Analyzing the European Union’s Perception of The Expected Implementation of Carbon Farming within The Carbon Removal Certification Framework Using Fuzzy Cognitive Mapping

MSC THESIS IN ENVIRONMENTAL SYSTEMS ANALYSIS

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Summary

In November 2019, the European Parliament formally declared a climate and environmental emergency, acknowledging the critical rise in global temperatures and stating an urgent need to reduce emissions. With emission reduction as goal, several pieces of legislation were published, laying the foundation for the Carbon Removal Certification Framework. This framework sets out to not just certify net carbon removals or net soil emission reductions, but also encourage innovation by farmers, foresters, and industries to further technological advancement, stimulate financing options through public and private sources, and focus on building trust through quality removals while fighting greenwashing. To receive certifications, operators must comply with the QU.A.L.ITY criteria and EU certification methodologies, as well as submit to third-party verifications and audits. However, several climate and environmental organizations have voiced criticisms of the framework regarding vague criteria and exclusion of social impacts and mitigation deterrence, with fears the framework will undermine the union's climate efforts and integrity of climate policy.

This research utilized a systemic perspective to map out the EU's perception regarding the future implementation of the framework with fuzzy cognitive mapping, in order to identify concepts and relationships believed by the Commission to be key for success of the framework. This in turn allowed for the discovery of feedback loops, unintended consequences, and leverage points in the system.

A fuzzy cognitive map created solely through policy document analysis was used to model interactions between 40 concepts identified in the "Proposal for a Regulation of the European Parliament and of the Council establishing a Union certification framework for carbon removals" and the "Impact Assessment report on the Regulation for a Union certification framework for carbon removals." A sensitivity analysis was then performed to visualize differences in system behavior after minor changes in relationships between concepts.

The results showed seven concepts perceived by the EU to be instrumental in the frameworks success: access to knowledge, costs, demand for removals, GHG emissions, participation, revenue, and trust. Further analysis revealed a trade-off between administrative burden and accuracy of quantification, and leverage points in costs, participation, and trust. Unintentional side effects like a potential decrease in long term food security and a trade-off between quantity and quality of removals was also discovered in the sensitivity analysis.

This research highlights potential systemic issues regarding the real-world implications of these findings and discusses how the EU can risk their climate goals and the environmental integrity of the policy by underrepresenting small farmers and placing economic benefits above climate benefits.

Contents

1. Introduction

In November 2019, the European Parliament formally declared a climate and environmental emergency, acknowledging the critical rise in global temperatures and stating an urgent need to reduce emissions. 2013-2022 was the hottest decade ever recorded, with average temperatures near the surface being 1.13-1.17° C higher than pre-industrial levels, with Europe warming at a faster rate compared to the global average (*Global and European Temperatures*, 2023). The continent is warming at a rate 1.6x faster than the rest of the world, a trend that will continue unless an immediate and decisive cut in carbon emissions is implemented, contributing to net neutrality and eventual net negative carbon emissions by 2050 (Lee et al., 2021; van der Schrier et al., 2013). Negative carbon emissions must be achieved through carbon sequestration. Carbon sequestration, along with construction using wood products, removed 230 million tons of CO2e (carbon dioxide equivalent) from the atmosphere in 2021 and is considered a key method to reducing the global temperature (European Commission, n.d.-a).

With emission reduction as a priority, several pieces of legislation were published, slowly paving the way to introduce carbon removals. In December 2019, one month after the Parliament declaration, EU officials agreed to make the Union climate-neutral by 2050, through the European Green Deal and the European Climate Law (European Parliament, n.d.). The Green Deal promises zero GHG emissions by 2050, a separation of economic growth and resource use, and "no person and no place left behind" (European Commission, 2021b). The Climate Law then added a checkpoint target of a 55% reduction in GHGs by 2030 (compared to 1990 levels) (European Commission, 2021b).-

To achieve this, the EU took on a list of 19 proposals, named the Fit for 55 package, with all proposed policies aimed at increasing emission reductions and removals. (European Commission, 2021a). As part of the package, the Regulation on Land Use, Forestry, and Agriculture was revised to include a carbon removal target for the EU with carbon sinks (Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND ..., 2021).

Despite the Climate Law's full implementation in July 2021, substantial GHG emission reductions are still needed for timely climate neutrality (European Council, n.d.). In December 2021, the EU published the Sustainable Carbon Cycles Communication, which re-emphasized the importance of carbon removals alongside GHG emission reduction to reach their 2050 climate goals. The document discusses carbon farming, the industrial capture, use, and storage of CO2, and the action steps needed to create a certification for removals. Finally, as of February 2024, a provisional agreement was reached, establishing a certification framework for "permanent carbon removals, carbon farming, and carbon storage in products" (European Parliamentary Research Service, n.d.).

The Carbon Removal Certification Framework (CRCF) Regulation sets out to not just certify net carbon removals or net soil emission reductions, but also encourage innovation by farmers, foresters, and industries to further technological advancement, stimulate financing options through public and private sources, and focus on building trust through quality removals while fighting greenwashing (2022/0394(COD), 2022). To receive certifications, operators must comply with the QU.A.L.ITY criteria and EU certification methodologies, as well as submit to third-party verifications and audits (European Commission, 2024).

However, the proposal has garnered substantial criticism from various experts in the field. Organizations like the Institute of Agriculture and Trade Policy have raised large concerns. This is the first framework of its kind, and some hold the opinion that this will become a guide for other carbon offset frameworks and markets internationally, and want to ensure that this regulation does not undermine the environmental integrity of climate policies (Scherger & Sharma, 2023). The main concerns revolve around what is not included in the framework proposal and general ambiguity. These groups claim the regulation does not include limits for removals in comparison to emission reduction, limits to how certification can be used, regulations for any carbon markets, or any social implications (Scherger & Sharma, 2023). If true, this opens the door for mitigation deterrence, greenwashing, as well as adverse and unaddressed social impacts (Diab, 2024; Scherger & Sharma, 2023). An overarching concern amongst several groups is the ambiguity and potential for loopholes regarding QU.A.L.ITY requirements, with fears that this proposal will undermine the nation's climate efforts and the integrity of the policy. The EU Parliament adopted what was said to be the final version of the CRCF in April 2024, with expected entry into force and publication into the Official Journal of the EU before the end of 2024 (Carbon Gap, 2024). That being said, the different methodologies comprising the proposal are not finalized, and are not expected to be until at least 2026, meaning there is time to analyse the policy and the EU's expectations (Carbon Gap, 2022, 2024). While the framework offers a confident and optimistic vision for carbon removals, it does not erase the uncertainties embedded in the document. These uncertainties and potential risks raise serious questions regarding the practical implications for carbon farmers and the policy's viability for small enterprises.

To understand the complex interactions happening within the framework, it is best to adopt a systemic perspective. This approach acknowledges the interconnected relationships the carbon farming sector has with economic structures and social dynamics, and therefore accepts that carbon removals are not an isolated activity that helps reach climate goals - they are engrained in a broader system. A unique feature of system dynamics, and a systemic perspective, is the incorporation of feedback mechanisms, which can help describe how systems can have non-linear, or unpredictable and complex, behaviour (Kok, 2009). The requirements of the framework can have wide-reaching consequences, and a systemic perspective is the best approach to identify relationships and feedback loops, which will then highlight blind spots and unwanted consequences, such as the entrenchment of unsustainable agricultural dynamics or excess financial burden on operators. Furthermore, with a holistic lens it is easier to treat the issue at the root cause, and not just symptoms (Hynes et al., 2020).

Utilizing a systemic perspective to analyse the CRCF policy design will ensure that activities implemented contribute to genuine sustainability and align short term actions like carbon farming with long term goals like carbon neutrality.

2. Research Objective

This research has two objectives. The first, which is more empirical in nature, is to map the EU's conceptualization of the Carbon Removal Certification Framework and identify potential systemic side-effects. The second, which is more methodological, is to assess the use of fuzzy cognitive mapping as a tool to analyse policy documents without supplemental co-production, interviews, or outside literature.
To achieve this, the following research questions will be asked:

General Research Question: How does the EU envision the implementation of carbon farming, and what systemic (side)-effects can be expected from this policy?

SRQI: What concepts are perceived by the EU as core elements for ensuring a successful implementation of the CRCF for carbon farming?
SRQII: How are the concepts interacting with each other in the framework, and what feedback loops are present?
SRQIII: What unintended consequences and leverage points of the CRCF become apparent through a system dynamics analysis?

3. Conceptual Framework

3.1 The Carbon Removal Certification Framework

The CRCF is a voluntary Union framework with the goal to foster the creation of high-quality removals of carbon emissions by operators, to aid in the EU's 2050 climate neutrality objectives. Carbon emissions regulated under the EU emission trading system (ETS), such as those from industrial activities, aviation, powerplants, or any carbon emission within the scope of Directive 2003/87/EC are not eligible for this framework as they are already governed by the EU and held to their own cap and trade system, and the CRCF intends to incentivize carbon emissions not covered by ETS. The framework contains specific criteria for the removals, rules for verification/certification, and rules pertaining to the recognition of certification schemed by the EU Commission (2022/0394(COD), 2022).

The QU.A.L.ITY Criteria was included to ensure to a high quality of each type of removal (mentioned in introduction), encompassed by quantification, additionality and baselines, long-term storage, and sustainability requirements. Quantification requirements state that removal activities must produce a net benefit, and is quantified with formula:

Net carbon removal benefit = $CR_{baseline} – CR_{total} – GHG_{increase} > 0$
where:
(a) $CR_{baseline}$ is the carbon removals under the baseline;

(b) CR_{total} is the total carbon removals of the carbon removal activity;
(c) $GHG_{increase}$ is the increase in direct and indirect greenhouse gas emissions, other than those from biogenic carbon pools in the case of carbon farming, which are due to the implementation of the carbon removal activity.
(d) In the case of carbon farming, $CR_{baseline}$ and CR_{total} shall be understood as net greenhouse gas removals or emissions in accordance with the accounting rules laid down in Regulation (EU) 2018/841.
(2022/0394(COD), 2022)

Removals must also be quantified in a comprehensive, transparent, and accurate way. The baseline is established by the Commission and will be consistent with similar activities, circumstances, and geographical context (2022/0394(COD), 2022).

Additionality is the second part of the QU.A.L.ITY Criteria and is responsible for the establishment of the baseline. For a removal to be additional, it must go beyond EU/national requirements, as well as the baseline, and is completed regarding the incentive nature of the certification (2022/0394(COD), 2022).

Long-term storage criteria states that the removal activity must completed in such a way that long-term storage is ensured. This includes the monitoring of removed carbon for signs of release and liability for the any released carbon during the storage period. For short term carbon removals such as carbon storage in wood products and carbon farming, all carbon is considered released after the expected holding period (2022/0394(COD), 2022).

Sustainability requirements ensure at least a neutral or positive impact on the environment by creating co-benefits for one or more of the sustainability objectives:

(a) climate change mitigation beyond the net carbon removal benefit referred to in Article 4(1);
(b) climate change adaptation;
(c) sustainable use and protection of water and marine resources;
(d) transition to a circular economy;
(e) pollution prevention and control;
(f) protection and restoration of biodiversity and ecosystems. (2022/0394(COD), 2022)

All specifics of regarding various aspects of the QU.A.L.ITY Criteria are listed in the individual certification methodologies, which are tailored to specific carbon removal activities and contain all pertinent rules to establish standardization and accuracy across all removals (2022/0394(COD), 2022).

To manage the certification process, the EU employs third-party groups called certification schemes. It is the certification schemes responsibility to make sure all removal activities follow the appropriate methodologies and any rules and criteria therewithin (2022/0394(COD), 2022).

