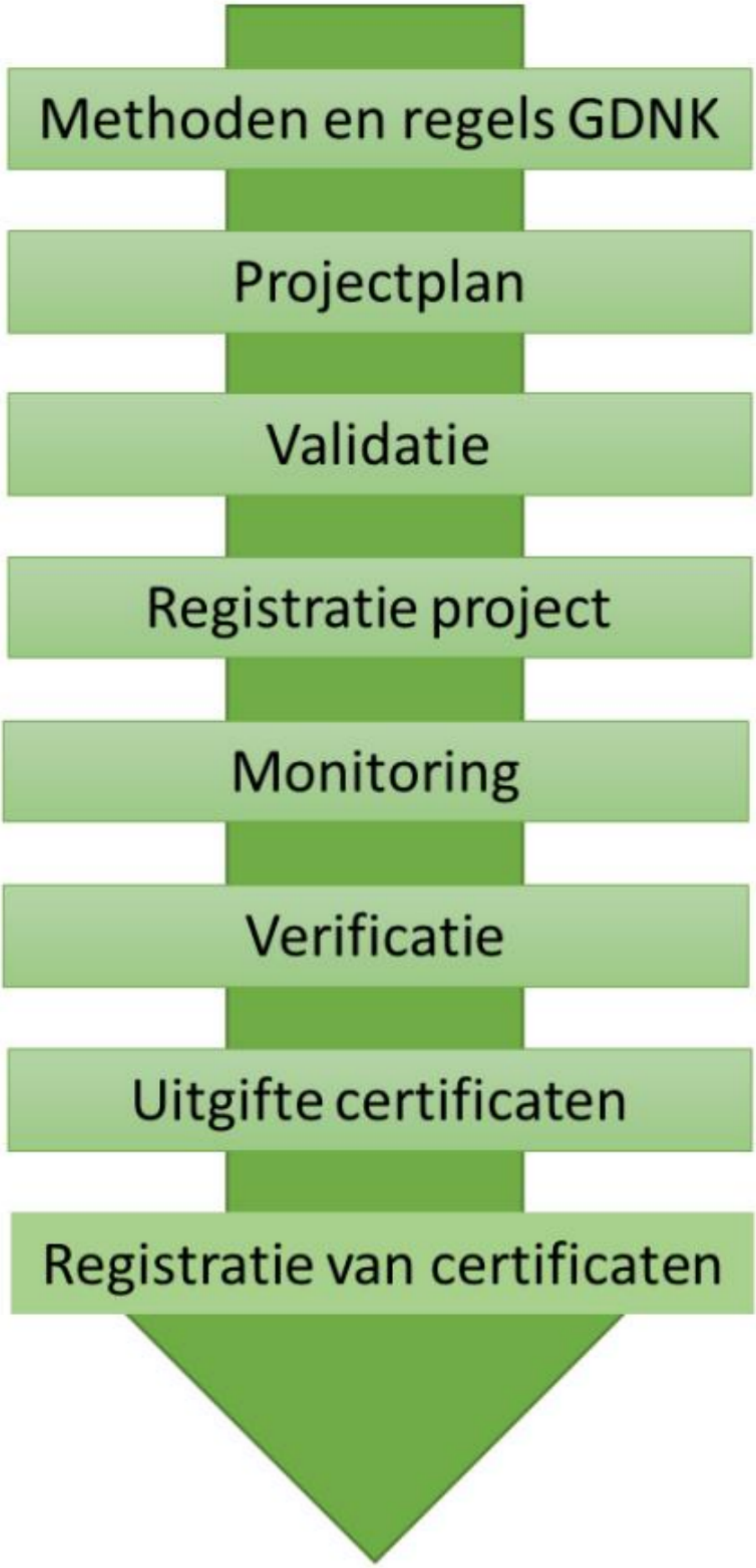

Figure B.3: Overview of project cycle for issuing and registering CO2 certificates. Originally used by GDNK (2019).