To achieve certification, an operator or operators must apply to a relevant certification scheme, and then once accepted provide a detailed description of the removal activity, their compliance with the QU.A.L.ITY Criteria, as well as expected removals and net removal benefit. Then a certification audit is conducted to verify the information detailed with a third-party group appointed by the certification schemes. If successful, a certification audit report will be given, containing the certification itself and a full summary of the audit conducted. All operators are subject to re-certification audits to ensure longevity and compliance, in which the operators are expected to be fully accommodating (2022/0394(COD), 2022).

A certification is proof of a high-quality carbon removal and can be used to qualify for funding, back up sustainability claims, become more attractive to investors, and can also be sold in the voluntary carbon market. All certifications will contribute to the EU's 2050 climate goals (2022/0394(COD), 2022).

3.2 Fuzzy Cognitive Mapping

Fuzzy cognitive mapping (FCMs) is a systems thinking tool used to map dynamics of a complex system, particularly feedback mechanisms through the visualization of stocks and flows (Kok, 2009). The map is comprised of a causal diagram with boxes to represent concepts (C_i, C_j, C_k,...) in the system and arrows to represent the relationships (C_iC_j). There is no consensus on the ideal number of concepts, however, experts in the field state that well-structured FCMs must balance between having enough concepts to properly represent the complexity of a system, while not having so much that it sacrifices clarity (Özesmi & Özesmi, 2003). Each arrow is given a weight (*eij)* to show the strength of the relationship between concepts. A positive value signifies an increase in one concept (C_i) leads to an increase in the second (C_j), while a negative value means there is an inhibitory effect (Kok, 2009). The state vector *A* represents the state of concepts, with a_i representing C_i, and so on. All values are placed in an adjacency matrix (*E*). This matrix is defined as *E* = *eij* and multiplied by *A* to calculate the new state vector *B* after one iteration.

Table 1: FCM properties and their definitions. (Kok, 2009)

Name	Variable or Equation	Definition
Concepts	C_1, C_2, C_3, ...	The drivers and important factors within the given system.
Directed Edge	C_1C_2 or C_iC_j	The variable representing the relationship between two concepts, from the first concept to the second.
State Vector	A $(a_1, a_2, a_3...)$	The value of a concept, with a_1 representing C_1, and so on.

Adjacency Matrix	$E = e_{ij}$	A matrix containing all relationship values. e_{ij} is representative of the weight of relationship C_iC_j.
New State Vector	$B = A \times E$	The new state vector *B* is calculated the current state vector *A* with the adjacency matrix *E*

Consider the following example FCM and corresponding adjacency matrix:

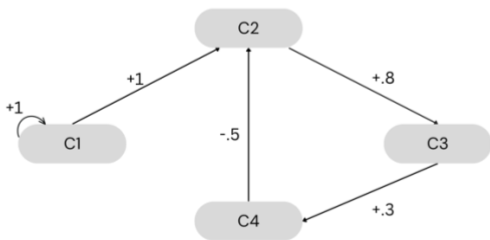

Figure 1. An example FCM

State vector $A = (1, 0, 0 ,0)$ Adjacency matrix $E = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & +.8 & 0 \\ 0 & 0 & 0 & +.3 \\ 0 & -.5 & 0 & 0 \end{pmatrix}$

New state vector $B = A \times E = (1, 0, 0, 0) \times \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & +.8 & 0 \\ 0 & 0 & 0 & +.3 \\ 0 & -.5 & 0 & 0 \end{pmatrix}$

$= 1 \times (1, 1, 0, 0) + 0 \times (0, 0, +.8, 0) + 0 \times (0, 0, 0, +.3) + 0 \times (0, -.5, 0, 0)$

$= (1, 1, 0, 0) + (0, 0, 0, 0) + (0, 0, 0, 0) + (0, 0, 0, 0+ = \underline{(1, 1, 0, 0)}$

This process can be repeated multiple times to produce a dynamic output, showing how the concepts interact over time.

While the map brings a better understanding of what the key elements are in terms of centrality, the dynamic output allows for a visualization of the concepts and states after they have been affected by system behaviour and then stabilized. In the dynamic output, the x-axis represents iterations (not time) and the y-axis represents the strength of the concepts relative to each other in the system (Nachazel, 2021; Özesmi & Özesmi, 2003). They can also show if the system is stabilized, with all concepts eventually staying at one value, or destabilized, with all concepts either exponential increasing or crashing to zero (Kok, 2009). If a system's dynamic output fails to reach stability, one should first tweak their relationship values and make sure everything is properly representative of the real-world system. If that is confirmed and the output is still destabilized, that represents a high level of sensitivity and unpredictability within the system, and can signify instability under the present conditions (Nachazel, 2021).

A stabilized output can provide much more information. The shapes made in the output can be used as indicators for system behaviour. In general, oscillation in dynamic output is rare, but if visible, the number of oscillations in the output can reflect system complexity, with increased oscillation indicating higher complexity or sensitivity (Sterman, 2000). If oscillations in the system dampen into eventual stabilization, that shows that negative feedback mechanisms are strong enough to self-regulate the system, and if the oscillations expand, the opposite can be said, that the positive feedback loops are too powerful.

While it is interesting to see the behavior changes in the graph use that information to identify specific ways concepts are influencing each other, the key information is the end value of concepts after stabilization. This shows the importance and strength of each concept, relative to its system. Sensitivity analysis can also be conducted to identify sensitive concepts and potential thresholds (Kok, 2009). In terms of policy, one could use the sensitivity analysis to represent potential strategies to see how they resolve and predict the system's response to changes. The selection of drivers for the FCM is also a key decision impacting the dynamic output. Drivers are concepts that are not influenced by any concepts in the system, but have very strong influences themselves on other concepts, hence 'driving forces'. The stable state shows the behavior of the system, but the systems behavior is in large part due to the drivers, and the potential state produced is therefore a direct result of the drivers chosen. If the entire map stayed the same but even one new driver was added or changed, the system would look different (Kosko, 1986).

A unique but valuable attribute of FCMs is that concepts can be concrete concepts with a defined, measurable quantities or abstract ideas such as a belief or emotion. Through the assignment of weights and matrix multiplication, the model can turn qualitative values to quantitative data. The nature of the model is also well suited for mapping non-linear changes within a system, accurately mapping how a small change in the state of one concept could lead to a large change in another (Kok, 2009). These features, along with the tools strong ability to map complex relationships, make this a beneficial method to answer the research questions.

In FCMs, concepts and relationships are typically determined through various methods of co-production, like stakeholder workshops, interviews, or a mix of the two; supplemented by document analysis. This FCM was produced solely from policy document analysis. All information contributing to the FCM was selected to ensure a focused analysis of the framework itself and to gain insight on the EU Commission's expectation of potential impacts, specifically for small and medium enterprises (SMEs), which encompasses carbon farming activities (European Commission, 2022). The inclusion of other documentation or meeting transcriptions of the creation of the above documents would provide further insight on the policy but would potentially contradict official opinions on expected impacts expressed by the Commission and were ultimately chosen to be left out for clarity.

4. Methods

4.1 Document Selection

The information for the FCM was received through two policy documents, accessed through EUR-Lex: "Proposal for a Regulation of the European Parliament and of the Council establishing a Union certification framework for carbon removals" and the "Impact Assessment report on the Regulation for a Union certification framework for carbon removals." The "Proposal for a Regulation of the European Parliament and of the Council establishing a Union certification framework for carbon removals" will be cited as the official EU document title, 2022/0394(COD), for succinctness.

4.2 Concept Identification and Clustering

Concepts were subsequently identified and coded in Atlas.ti, a qualitative analysis software. "Coding" refers to the labelling of data segments and then using said codes to refine, filter, and compare data, thus facilitating a full understanding of the original source (Charmaz, 2012). All codes were created from text in the document containing causal conjunctions, or phrases containing cause-effect statements, with significant themes explicitly referenced in the documents were coded in Atlas.ti. 'Significant themes' were identified by the length of text dedicated to it and the frequency of the theme's appearance. These criteria indicated that said theme was involved with multiple other aspects of the framework and therefore played a role in the system dynamics.

The initial round of coding produced 120 codes, which were narrowed down by frequency, signified by how often the code was brought up; and explicitness, or how directly the cause-effect relationship was stated (Axelrod, 1976). All codes were transferred to an Excel sheet and were henceforth referred to as "concepts". Initially, slips of paper were used to group together similar concepts in piles, and then the concept clusters were finalized in Excel. Two professionals were then consulted. One has proficiency in the documents and the other an expert in fuzzy cognitive mapping. Their opinions, in combination with the above criteria resulted in a list of 44 concepts. Throughout the rest of the FCM production, four more concepts were clustered, producing a final list of 40 concepts, labelled C1 to C40. Four of those concepts, C1-C4 respectively, were identified as drivers of the systems. These concepts are categorized by having substantial outgoing influence on system behavior, while not being influenced by any other concepts, and are often key concepts (Edwards & Kok, 2021).

4.3 Relationship Identification and Weights

Relationships, and their direction, were identified directly from the documents. For example, if the sentence "X leads to higher levels of Y" was stated, "X" and "Y" would be identified as the concepts, and X → Y would be the inferred direction of the relationship. All concepts were included in an Atlas.ti network, which allows for the creation of labelled connections between any two concepts.

Each relationship was then categorized as positive or negative, based on wording used in the documents. Positive relationships were identified by words and phrases such as "increasing", "leads to more", "contributes to further". Negative relationships were identified by words and phrases such as "decreasing", "leads to a decline in", "diminishes". Relationships were then color-coded for clarity: red for negative and green for positive.

Each relationship was recategorized into one of six levels of strength: +, ++, +++, -, --, and ---, based on their level of frequency and explicitness (Axelrod, 1976). Weights were then assigned a numerical value in Atlas.ti between 1 and -1 for interpretability (Jetter & Kok, 2014). Positive relationships were reassigned as: + (3), ++ (.5), and +++ (.8). Negative relationships were reassigned as: with – (-.3), -- (-.5), --- (-.8). Finally, all drivers were given a start value of 1 due to their positive influence on the system.

4.4 Dynamic Output

A dynamic output was produced in Excel using an adjacency matrix. Each cell represented the relation from one concept to another, with the rows in the spreadsheet signifying influencing concepts and the columns signifying the influenced concepts. Using the *MMULT(...)* function, the state vector was multiplied by the adjacency matrix. The calculations repeated iteratively, to simulate the behavior of the concepts over time. The system's state was observed at stabilization.

5. Results

5.1 FCM Characteristics

5.1.1 Concepts

The final FCM contains 40 concepts, with four drivers, signified by a "★" in Table 1. The list encompasses political, social, economic, and environmental concepts, with the majority being mentioned in the impact assessment of the CRCF, not the CRCF Proposal. Table 1 shows all concept names and meanings, which have been created to be as close to the policy document wording as possible. However, due to the merging of concepts, some names have been generalized. All previous concept mergings are shown in Table 1 in Appendix 1.

Table 1: Concepts included in the FCM and their meanings.