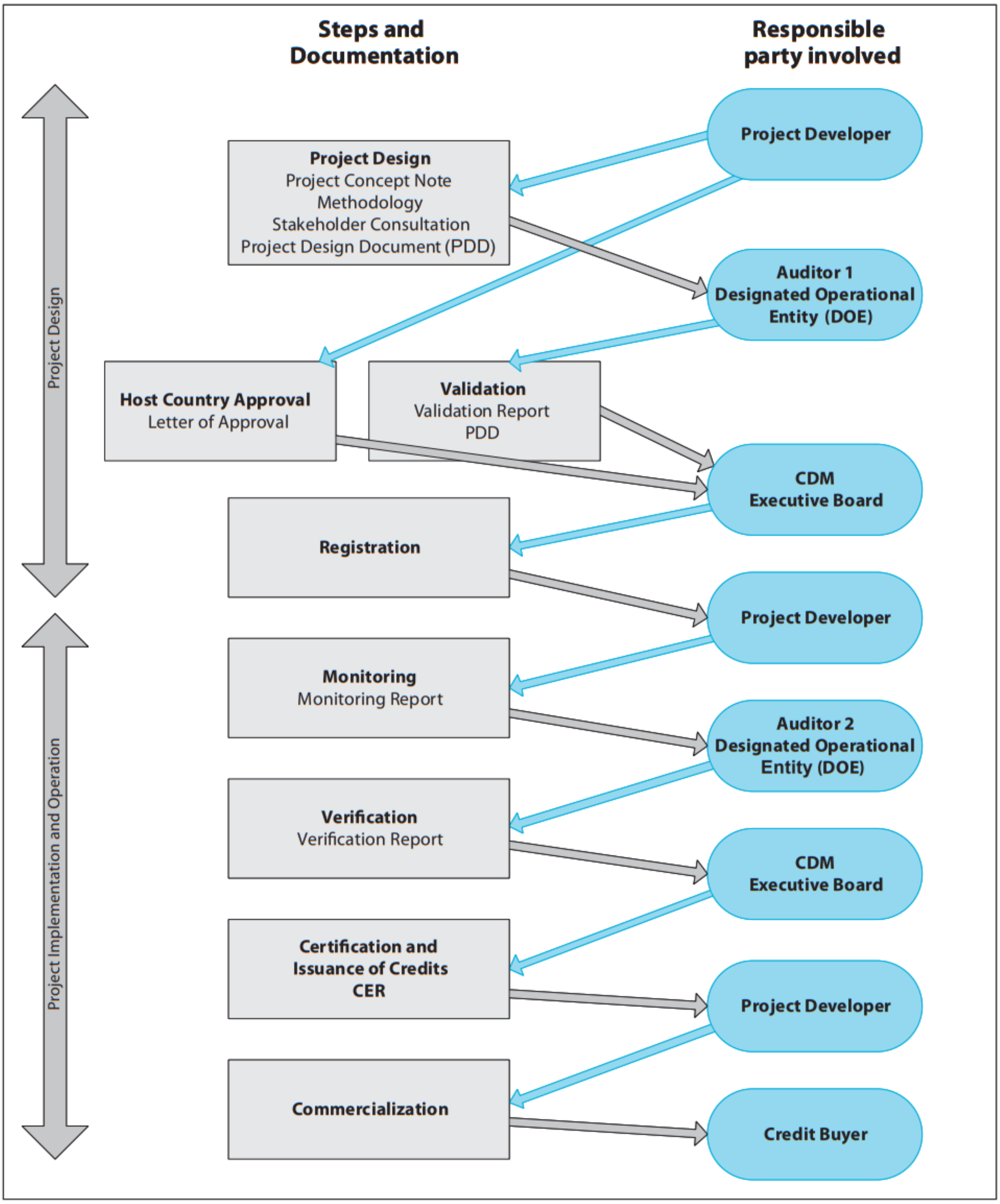

Figure B.4: The CDM Project Cycle. Originally used by Kollmuss, Zink, and Polycarp (2008).

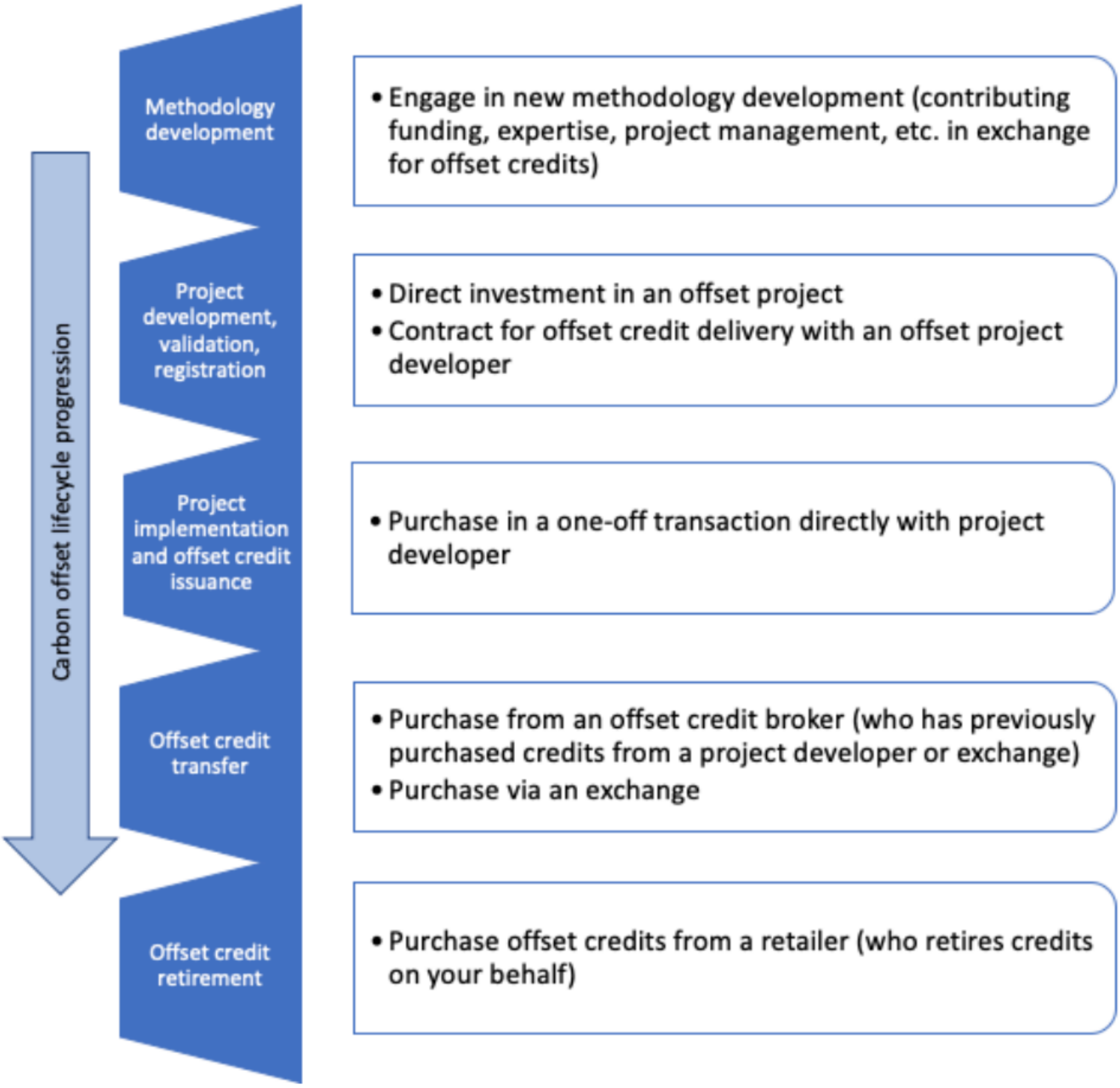

Figure B.5: Carbon offset credit lifecycle and buyer purchase options at each stage. Originally used by Broekhoff et al. (2019).

B.2 Detailed Description of Process

B.2.1 Project Planning

The initial phase of the Carbon Credit creation process involves several important actions before the project begins, related to rules and paperwork. To bring the project to life, project developers secure financing from investors, undergo validation by an independent verifier, and register the project. Registration signifies approval and eligibility to generate Carbon Credits (Broekhoff et al., 2019).