Concept Name:	Meaning:
★ C1 Implementation of a Policy Baseline (Other Supplemental Policy)	Elements of the CRCF that come from existing and relevant EU legislation, such as the Common Agriculture Policy, the Taxonomy Regulation, the LULUCF Regulation, etc.
★ C2 Long Term Storage Criteria	Part of the QU.A.L.ITY Criteria, actions aimed at ensuring the long-term storage of carbon, such as monitoring and mitigating any potential risks of the release of stored carbon.
★ C3 Quantification Actions	Part of QU.A.L.ITY Criteria, actions to ensure proper quantification of carbon removals.
★ C4 Transparency Actions	Part of transparency criteria to ensure trust and harmonisation for operators.
C5 Accuracy of Quantification and MRV	The level of accuracy both required and therefore achieved when quantifying carbon removals.
C6 Access to Knowledge	The knowledge and data available to operators about carbon farming and the CRCF.
C7 Additionality	Part of QU.A.L.ITY Criteria, the level that carbon removal activities go beyond requirements already placed on operators by the Union and member states.
C8 Administrative Burden	Resources needed to adhere to administrative procedures, which can include time, money, paperwork, etc.
C9 Afforestation Activity	The "Conversion of land that has a non-forest use to forest, or restocking of trees on land that has been depleted of trees..." (European Commission, 2022).
C10 Agroforestry Activity	The "Planting of woody biomass (e.g. trees, hedges, shrubs etc.) on agricultural land" (European Commission, 2022).
C11 Business Opportunities	The potential that CR carbon removals can be used in other, profitable ways.
C12 Carbon Removal Quantity	The quantity of carbon removals achieved through carbon farming, as calculated by "net carbon removal benefit," or $CRbaseline - CRtotal - GHGincrease > 0$

	(2022/0394(COD), 2022)
C13 Carbon Sinks (Via Carbon Farming Activities)	“Forests and other ecosystems that absorb carbon, thereby removing it from the atmosphere and offsetting CO_2 emissions” (European Environment Agency, n.d.).
C14 Co-Benefits	Benefits from carbon farming activity besides climate change mitigation.
C15 Comparability and Competition for Certifications	The comparability of carbon removal certificates across different certification schemes and operators.
C16 Competition for Land	The competition from multiple individuals for land- a finite resource, for the purpose of carbon farming.
C17 Demand for Land-Based Carbon Sequestration for Afforestation Activity	The level of demand from carbon farmers for land because of its afforestation potential.
C18 Demand for Removal Certificates	The level of demand from society for carbon farming removal certificates.
C19 Diversity of Certification Approaches	The number of different ways an operator can receive/apply certification as decided by the Commission.
C20 Economic Diversification in Rural Areas	The new/different ways an individual in a rural area can receive an income.
C21 First Movers	The first wave of operators to seek certification.
C22 Framework Effectiveness (As a Policy)	The ability of the CRCF to accomplish the objectives set out by the EU, which are “(i) to ensure the high quality of carbon removals in the EU, and (ii) to establish an EU governance certification system to avoid greenwashing by correctly applying and enforcing the EU quality framework criteria in a reliable and harmonised way across the Union” (2022/0394(COD), 2022).
C23 GHG Emissions (Including Leakage)	The amount of GHG emissions as influenced only by the concepts in this system.
C24 Harmonisation	The amount of combined information on certification schemes, costs, rules, and procedures of all aspects of the CRCF to create a level-playing field.
C25 Implementation and MRV Costs	The costs associated with the implementation, monitoring, reporting, and verifying carbon farming activities, as well as transaction costs associated with changing certification schemes.
C26 Incentivization	Number of actions created by the EU that aim to increase the willingness of the operator
C27 Innovation in Agricultural Communities	New ideas, and their implementation, in carbon farming communities.
C28 Long-Term Food Security	The level of “regular access to enough safe and nutritious food for normal growth and development and an active and healthy life” (FAO UN, n.d.)
C29 Operators Seeking Certification (Participation)	The number of carbon farmers pursuing EU certification for carbon removals via carbon farming
C30 Perceived Risk of Failure	The prevalence of perception that seeking or receiving certification will lead to financial risk or public judgement.
C31 Quality of Certified Carbon Removals Compared to Policy Baseline	The overall level of quality of carbon removals, as compared to the Commission determined baseline.
C32 Revenue	The amount of money potentially available for operators because of their carbon removals. This can be through the voluntary carbondo market, business opportunities, or other ways.
C33 Simplified MRV Procedures for Small Scale Activities	The availability of monitoring, verifying, and reporting procedures altered for small and medium enterprises' carbon removal activities.
C34 Small or Micro Sized Enterprises	European businesses with <250 staff members and ≤ 250 million in revenue per year OR ≤ 43 million in total assets (European Commission, n.d.-b).
C35 Soil Carbon Activity	Amount of activity that Increases the level of carbon stored in soils by “practices such as cover cropping, improved crop rotations, reduced tillage, deep rooting crops, conversion from arable to grassland and other management of grazing land and grassland” (European Commission, 2022).
C36 Soil Health (Quality and Resilience)	A combination of soil fertility, resiliency, and carbon storage capacity.
C37 Stakeholder Involvement	The level of outside (non-EU official) involvement in contribution to the framework.
C38 Sustainability Criteria	Part of the QU.A.L.ITY Criteria, a group of actions implemented to prevent carbon farming methods from causing undue harm to the environment.
C39 Technology Innovation	The number of new ideas, and their implementation, pertaining to technology.
C40 Trust	The amount of trust operators and non-operators have in the framework to be successful and beneficial for themselves.

5.1.2 FCM and Key Interactions

Figure 2 shows the completed FCM, allowing a full picture of how aspects of the CRCF and carbon farming affect each other. There are 107 relationships in the model, with 1,296 total relationships possible, giving it an overall density, or measure of connectivity, of .08. 27 of said relationships are negative and 80 are positive. Out of the drivers, transparency actions (C4) has the strongest input on the system, leading to comparability and competition for certifications (C15), harmonisation (24), and access to knowledge (C6), with the latter two involved in multiple feedback loops and access to knowledge having a high number of relationships. The same can be said for long-term storage criteria (C2), as it does not have the most relationships out of all the drivers, it also has a relationship with a key concept, quality of removals compared to the baseline (C31). A larger version of Figure 2 is in the appendix, and Figures 3,4, and 5 allow a closer understanding of key interactions.

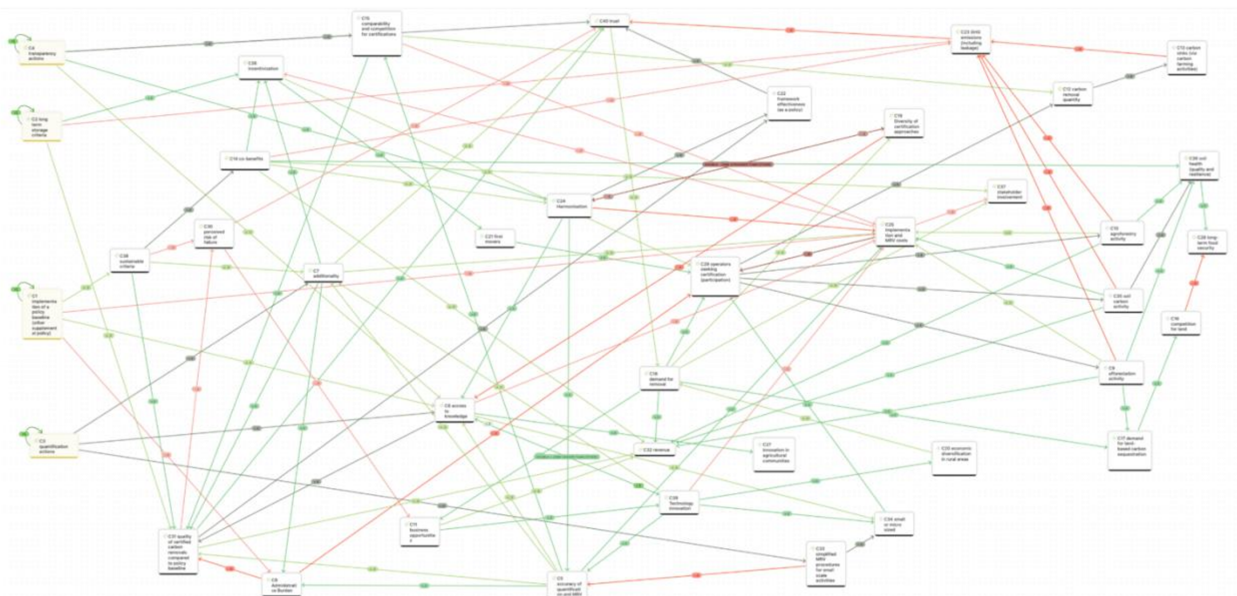

Figure 2: The fuzzy cognitive map created from the CRCF Regulation Proposal and the CRCF Impact Assessment, showing the EU Commissions expectation for implementation.

Table 2 shows the centrality of concepts as determined by the number of relationships and the weight value of relationships, which can be an indicator of importance of the concept within a system (Özesmi & Özesmi, 2004). The most central concept in the FCM by number of relationships is a tie between C6, Access to Knowledge, and C25, Implementation and MRV Costs, but the most central concept by weight value is C29, Operators Seeking Certification (Participation). The collective weight value of C6 and C25 are 5.4 and 5.1, respectively. The centrality as determined by the number of relationships for C29 is only 10, showing that the weight value of relationships both incoming and outgoing are much higher than C6 or C25. They have a relationship with more concepts, but not to the strength of C29. The driver with the most influence is C4, Transparency Actions, with the same number of outgoing relationships as C1, Implementation of a Policy Baseline, but with a stronger effect on its related concepts, creating a higher weight value centrality. For the drivers, while technically there is a +1-relationship circling back on itself, it is not shown in Table 2, because that arrow is used as means to kickstart the iterations and calculations and is not representative of a relationship with itself. Removal quality (C31) is also a top concept in terms of centrality, with 11 relationships total and a weight value of 5.3.

Table 2: The centrality of FCM concepts as determined by the number of relationships and the weight value of said relationships, used as indicators of concept importance. The four highlighted concepts [access to knowledge (C6), implementation and MRV costs (C25), operators seeking certification (participation) (C29), and quality of certified carbon removals compared to policy baseline(C31)] are deemed the most central either by # of relationships or combined weight value of relationships.

Concept Name:	Incoming Relationships	Outgoing Relationships	Centrality (# of relationships)	Incoming Value	Outgoing Value	Centrality (Value)
★ C1 Implementation of a Policy Baseline (Other Supplemental Policy)	0	4	4	0	2.2	2.2
★ C2 Long Term Storage Criteria	0	3	3	0	2.1	2.1
★ C3 Quantification Actions	0	3	3	0	3.4	3.4
★ C4 Transparency Actions	0	4	4	0	3.4	3.4
C5 Accuracy of Quantification and MRV	3	6	9	1.5	2.4	3.9
C6 Access to Knowledge	7	5	13	3.2	2.2	5.4
C7 Additionality	4	5	9	1.9	2.1	4.0
C8 Administrative Burden	3	2	5	1.3	1.0	2.3
C9 Afforestation Activity	1	5	6	0.8	2.3	3.1
C10 Agroforestry Activity	1	4	5	0.8	1.9	2.7
C11 Business Opportunities	2	2	4	0.8	0.8	1.6
C12 Carbon Removal Quantity	2	1	3	1.1	0.8	1.9
C13 Carbon Sinks (Via Carbon Farming Activities)	1	1	2	0.8	0.5	1.3
C14 Co-Benefits	1	6	7	0.8	2.2	3.0
C15 Comparability and Competition for Certifications	2	3	5	1.3	1.1	2.4
C16 Competition for Land	1	1	2	0.5	0.5	1.0
C17 Demand for Land-Based Carbon Sequestration for Afforestation Activity	2	1	3	1.0	0.5	1.5
C18 Demand for Removal Certificates	2	6	8	0.6	2.6	3.2
C19 Diversity of Certification Approaches	2	2	4	0.8	0.8	1.6
C20 Economic Diversification in Rural Areas	1	1	2	0.5	0.3	0.8
C21 First Movers	1	1	2	0.5	0.5	1.0
C22 Framework Effectiveness (As a Policy)	2	1	3	1.6	0.8	2.4
C23 GHG Emissions (Including Leakage)	6	1	7	2.6	0.5	3.1
C24 Harmonisation	3	5	8	1.1	2.8	3.9
C25 Implementation and MRV Costs	10	3	13	3.7	1.4	5.1
C26 Incentivization	4	2	6	1.8	0.8	2.6

C27 Innovation in Agricultural Communities	1	0	1	0.5	0.0	0.5
C28 Long-Term Food Security	2	0	2	1.0	0.0	1.0
C29 Operators Seeking Certification (Participation)	6	4	10	3.1	3.2	6.3
C30 Perceived Risk of Failure	2	2	4	0.6	0.6	1.2
C31 Quality of Certified Carbon Removals Compared to Policy Baseline	7	4	11	3.4	1.9	5.3
C32 Revenue	7	0	7	2.9	0.0	2.9
C33 Simplified MRV Procedures for Small Scale Activities	1	2	3	0.8	1.3	2.1
C34 Small or Micro Sized Enterprises	3	1	4	1.6	0.5	2.1
C35 Soil Carbon Activity	1	4	5	0.8	2.3	3.1
C36 Soil Health (Quality and Resilience)	4	1	5	2.3	0.5	2.8
C37 Stakeholder Involvement	3	0	3	0.9	0.0	0.9
C38 Sustainable Criteria	1	4	5	0.3	1.9	2.2
C39 Technology Innovation	2	6	8	0.8	2.8	3.6
C40 Trust	6	1	7	3.2	0.3	3.5

Table 3 shows all the feedback loops present in the FCM. Feedback mechanisms are integral to fuzzy cognitive mapping and discovering previously unforeseen elements of the system. Most feedback loops in Table 3 are similar, with the same feedback loop shown, with a one concept difference. The relationships involved in the feedback mechanisms are also responsible for oscillation in dynamic outputs, and can aid in stabilization, as shown in the next section.