Project Design These actions include developing the project concept, selecting appropriate methodologies and standards, and engaging in consultations with stakeholders to ensure the project's compatibility with local communities. All of these activities are reported in the Project Design Document (PDD) (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022). Independent standard setters outline the precise steps, procedures, and requirements that must be fulfilled in order to produce carbon credits in accordance with that standard (Wessel and Boer, 2023).

Project Concept A feasibility study evaluates various aspects such as technical feasibility, investment requirements, development and operational costs, anticipated returns, administrative and legal challenges, as well as potential risks and obstacles. The project owner carefully assesses the study's findings to make an informed decision on whether to proceed with the project or not (Kollmuss, Zink, and Polycarp, 2008).

Methodology Development To obtain certification for GHG reduction, a specific methodology or protocol is required. This methodology sets out the guidelines for project developers to establish a project baseline, determine project additionality, calculate emission reductions, and monitor key parameters. Many programs have a collection of approved methodologies. In cases where no approved methodology exists for a specific project type, project developers have the option to submit a new methodology for approval to the Methodology Panel. Additionally, project developers can propose new methodologies to be considered for program approval and adoption (Broekhoff et al., 2019; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022). In the Netherlands, the SNK *Rulebook* includes all the proposed methodologies approved by the SNK (GDNK, 2019)

Project Design Document (PDD) This document provides a description of the project activity, including the selected technology, methodology, monitoring of technical parameters, estimation of emission reductions, and the project's contribution to sustainable development. It serves as a crucial document for evaluating carbon credit transactions and contract proposals related to the project. Throughout the implementation phase, the PDD is utilized to ensure that the project adheres to the parameters outlined in the document (Kollmuss, Zink, and Polycarp, 2008).

Stakeholder Consultation(s) In order to engage all relevant stakeholders and gather their input, the project developer is required to communicate the details of the proposed project through suitable media channels. The project developer must respond to any feedback or issues expressed by stakeholders and lay out steps to reduce any potential negative effects. The PDD must include the findings of these stakeholder discussions (Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

Project Validation Once the PDD is prepared, at least two experts from the Board of SNK verify the project design (GDNK, 2019). This verification process ensures that the project aligns with the chosen methodology, aims to achieve the projected carbon reduction, and avoids any negative impacts (Wessel and Boer, 2023). The validation phase comprises five stages: a desk review of the PDD, on-site visits and follow-up interviews with stakeholders, a 30-day public comment period, resolution of outstanding issues, and the release of the final validation report. The SNK is then presented with the validation report and the PDD for evaluation and registration (Kollmuss, Zink, and Polycarp, 2008).

Project Registration The project is formally registered once the SNK gives its approval, based on the PDD, validation report, and public comments (Kollmuss, Zink, and Polycarp, 2008).

B.2.2 Project Implementation and Management

Once a program is implemented, it undergoes monitoring and periodic verification to assess the number of emission reductions it has achieved. The credits resulting from these reductions are typically deposited into the project developer's account within a registry system managed by the program (GDNK, 2019; Broekhoff et al., 2019). While the start of a project can occur before official approval, it is important to note that additional documents need to be submitted in such cases. Failing to provide these documents may result in the project being rejected. Therefore, it is crucial for project developers to ensure that all required documentation is supplied to increase the chances of approval.

Project Monitoring Project developers must create monitoring reports that document the progress of the project and the amount of carbon reduction accomplished during the active phase of the project (Wessel and Boer, 2023). These reports should accurately assess the emission reductions achieved throughout the running phase and must follow the guidelines and practices specified in the PDD. The SNK then approves the monitoring reports. Although there are no criteria for the frequency of monitoring periods, it is often a balancing cost and revenues (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; GDNK, 2019).

Project Verification The monitoring report and any necessary supplementary materials must be delivered by the project developer to the verifier. The verifier, usually different than the one involved in the validation process to reduce conflicts of interest, carries out an evaluation that involves a desk review and, if necessary, an on-site inspection. It drafts a verification report that outlines any potential problems or faults with the monitoring procedure based on their examination. These problems are addressed and resolved by the project developer, after which the verifier creates a final verification report (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008).