*Table 3: Feedback Loops in the FCM, as labelled by concept number. Demand for removals (C18) and participation (C29) appear in the most feedback loops, 10 out of 18, with trust (C40) appearing in the second most at 9 out of 18 feedback loops. A high number of feedback loops for a concept can indicate a high level of both influence and sensitivity for said concept. *The last two feedback loops in this table are instances of double arrows, indicating a bidirectional influence between two concepts, creating feedback mechanisms.*

Feedback Loop	-/+
C29 →C10 →C25 →C29	-
C29 →C9 →C25 →C29	-
C29 →C35 →C25 →C29	-
C11 →C39 →C20 →C18 →C11	+
C31 →C22 →C40 →C18 →C11 →C39 →C5 →C31	+
C29 →C10 →C25 →C26 →C29	-
C29 →C9 →C25 →C26 →C29	-
C29 →C35 →C25 →C26 →C29	-
C7 →C40 →C18 →C11 →C39 →C5 →C7	+
C15 →C11 →C39 →C5 →C15	+
C15 →C31 →C40 →C18 →C11 →C39 →C5 →C15	+
C31 →C40 →C18 →C11 →C38 →C6 →C31	+
C29 →C10 →C23 →C40 →C18 →C29	-

C29 →C9 →C23 →C40 →C18 →C29	-
C29 →C35 →C23 →C40 →C18 →C29	-
C40 →C18 →C29 →C12 →C13 →C23 →C40	-
*C24 →C19 →C24	+
*C24 →C5 →C24	+

The rest of this section will take a closer look at interesting interactions within the FCM, with Figures 3, 4, and 5 singling out the involved relationships for a more comprehensive understanding. Figure 3 highlights a trade-off between accuracy of quantification and MRV (C5), and, administrative burden (C8), in the map dynamics. A high accuracy of quantification for carbon removals allows for a greater quality of removals, which directly and positively impacts the framework's effectiveness. However, a greater accuracy of quantification also increases the administrative burden, which then lowers both quality (C31) and participation (C29). A decrease in participation then leads to a decrease in removal quantity (C12). Simplified MRV procedures (C33) are a part of the framework to encourage SME participation (C34), but that simplified procedure lowers the required accuracy, which again ultimately lowers the quality of removals. This trade-off between accuracy (C5) and administrative burden (C8) is also a trade-off between quality (C31) and quantity (C12) of carbon removals. The impact assessment stated the trade-offs between accuracy (C5) and costs (C25), as well as between accuracy (C5) and administrative burden (C8), but no direct trade-off between quantity (C12) and quality (C31) is mentioned (European Commission, 2022).

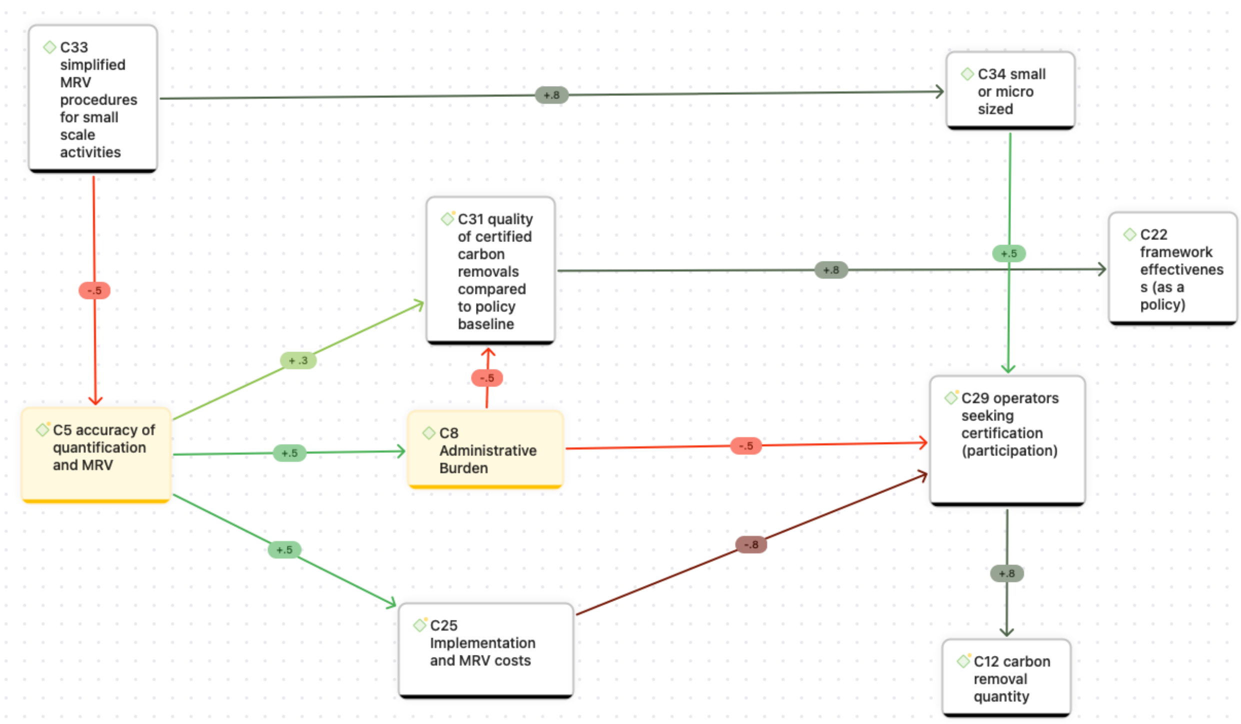

Figure 3: The trade-off between accuracy of quantification and MRV (C5), and administrative burden (C8) in the map dynamics. This trade-off between accuracy (C5) and administrative burden (C8) is also a trade-off between quality (C31) and quantity (C12) of carbon removals, the latter which is not mentioned in the policy documents.

Figure 4 has two feedback loops visible, which are closely related to each other. In the documents, a high diversity of certification approaches (C19) is seen as a barrier for operators because it can inhibit their access to knowledge (C6) and cause an increase in costs (C25) and decrease in participation (C29). To combat this, the Commission included harmonisation (C24) as a main goal of the framework: by harmonising the rules, procedures, and overall certification schemes, the diversity of certification approaches will go down, in time increasing access to knowledge (C6) and participation (C29) while decreasing costs (C25). However, an increase in framework effectiveness (C22) causes an increase in trust (C40), which then increases the demand for removals (C18). The high demand for removals then ultimately increases the number of certifications approaches available for operators (C19), which then negatively affects harmonisation (C24). The feedback loop happening through C24→C22→C40→C18→C19→C24 is negative and therefore a stabilizing dynamic on the system, which works well to balance the positive feedback loop between C19 and C24. Neither of these feedback loops in their entirety is discussed in the documents, only individual relationships. The closest instance is in section 2.1.3 of the impact assessment, where the issue of certification diversity, and its effects on costs, is introduced. Then, later on in the section the concept of harmonisation to decrease diversity is mentioned (European Commission, 2022, p. 6).

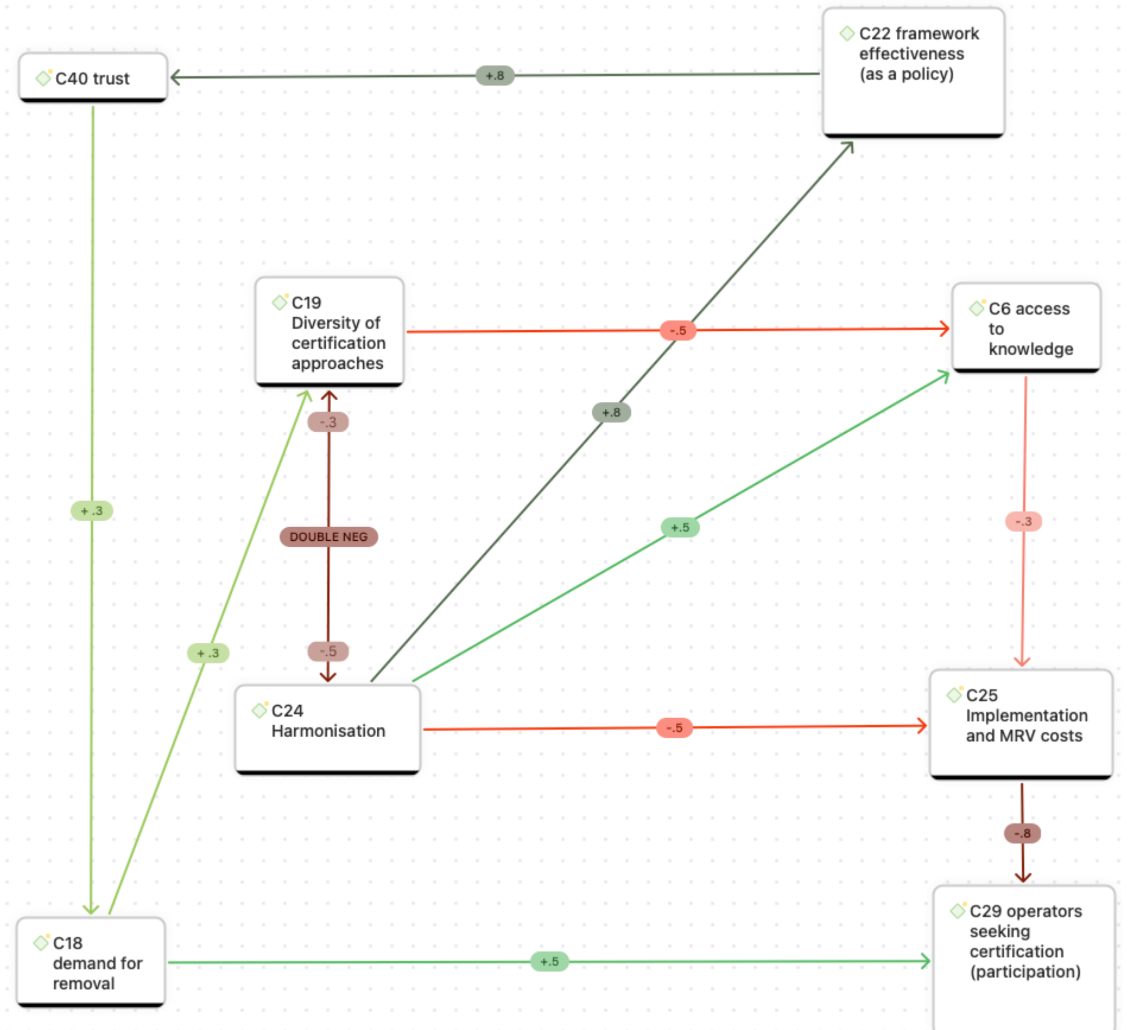

Figure 4: Balancing feedback mechanisms shown through the increase of harmonisation (C24) attributing to an increase in framework effectiveness (C22), trust (C40), and demand for removals (C18). The number of certification approaches (C19) will then rise to capitalize off the demand for removals, which will lower harmonisation (C19). Within the larger feedback mechanism is a smaller bidirectional relationship between diversity of approaches (C19) and harmonisation (C24), where they are influencing each other simultaneously.