Project Certification / Issuance Once the verification report is completed, it is submitted to the SNK for certification (GDNK, 2019). Upon certification, the project is issued Certified Emission Reductions. These credits are subsequently transferred to the registry account of the project participant who is entitled to them, after the payment of any required fees. The issuance of credits can occur either as a one-time event or on a continuous basis throughout the operational phase of the project (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

Commercialization / Offset Credit Transfer / Trade Once the carbon credits are issued, project developers have the opportunity to sell them to potential buyers (GDNK, 2019). Project developers also have the option to sell credits directly to end buyers. Direct trade is a common practice in the absence of a unified standard. Traders play a role in arbitrating between different markets and speculating on price increases. Emerging derivative markets provide additional avenues for trading carbon credits, although these markets are still in their early stages of development. The credits can be sold either to companies that aim to reduce their emissions or to trading companies that facilitate the transaction between the seller and the end user of the credits (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008). The sale of carbon credits can take place at any phase of the project, even during the planning phase. Typically, the project developer receives payment for the credits after they have been delivered. However, in some cases, an advance payment may be received (Kollmuss, Zink, and Polycarp, 2008).

Credit Retirement To use a carbon credit, the holder must retire it. Each carbon offset program's registry specifies the retirement process. It is important to note that Carbon Credits can change hands multiple times before they are ultimately used by retiring them. A credit must be taken out of circulation after it has been retired as it can no longer be transferred, traded, or used. To maintain openness and accurate credit monitoring, the retirement of credits is an important step that needs to be formally registered in the standard setter's central registry (Wessel and Boer, 2023; Broekhoff et al., 2019; IOSCO, 2022). After the completion of the transaction, the certifications change their status to "no longer available" (GDNK, 2019).

B.2.3 Key Involved Stakeholders

Project Funders / Investors They are banks, private equity firms, private investors, non-profit organizations, academic institutes, and other organizations. These entities provide financial resources such as loans or equity investments to support the development and implementation of the projects. Certain standards have specific criteria regarding the type of funding, in addition to the revenue generated from offsetting activities. These criteria ensure that the funding sources align with the objectives and principles of the offset standards (Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022). They do not get involved in a specific procedure, and thus, they are not part of the above-mentioned flowchart.

Project Owner Individuals, private companies, and other organizations can play the role of the owner of the project, as well as the responsible party for its physical installation. They are responsible for the overall management, ensuring that emission reduction activities are carried out effectively (Kollmuss, Zink, and Polycarp, 2008).

Project Developers Individuals, organizations, Non-Governmental Organizationss (NGOs), consultants, or specialized services providers can play the role of the developer of the project. They may be the same as or different from the project owner. They are responsible for the overall development of the project and coordinating all the necessary activities to gather the materials required for creating a product or achieving the project's objectives (Kollmuss, Zink, and Polycarp, 2008; Favasuli and Vandana, 2021).

Stakeholders Individuals and organizations who have a direct or indirect interest in the emission reduction project. This encompasses parties interested in developing a specific project, such as project owners, developers, funders, local populations, and host communities. It also includes parties affected by the project, such as local populations, and host community environmental and human rights advocates. Additionally, national and international authorities play a crucial role in the project development process (Kollmuss, Zink, and Polycarp, 2008).

Third-Party Auditor A third-party auditor exists to validate and verify the climate-saving potential and achieved emission reductions of a project. These auditors play a critical role in ensuring the credibility and accuracy of the project's results. To avoid any conflicts of interest, the validating auditor is separate from the entity responsible for project verification, ensuring an impartial evaluation of the project's compliance and performance (Kollmuss, Zink, and Polycarp, 2008; IOSCO, 2022).

SNK It is the National Carbon Market Foundation, the authority that assesses plans, issues certificates, and facilitates transactions between suppliers and buyers SNK operates independently, with the authority to determine the rules and methods outlined in the *Rulebook*. The board of SNK, consisting of independent members, establishes these rules and methods without external influence from third parties, the national government, or public and private entities (SNK, n.d.).