Figure 5 highlights a delicate balance of opposing influences in the system. In the framework, afforestation is identified as one of the main forms of carbon farming that can be used as a means for carbon removal. In the CRCF impact assessment, it is then stated that a potential side effect on rural communities is that a higher demand for afforestation activity will lead to more demand for this version of carbon sequestration, which increases competition for land, ultimately decreasing long-term food security (European Commission, 2022). The solution then listed is that “the certification criteria to address potential sustainability impacts will promote activities that have no negative impacts on food security at Union level and recommended to build collaboration arrangements with rural communities” (European Commission, 2022, p.35). As a result, afforestation activity (C9), has both positive and negative influences on long term food security (C28). The positive influence, afforestation activity (C9) → soil health (C36) → long term food security (C28) is the stronger and more direct influence, and as shown in the dynamic output in the next section, currently outweighs any potential adverse effects to food security.

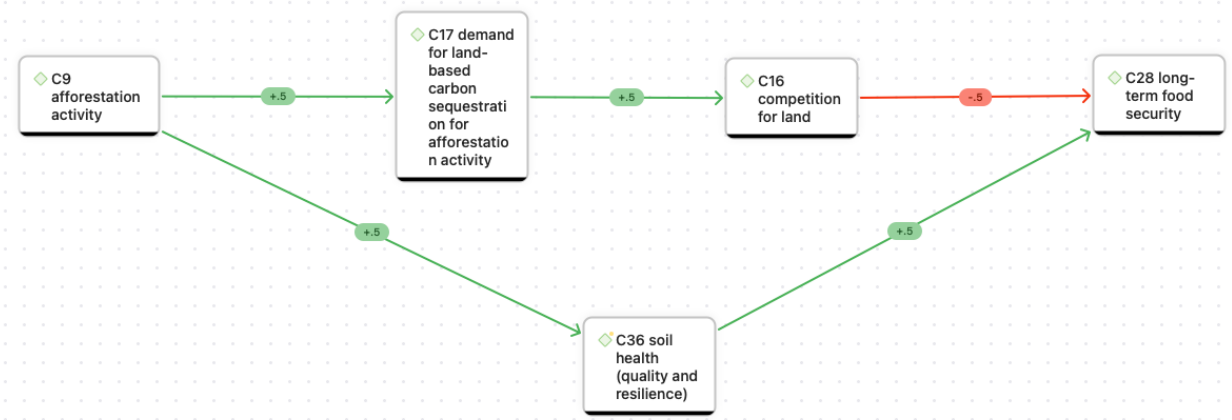

Figure 5: Opposing influences found in the impact assessment regarding afforestation activity (C9) and food security (C28), where increased competition for land (C16) is stated to be a potential side effect of the increased demand because of the (expected) success of the framework. This land competition will then negatively impact long-term food security (C28), due to decreased land availability for agricultural activities.

5.2 Dynamic Output and Sensitivity Analysis

5.2.1 Dynamic Output

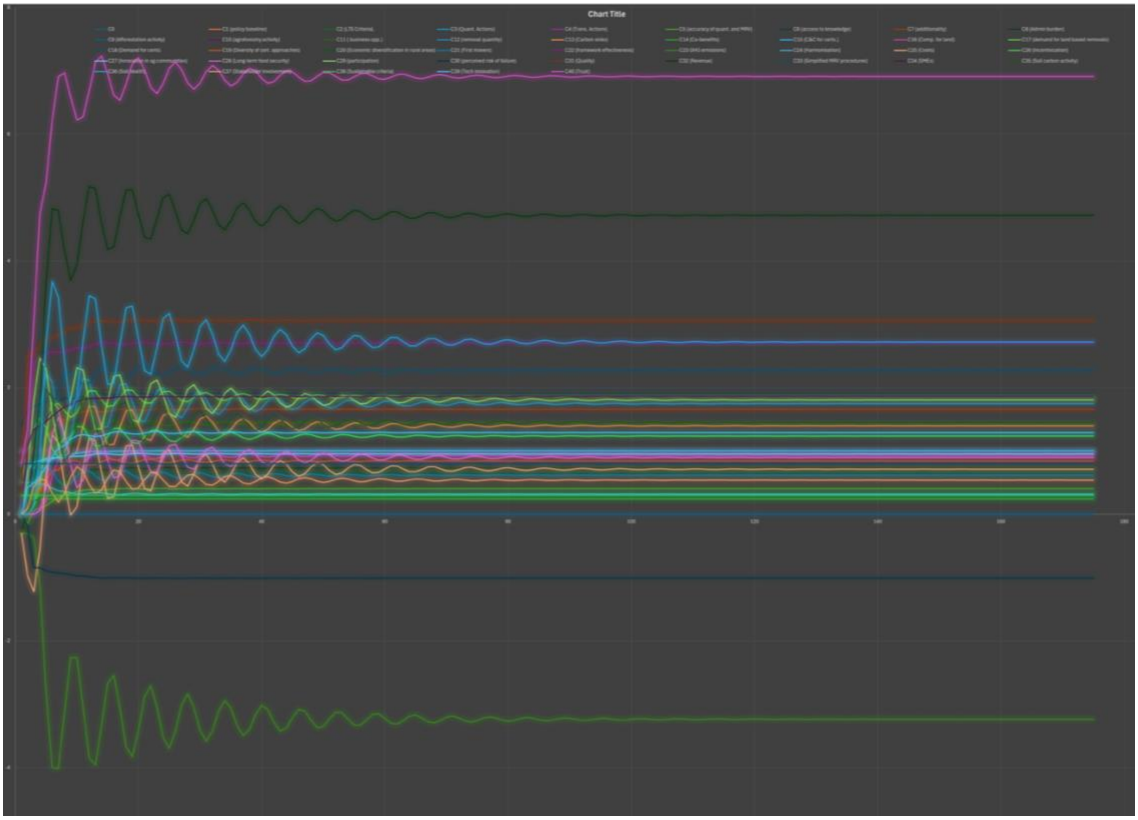

Figure 6: Dynamic Output of the FCM, showing the stable state of the system, with the x-axis representing iterations of adjacency matrix multiplication and the y-axis representing strength of the concept in relation to the other concepts in the system. The top and bottom two concepts visually stick out from the other 36 that are clustered in the middle, and they are trust (C40) and revenue (C32), and then perceived risk of failure (C30), and GHG emissions (C23), respectively.

In Figure 6, an oscillation of several concepts is shown, visualizing the behavior of the positive feedback loops in the system, with the strengthening positive feedback loops causing rapid growth and the weakening positive feedback loops causing rapid decline. The negative feedback loops act as dampeners in the system, causing the stabilization at the 244th iteration, although the order of concepts is visibly apparent at around the 100th iteration. The end state values of the concepts are shown in Table 4, in decreasing order, matching the output. Trust (C40) and GHG emissions (C23) are two driving concepts in this dynamic output, with trust having the highest end state value at around 6.91 and GHG emissions having the lowest at around –3.24. Only two of the 36 influenceable concepts (excluding the drivers) have an end state value below zero – GHG emissions as mentioned and perceived risk of failure (C30). This visualization, and the final order of concepts, brings clarity to the complex system dynamics shown in the map, representing a potential system state.

Table 4: Dynamic output concept values after reaching a stable state. These numbers represent the strength of the concept in the system and are used comparatively.

#	Concept	End Value
1	C40 Trust	6.91
2	C32 Revenue	4.72
3	C31 Quality of Certified Carbon Removals Compared to Policy Baseline	3.06
4	C36 Soil Health (Quality and Resilience)	2.72
5	C22 Framework Effectiveness (As a Policy)	2.70
6	C18 Demand for Removal Certificates	2.27
7	C6 Access to Knowledge	1.91
8	C34 Small or Micro Sized Enterprises	1.86
9	C17 Demand for Land-Based Carbon Sequestration for Afforestation Activity	1.86
10	C29 Operators Seeking Certification (Participation)	1.81
11	C12 Carbon Removal Quantity	1.74
12	C7 Additionality	1.66
13	C9 Afforestation Activity	1.44
14	C10 Agroforestry Activity	1.44
15	C35 Soil Carbon Activity	1.44
16	C11 Business Opportunities	1.43
17	C13 Carbon Sinks (Via Carbon Farming Activities)	1.40
18	C39 Technology Innovation	1.29
19	C26 Incentivization	1.23
20	C15 Comparability and Competition for Certifications	1.01
21	★ C1 Implementation of a Policy Baseline (Other Supplemental Policy)	1.00
22	★ C2 Long Term Storage Criteria	1.00
23	★ C3 Quantification Actions	1.00
24	★ C4 Transparency Actions	1.00
25	C27 Innovation in Agricultural Communities	0.95
26	C16 Competition for Land	0.93
27	C28 Long-Term Food Security	0.90
28	C19 Diversity of Certification Approaches	0.84
29	C33 Simplified MRV Procedures for Small Scale Activities	0.8
30	C8 Administrative Burden	0.73
31	C25 Implementation and MRV Costs	0.71
32	C20 Economic Diversification in Rural Areas	0.64
33	C21 First Movers	0.62
34	C37 Stakeholder Involvement	0.54
35	C5 Accuracy of Quantification and MRV	0.40
36	C24 Harmonisation	0.32
37	C38 Sustainable Criteria	0.30
38	C14 Co-Benefits	0.24
39	C30 Perceived Risk of Failure	-1.01
40	C23 GHG Emissions (Including Leakage)	-3.24

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5.2.2 Sensitivity Analysis

The following subsections present three areas of sensitivity found within the FCM after conducting a full sensitivity analysis. These areas pertain to carbon farming activities (afforestation, agroforestry, and soil carbon activity), costs, participation, trust, demand, and their relationships in the system.

5.2.2.1 The relationship between carbon farming activities and costs

In the FCM, the relationships between the afforestation activity (C9), agroforestry activity (C10), soil carbon activity (C35), and costs (C25), are established at +.3, +.4, and +.5 respectively. This is to represent the slightly different costs associated with implementation and MRV requirements for each activity. Figure 7 shows the result of strengthening the relationship between afforestation activity (C9) and costs (C25) by .2, with the other two analyses shown in the appendix, as their results are different from the original system but similar to each other. This change results in a drastic increase in oscillation, revealing a point of sensitivity. The dampening of oscillations is an indicator that the negative feedback mechanisms are still not overpowered (Meadows, 2009).

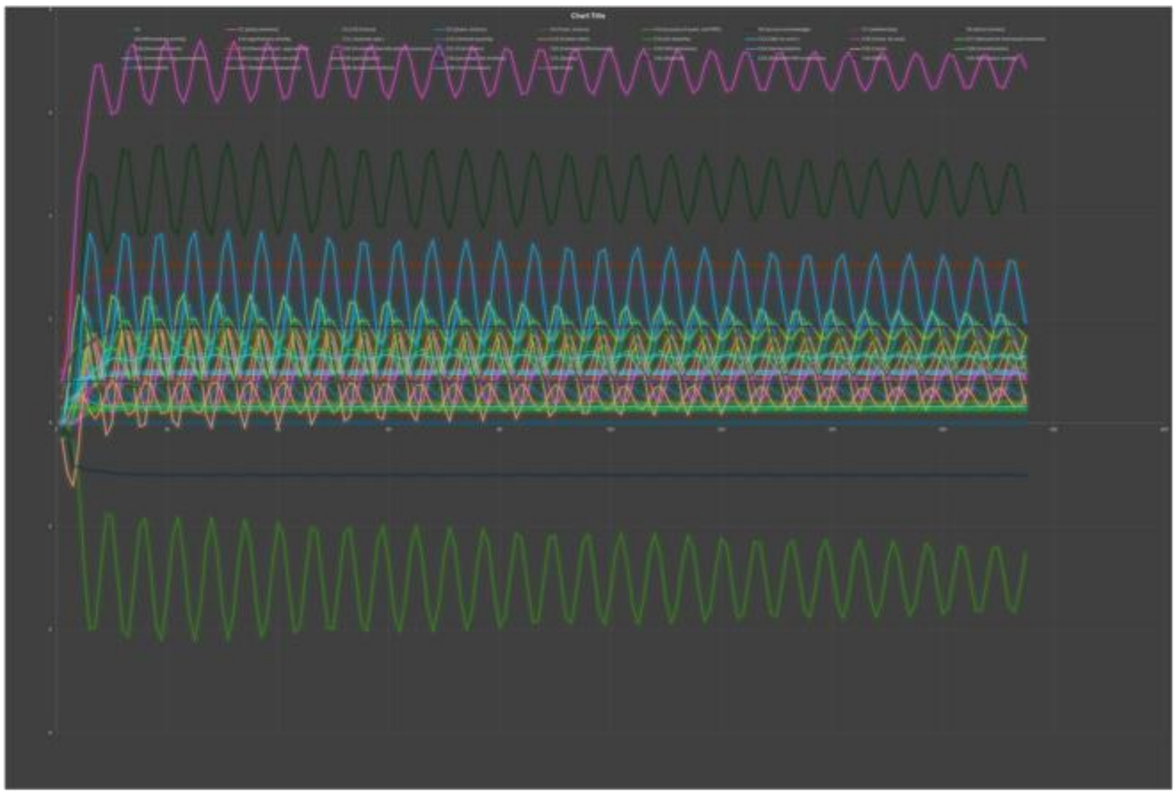

Figure 7: The dynamic output after a .2 increase in relationship between afforestation activity (C9) and costs (C35). The small change caused substantial oscillation, which is also visible after a .2 increase between costs and agroforestry activity (C10) and costs and soli carbon activity (C35).

Table 5 shows the notable changes in end values compared to the original system. These relationship changes result in soil health (C36), carbon removal quantity (C12), and all carbon farming activities (C9, C10, and C35) moving down in concept value, and implementation and MRV costs (C25) increasing. Besides the shift in concept strength, these changes do not destabilize the system, but greatly increase the intensity of oscillation and therefore the number of iterations before stabilization. The original dynamic output stabilizes fully at the 244th iteration, and figures 7, 8, and 9 stabilize sometime after the 1000th iteration. This slow speed of convergence is because feedback loops involved are also being strengthened, increasing the overall complexity. As of right now the system is resilient enough to still reach stabilization, but Figures 10 and 11 show a tipping point in each carbon farming/cost relationship, causing destabilization.

Table 5: The stable end state concept values of the most changed concepts after three different sensitivity analyses, increasing the relationship afforestation activity (C9) and costs (C35), agroforestry activity (C10) and costs (C25), and soil carbon activity (C35) and costs (C25).

Concept	Current Situation	Afforestation & Costs	Agroforestry & Costs	Soil Carbon & Costs
C6 Access to Knowledge	2.22	1.91	1.91	1.91
C11 Business Opportunities	1.57	1.42	1.42	1.42
C12 Carbon Removal Quantity	1.87	1.64	1.62	1.64
C15 Comparability and Competition for Certifications	1.07	1.00	1.00	1.00
C16 Competition for Land	1.01	0.89	0.89	0.89
C19 Diversity of Certification Approaches	0.54	0.83	0.83	0.83
C25 Implementation and MRV Costs	0.74	0.86	0.81	0.86
C26 Incentivization	1.29	1.19	1.20	1.19
C27 Innovation in Agricultural Communities	1.11	0.95	0.95	0.95
C34 Small or Micro Sized Enterprises	2.01	1.85	1.85	1.85
C36 Soil Health	2.92	2.54	2.47	2.54
C37 Stakeholder Involvement	0.59	0.48	0.50	0.48

Figures 8 and 9 show that if an individual relationship between any of the carbon farming activities and costs strengthens/increases by a value of .3, or if all three relationships collectively increase by a value of .1, then the system destabilizes, representing unsustainable and unpredictable behaviour in the real-world environment. With a destabilized system, there are no end values or a final order of concepts, only exponential and continuous oscillation.

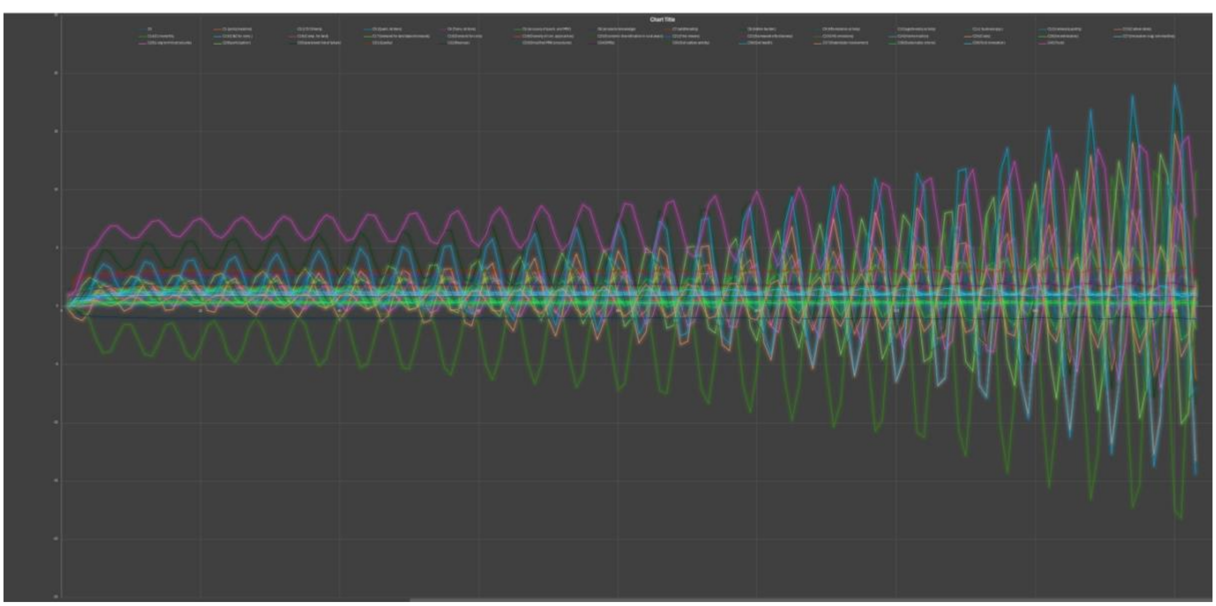

Figure 8: The dynamic output after a .3 increase in the relationship between afforestation activity (C9) and costs (C25), resulting in system destabilization.

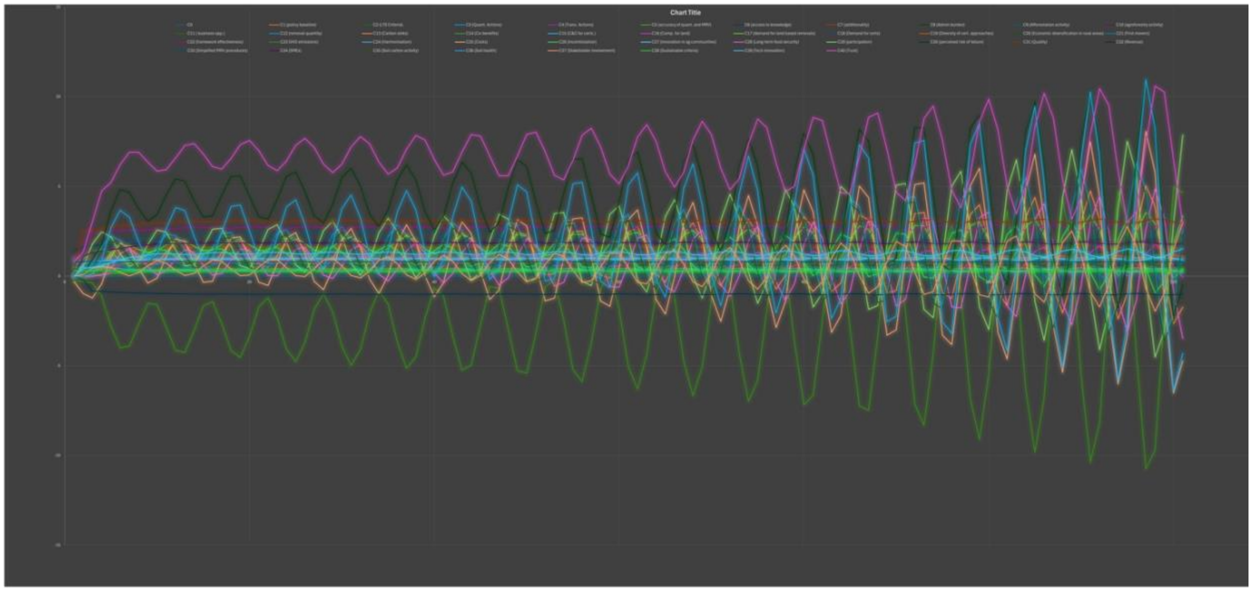

Figure 9: The dynamic output after collectively strengthening the relationships between afforestation activity (C9), agroforestry activity (C10), and soil carbon activity (C35) with costs (C25) by .1, resulting in destabilization

5.2.2.2 Operators seeking certification (participation)

In addition to cost and carbon farming activities, participation (C29) is also a very sensitive concept with potential to destabilize the system. Figure 11 shows the dynamic output after increasing all of participation's (C29) outgoing relationships by .2. This marks another tipping point in the system- demonstrating how if participation increases, there also needs to be an increase in the relationships within negative feedback loops. This would strengthen their dampening properties and offer the system more resilience.