Standard Setter They are organizations, mostly NGOs, that certify and issue Carbon Credits for a project based on its objectives and volume of reduced emissions (Favasuli and Vandana, 2021). Also, they keep a registry of the certified credit projects, credit issuance, and retirement (IOSCO, 2022), When national and international legislation is lacking, they establish a framework of rules and guidelines for voluntary emission reduction credits (Kollmuss, Zink, and Polycarp, 2008). They emphasize the methodology and the verification by accredited auditors (Wessel and Boer, 2023).
Key Players: Verra, Gold Standard, Climate Action Reserve, and American Carbon Registry (Wessel and Boer, 2023)

Relevant Authority of Country It is the official authority responsible for Carbon Credit matters in the country where the project is implemented. It plays a crucial role in monitoring, evaluating, and approving Carbon Credit projects, ensuring compliance with national regulations and guidelines (Kollmuss, Zink, and Polycarp, 2008).

Brokers / Traders They are professionals, often banks, investment funds, and speculators, who are actively engaged in the trading of emission reductions. They profit from market price inefficiencies and arbitrage possibilities. They reduce the duration of direct trade between project developers and end users (IOSCO, 2022). Retail traders acquire significant quantities of credits directly from the suppliers, then package these credits into portfolios and sell them to end buyers, usually earning a commission in the process (Favasuli and Vandana, 2021). Brokers, on the other hand, arrange transactions for non-standardized products, occasionally traded and often in small volumes. They purchase Carbon Credits from retail traders and market them to end buyers, also typically earning a commission (Wessel and Boer, 2023; Kollmuss, Zink, and Polycarp, 2008).

Exchanges They serve as markets for the listing, buying, and selling of verified credits between project developers and buyers (IOSCO, 2022). They provide a convenient way for consumers and businesses to access a portfolio of project offsets (Kollmuss, Zink, and Polycarp, 2008). They are usually preferred for frequent trades or large volumes of products with standardized contracts or products (Favasuli and Vandana, 2021).
Key players: CBL's Nature-based Global Emission Offset (N-GEO) and ACX Global Nature Token (Favasuli and Vandana, 2021)

End Users Individuals, companies, organizations, or governments meeting their sustainability goals purchasing credits to use them. These buyers are responsible for retiring the credits. By using the credits, they effectively balance out or neutralize their own emissions. (Kollmuss, Zink, and Polycarp, 2008).
Early key players: Apple, Google, airlines, and oil and gas companies (Favasuli and Vandana, 2021)

Appendix C

Interview Results Tables

In the following section, the interview results are presented in tabular format. Each table corresponds to a specific theme and sub-theme discussed in Chapter 4. The tables provide a summarized view of the interviews, with rows representing each code identified in that part of the interview and columns corresponding to the roles of the interviewees. An "X" is placed in the intersection if the code was mentioned by the respective interviewee. This tabular representation allows for a clear and concise overview of the data collected during the interviews.

C.1 Existing Knowledge Management Systems

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Project Management System	Different Initial Plan, Common Place for a Project, Shared File Management, Shared Communication					
WOCAT & Climate Change Mitigation Portal	Database Translation of Outputs					
Smart AG by AgroInsider - Portugal		Water and Chlorophyll Data, Pilot Case				
Agunity - Indonesia		Farming Data, Banking Data				
Smart Biogest		Production Data to Gas Production				
National Registry System		Not Ordinary KMS, Details and Registry of a Project (Location, Actors, Duration, Funding)				
Akshara		Project Details, Emission Reductions, Only Plan, Not Real-Time Data Real-Time Data (Future Addition)				
SNK Database				Methodology Documents for Carbon Farming, Cycle Analysis, Information on Bio-based Methods		
SOMERS Model				Calculation Tool for Peatlands, Easier Monitoring, Huge Database		

Table C.1: Existing KMS Identified through the Interviews.

C.2 Theoretical CFKMS Insights - Reasons for Effectiveness

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Increase Validation Data Availability		X				
Holistic Knowledge Integration		X			X	
Transparency		X				
Endless Applications		X				
Multi-Stakeholder Collaborative Knowledge Sharing		X			X	
Social Impact		X			X	
Lower Carbon Farming Information Costs				X		
Enhance Policies Search				X		
Enhance Farmer Support				X		
Lower Transaction and MRV Costs				X		
Increase Potential Projects				X		
Non-Biased Information				X		
Knowledge-Driven Policy Development					X	
High Demand						X