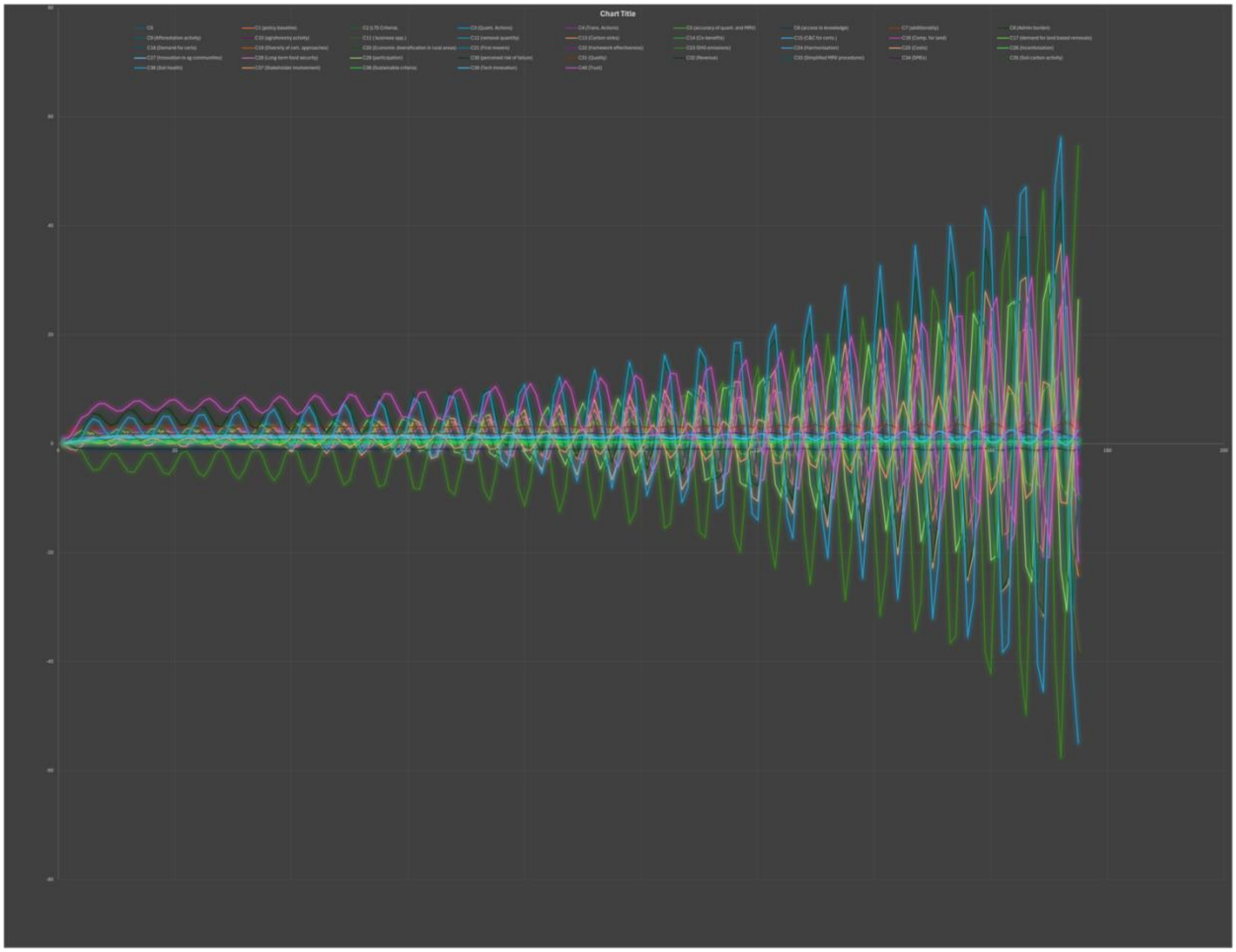

Figure 10: .2 increase in all outgoing participation relationships.

5.2.2.3 Trust and Demand Relationship

The final point of interest to be discussed is the relationship from trust (C40) to demand for certificates (C18). The initial relationship value is .3, and Figure 12 shows the dynamic output after increasing said relationship to .5. This change furthers oscillation and increases the sensitivity of the system since this relationship is in nine out of 18 feedback loops present. Four of those loops are positive and five are negative, which explains why the system still achieves stabilization. Upon further strengthening of the relationship, the system drastically increases in complexity. Stabilization is not reached until well after 5,000 iterations, visualizing how the dampening aspects of the system take longer to work effectively once single relationships are intensified.

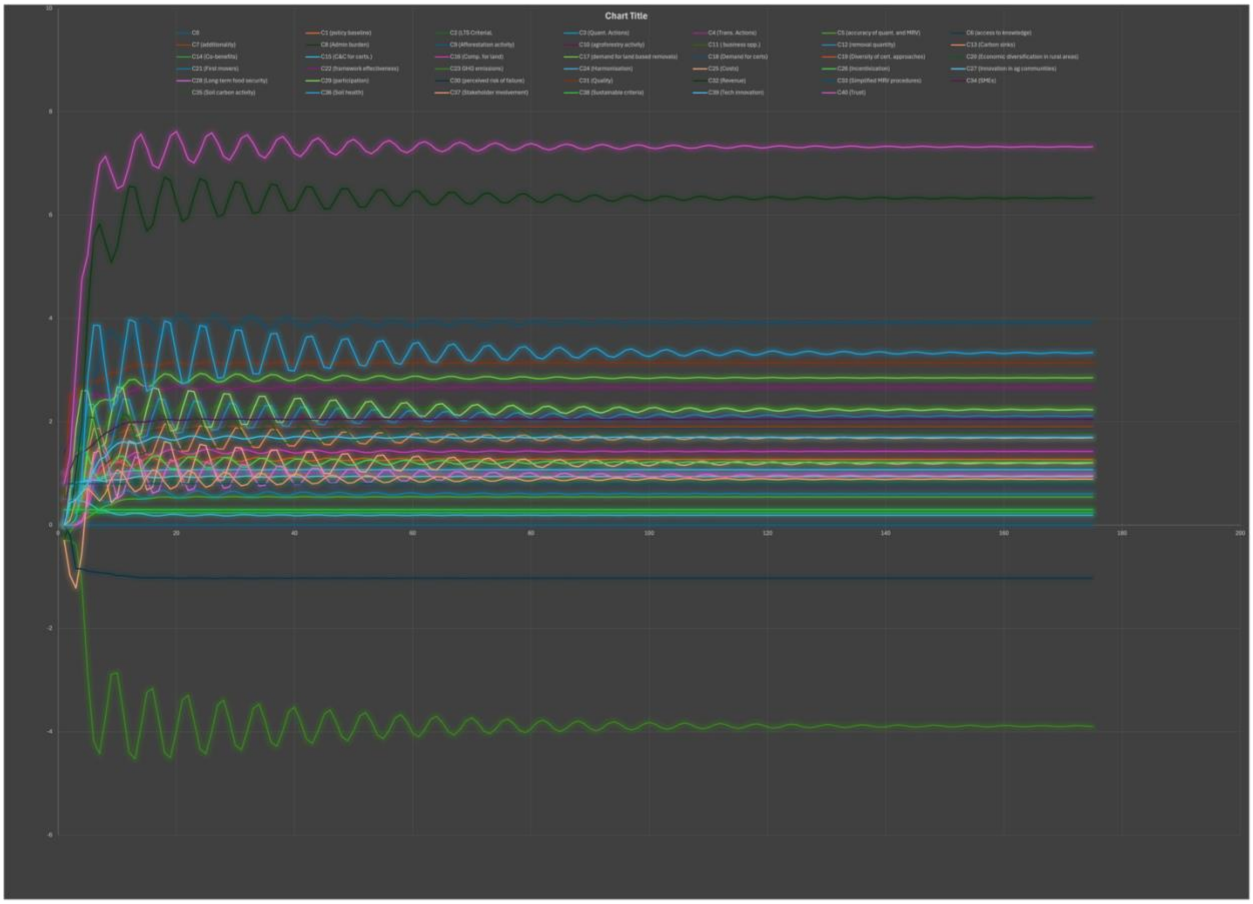

Figure 11: Dynamic Output after increasing Trust/Demand relationship by .2.

Table 4 highlights notable changes in the concept order after the trust/demand relationship change. Trust (C40), Revenue (C32), Perceived Risk (C30), and GHG Emissions (C23) are still the top and bottom two concepts, respectively, with substantial jumps happening in the middle section of the output. Demand for certificates (C18), of course, moves up, along with Business Opportunities (C11) moving up 8 spaces. However, Access to Knowledge (C6) moves down six spaces, and Competition for Land (C16), Diversity of Certification Approaches (C19), and Implementation and MRV Costs (C25) all move up seven, eight, and nine spaces, respectively.

Table 4: Main changes in end state values after trust → demand relationship change

↑/↓	#	Concept	End Value
↑ 8	8	C11 Business Opportunities	2.27
↓ 3	11	C34 Small or Micro Sized Enterprises	2.05
↓ 6	13	C6 Access to Knowledge	1.87
↑ 7	19	C16 Competition for Land	1.42
↑ 8	20	C19 Diversity of Certification Approaches	1.27
↓ 2	21	C26 Incentivization	1.21
↑ 9	22	C25 Implementation and MRV Costs	1.20
↓ 3	23	C15 Comparability and Competition for Certifications	1.07

↓ 4	29	C27 Innovation in Agricultural Communities	0.94
↑ 3	31	C37 Stakeholder Involvement	0.89
↓ 4	33	C33 Simplified MRV Procedures for Small Scale Activities	0.80

6. Discussion

This research set out to map the EU's conceptualization of the Carbon Removal Certification Framework and identify potential systemic side-effects, as well as assess the use of fuzzy cognitive mapping as a tool to analyse policy documents without supplemental co-production, interviews, or outside literature. The following sections will address the specific research questions and their broader implications for real life policy implementation, then discuss the limits of the research.

6.1 SRQ1: What concepts are perceived by the EU as core elements for ensuring a successful implementation of the CRCF for carbon farming?

There are multiple ways to determine key concepts when looking at the results, as shown in Table 5. Access to knowledge (C6), costs (C25), participation (C29), and removal quality (C31) are all core concepts in terms of centrality with either a high number of relationships, a high total weight value, or both. Demand for removals (C18) and participation (C29) are in the most feedback loops, 10 out of 18, meaning they play key roles indirectly reinforcing or stabilizing other concepts and the overall system. In the dynamic output shown in Figure 5, trust (C40) visually sticks out as the top concept, or the concept with the highest dynamic output end value in comparison to the rest of the system, signifying its importance. Finally, costs (C25), participation (C29), trust (C40), and demand (C18) all have relationships that contain major leverage points, which will be further discussed in section 6.3.

Table 5: The most important concepts (as perceived by the EU), as determined by looking at the centrality of concepts, their involvement in feedback loops, their end values in the dynamic output, and whether or not they contain leverage points.

Key concept	**as determined by…**			
	Centrality	Involvement in feedback loops	High end value in dynamic output	Leverage point
Access to knowledge (C6)	✓			
Demand for removals (C18)		✓		✓
Costs (C23)	✓			✓
Participation (C29)	✓	✓		✓
Removal quality (C31)	✓			
Trust (C40)			✓	✓

The six concepts listed are all core elements in the system's behavior and can be grouped together based on their roles as discussed in the documents. Participation (C29), demand (C18), and trust (C40) are concepts influenced by market forces and dynamics. Demand and trust are crucial to increase participation, which is stated by the impact assessment to be responsible for ensuring the scalability of carbon farming removals, which contributes to widespread sustainability (European Commission, 2022). Trust is also key in ensuring stakeholder confidence amid rising demand and participation.

The quality of removals (C18) is central to the integrity of the framework and its effectiveness, as removal quality is directly stated as a key indicator for effectiveness in both documents' multiple times (2022/0394(COD), 2022; European Commission, 2022). The concept also directly increases trust and therefore has minor influence over market conditions as well. The last two concepts, implementation and MRV costs (C25) and access to knowledge (C6), play direct roles in operator's capacity to engage with the framework. Low access to knowledge can hinder the certification process and high costs can act as a barrier to entry for potential operators and prevent them from starting the process completely.

These six concepts are perceived by the EU as core elements in ensuring a successful implementation of the CRCF for carbon farming, with participation (C29) being perceived as the most important concept. When looking at the FCM and the relationship described in the documents, all concepts lead back to participation. Participation is also in several feedback loops and is a point of sensitivity in the system. This is presenting a vision of the EU's expected implementation, which prioritizes a well-governed, harmonized, scalable system that has multiple opportunities to aid in broadening participation.