Table C.2: Theoretical CFKMS Insights - Reasons for Effectiveness

C.3 Theoretical CFKMS Insights - Challenges

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Scale Concern		X	X			
Diverse Knowledge Perspectives		X	X		X	
Not Another Manual		X				
Dynamic Policy and Structure Changes			X			
A Priori rather Contextual Design			X			X
Complex Dynamic Targets			X			
Continuous Evolving Definitions			X			
Efficient Adaptive System Transition			X			
Non-Digital Project Processes				X		
Expensive Implementation				X		
Monetization of Knowledge					X	

Table C.3: Theoretical CFKMS Insights - Challenges

C.4 Theoretical CFKMS Insights - Practices for High Adoption

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Effective Market Demand	X					
Financial Incentives	X	X				X
Hyperlocal and Quality Information	X	X		X	X	X
Knowledge Sharing Promotion	X				X	
Accessible	X					
Available	X					
Government-Backed Scalability		X				
Non-Financial Incentives		Life Improvement, Promises, Reputation, Motivation, etc.				X
Policy Intervention		X				
User Training			X			
Stakeholder Support			X			
Adaptive System			X			
Initiate Action				X		
Force by SNK				X		
Social Media Utilization					X	

Table C.4: Theoretical CFKMS Insights - Practices for High Adoption

C.5 Practical CFKMS Insights - Groups of Users

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Researchers	X	X			X	X
Farmers / Landowners / Developers		X	X	X	X	X
Businesses/Buyers		X				
Government/Policymakers		X	X	X	X	
Funders/Donors		X				X
General Public			X		Passive Participant	
Journalists			X			
SNK				X		
Validators					X	

Table C.5: Practical CFKMS Insights - Groups of Users

C.6 Practical CFKMS Insights - Features

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Metrics	Researchers	Researchers			Farmers, Policymakers	
Contextual Applications	Researchers	X	Policymakers	Farmers		Funders
Success and Replicable Stories	Researchers	Researchers			Farmers	Funders
Failure Stories	Researchers					Funders
Soft Knowledge Insights		Researchers (Policies and Regulations)	Public Acceptance, Business Models, Policies, etc.			Farmers, Funders (Regulations)
Financial Steams		Farmers				Farmers
Financial Tools		Funders				
Project-based Hub		MRV for Policymakers			Farmers (Communication Channels, Project Status, etc.)	Funders (Profiles, Communication Channels, Active Projects, etc.)
Digital Guided Procedure		Farmers (+ PDD-related Documents)	Farmers	Automated Monitoring for Farmers, SNK	Farmers	Farmers
Market Demand		Researchers				
Earth Observation		Researchers		SNK		
Learning Environment		X			Current and Future Farmers (Practical Agricultural Education, Technology Integration, etc.)	
Announcements					Farmers	

Table C.6: Practical CFKMS Insights - Features

C.7 Practical CFKMS Insights - Display of Information

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Videos, Diagrams, and Images		X				Farmers, Funders (Projects)
Education Systems					For Learning	
Text, Tables, and Charts					Publications	Farmers, Funders (General Knowledge) Farmers (Financing Streams and Regulations)
Interactive On-site Experiences					Farmers	

Table C.7: Practical CFKMS Insights - Display of Information

C.8 Carbon Credit Acquisition Process - Online Brokering Platform for Trading Carbon Credits

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Certificate Trading Platform				X		
Farmers Certificates				X		
Certificate Search for Buyers				X		
Essential for Carbon Farming Scale-Up				X		
External Platform rather than part of CFKMS				X		

Table C.8: Carbon Credit Acquisition Process - Online Brokering Platform for Trading Carbon Credits

C.9 Carbon Credit Acquisition Process - Challenges

Code	University Researcher	Think-Tank Researcher	Advisor / Consultant	Advisor / SNK Member	Farmer	Funder
Expensive and Difficult Project Design		X		X		X
Exclusive, Expensive, and Contextual Process		X				Carbon Prices
Critical Profitability Planning at Project Design		X				
Multi-Layered Carbon Market		X				
Selecting the Right Carbon Market			X			
Expensive and Time-Consuming MRV				X	X	
Integrating Monitoring and Research						X

Table C.9: Carbon Credit Acquisition Process - Challenges