Other concepts not stated here are important for the success of minor mechanisms within the model but are not a part of the EU's core elements critical to the certification framework. Some of the issues brought up by Carbon Gap and the Institute for Agriculture and Trade Policy, such as greenwashing and mitigation deterrence, are briefly mentioned once or twice and then never again, and other concerns, like conflicts of interest between large-scale and small-scale farming operations and adverse social impacts, are never discussed.

Just as concepts discussed in length are noted as instrumental for the framework's success, it can also be stated that concepts not discussed in either the proposal or the impact assessment are not considered priorities and do not align with the EU's vision for what a successful carbon removal certification framework looks like. Mitigation deterrence is a potential threat when promoting carbon removals as a means to reach climate goals, and the fact that it is not in this system only adds validity to the worries of climate experts (Scherger & Sharma, 2023). It's absence in this system, in combination with the core concepts defined above, suggest that the EU is sacrificing the environmental integrity of the policy in favor of increased participation, demand, and an overall high level of scalability. The European Environmental Bureau also noticed a potential for the framework to cause "carbon tunnel vision" and an intensification of removal practices regardless of environmental effects due to a lack of safeguards (Ibbott, 2024).

6.2 SRQ2: How are the concepts interacting with each other in the framework, and what feedback loops are present?

The EU's perceived implementation of the CRCF is a complex and sensitive system, with 18 identified feedback loops. Individually, positive feedback loops can cause exponential growth or decline, reinforcing either growth or collapse to unsustainable levels if left unchecked, while negative feedback loops can act as a counterweight and aid in homeostasis by reversing or stopping the direction of change imposed by positive feedback loops (Garcia & Ramón, 2014; Meadows, 2009). When incorporated together they influence a system in a way that promotes growth while mitigating potential risks and maintaining a level of stability.

The majority of positive, or reinforcing, feedback loops include concepts such as technology innovation (C39), business opportunities (C11), demand for removals (C18), with a few others appearing less frequently, such as trust (C40), accuracy of quantification (C5), and comparability/competition of removals (C15). While they all contain one or two concept differences, they all represent exponential growth in the system- more demand, more business opportunities, more trust. However, the sensitivity analysis in section 5.2.2 shows that prioritizing demand in the system leads to unsustainable outcomes. Specifically, the increase in demand reduces knowledge, which in turn causes a dramatic increase in then land competition, diversity of approaches, and costs to accommodate, or balance, the system. Over half of the negative feedback loops include implementation costs (C25), and as shown in the sensitivity analysis in section 5.2.2.2, the stabilizing concepts (like costs) need to rise at a corresponding level in order to maintain a balance in the system.

The only positive feedback loop that tells a story different from the others involves the concept harmonisation (C24). This concept is also in one negative feedback loop, and together they further highlight how positive and negative feedback loops are needed in tandem. Figure 2 in section 5.1.2 illustrates how the negative feedback loop happening (harmonisation C24 → framework effectiveness C22 → trust C40 → demand C18 → diversity of certification approaches C19 → C24) helps stabilize the positive feedback loop between diversity of certification approaches (C19) and harmonisation (C24).

The system is structured to promote growth through key feedback loops that include business opportunities (C11), technology innovation (C39), and demand for removals (C18). This represents a broader trend common in society and policy: the urge to lean into growth and the tendency to diversify when there is potential for increased profit. In the real world, diversification seems like it would increase accessibility, with potential for more variation in methods and costs for different operators, but this system shows that this will have the opposite effect, reducing accessibility for SMEs when navigating the framework. While diversification of certification approaches can have the appearance of greater flexibility, this expansion will diminish the participation of SMEs because a high diversification of approaches requires a more in depth understanding of the different processes and higher transaction costs when switching between them. This would not be an issue for every operator, but for those with limited time and resources, like farmers, the certification process would become inaccessible. High complexity has also been listed as a main barrier to implementation in a study to understand concepts influencing the adoption of sustainable farming practices, as they increase feeling of insecurity and low perceived feasibility (Rizzo et al., 2024). As it is modelled, diversity of certification approaches is the 34th concept, and harmonization is the 36th, implying that they are very weak concepts in the system. This goes against what the EU is aiming for, as harmonization is a specific objective of the framework. Neither of these concepts are sensitive points in the system, but these feedback mechanisms were not mentioned in the documents, and upon implementation extra attention will be needed to determine the best amount of each of the two concepts to have a scalable system while maintaining accessibility for SMEs within carbon farming.

The system's inclination to shift towards profit also shows further potential for greenwashing. The proposal states that the removal certificates can have several different uses, most of which revolve around ways to increase financing or revenue, to ultimately increase incentives. The urge to diversify would lower the environmental integrity of the policy because the primary driving force is economic benefit, with climate benefits being secondary (Ibbott, 2024). Diversification and multiple approaches could also lead to mistakes in the MRV process, misrepresenting how much carbon was removed. Fears for greenwashing is a common thread throughout climate organizations' criticisms, with all of them believing stricter limits and regulations need to be decided on before implementation (Carbon Gap, 2022; Ibbott, 2024; Scherger & Sharma, 2023). While this system shows an inclination for growth, the key negative feedback loops, including costs (C25) and harmonization (C24), must be appropriately represented in the real world implementation to lower greenwashing risks and aid stability.

6.3 SRQ3: What unintended consequences and leverage points of the CRCF become apparent through a system dynamics analysis?

6.3.1 Unintended Consequences

The first unintended consequence revolves around Figure 2 in the section 5.2.2, which shows the trade-off between accuracy of quantification (C5) and administrative burden (C8). A higher accuracy increases the quality (C31) but increases administrative burden (C8) as well, which lowers participation. Too high of an administrative burden was viewed as a hindrance to SMEs by the EU, and thus simplified MRV procedures for small scale activities (C33) was added to counteract what the administrative burden would do to participation levels (European Commission, 2022, p.20). However, by adding this option to increase participation, in particular SME participation, it unintentionally created a new trade-off between quality and quantity.

There are several real-world implications for this unintended trade-off. Quality of removals is one of two concepts the EU used to define framework effectiveness. The documents stress quality of removals, and the QU.A.L.ITY Criteria, but states that to receive certification, an operator only needs to surpass a baseline, which has not been determined yet. According to the impact assessment, the baseline must be "reflecting the standard performance of comparable activities in similar social, economic, environmental and technological circumstances and geographical locations should be preferred" (2022/0394(COD), 2022, p.2). If SMEs choose the simplified MRV procedures over the more accurate quantification, it opens two possibilities. First, all removals that pass the quality baseline, as determined through the certification process, are certified with dubious quality. The simplified procedures can cause an increase in inaccurate quantification, which would go against the initial goal of the framework, compromising the integrity, and diminishing trust. It will also lead to an increase in the perceived risk of failure (C30): claiming quality as a main goal of the framework but not enforcing the strict quality requirements can open the door for greenwashing accusations, or mitigation deterrence- which would also undermine trust. The second outcome, depending on how much more information becomes available on the simplified procedures, is that SMEs spend time and resources trying to attain a certification using said procedures, only to be denied for not meeting the quality criteria. This would again negatively affect operator and stakeholder trust. The EU is expected to ensure that this does not happen, but the documents, which include the proposal for the framework that has been passed, do not go into any further detail on how to manage this trade-off.

The second unintended consequence involves Figure 4, which is a very short chain of concepts pertaining to afforestation activity (C9) and long-term food security (C28). In the impact assessment, it is stated that carbon farming activities (C9, C10, and C35) will help increase long-term food security (C28) by increasing soil health (C36). At the same time, the impact assessment also states that afforestation's high potential for carbon removal will cause an increase in demand in the land-based carbon sequestration that will accompany said afforestation activities (C17), creating more competition for land (C16). This is because more operators will want to switch from agricultural farming to afforestation activities, therefore decreasing long-term food security (C28).

Fujimore et al. analysed the potential negative impacts of different land-based emission mitigation tactics using six different agroeconomic and integrated assessment models and found that afforestation policy had the most negative side effects on food security compared to bioenergy and non-CO2 emission reduction (Fujimori et al., 2022). Without proper strategy in the policy, this side-effect will add unnecessary burden to farmers, not just through decreased food security, but the tension that will bring within the community. Scarcity would drive up both food and land prices, and smaller farmers would have to make a choice that best benefited them. Due to the comparatively higher economic benefits associated with afforestation, it is also possible that larger corporations invest more into this activity, pushing smaller farmers out of the land completely.

Conflicts of interest are also a concern of the Institute for Agriculture and Trade Policy, in fear that they further disregard small scale farming operations (Scherger & Sharma, 2023). They bring into concern that the expert group, that is selected by the EU to assist in developing parts of the framework, is predominantly corporate groups and businesses, and when given the opportunity to develop methodologies and influence decisions they will do so in a self-serving manner (Scherger & Sharma, 2023). This raises more questions about the motivation for this framework, because if an improved climate, achieved by carbon removals, is an end goal, then small and medium farmers need better representation in the framework.

6.3.2 Leverage points

It can be concluded from the sensitivity analysis that the main leverage points lie within the concepts implementation and MRV costs (C25), operators seeking certification (participation) (C29), and trust (C40). Minor adjustments to their relationship values led to major differences in the dynamic output outcomes in terms of behavior and end value concept order. These three concepts therefore need extra attention upon implementation to ensure success.

As shown in section 5.2.2.1, a .2 increase of the outgoing relationship from costs to afforestation activity, agroforestry activity, and soil carbon activity simulates a rise in the costs associated with these activities. Individually, there is minimal change to the end order of concepts. However, any other increase results in destabilization. The system can handle a .2 increase of one of the relationships but nothing stronger than that, and not all three at once, which seems more representative of the real-world implementation of the framework. This is a leverage point in the system and should be used as a warning for implementation. In a systematic review analysing the concepts affecting the adoption of climate smart agriculture, cost was identified as a key characteristic of the practices examined when deciding to adopt, mentioned in 37 out of 49 papers, and was perceived as a main barrier to farmers (Gemtou et al., 2024).

The second leverage point identified lies within the concept participation (C29). When the outgoing relationships of participation were strengthened by a value of .2 the system destabilized. This is because participation is in nine out of 18 feedback loops, and increasing the value of those relationships strengthened the feedback loops to a degree that could not be balanced. An increase in participation without an increase in regulation can create a rate of growth that is unsustainable. In a system analysis of various carbon farming schemes, researchers in Belgium recognized the rapidly growing demand of carbon removal credits and stressed the importance of an equally strong governance system to handle proper supply. Without proper regulations, a large increase in participation will lead to a decline in environmental integrity, and the analysis highlighted the importance of maintaining a balance between growth and sustainability (Annys et al., 2022). The authors suggest that policies ensure comprehensive MRV procedures, directly contradicting the CRCF, which has simplified MRV procedures to help increase participation of SMEs. In the original output of the FCM, stabilization is possible, but policymakers need to be prepared to scale up these regulations to match participation levels.

The final leverage point is found between the concepts trust (C40) and demand for certifications (C18). The strengthening of the relationship from .3 to .5 still resulted in a stabilized system, but with substantial changes in the final concept order, as shown in Table 4. The increased demand leads to more business opportunities (C11), but the system also shows an increase in land competition (C16), diversity of certification approaches (C19), and cost (C25); with a large decrease in access to knowledge (C6). These unforeseen consequences call for similar considerations to the previous leverage point, and the need to have regulations keep up with demand.

Through the sensitivity analysis, it was also further cemented that trust plays a key role in the success of the framework, in the EU's conceptualization. Trust is mentioned multiple times, but more so revolving around trust in the quality of removals, and less overall political trust. It was identified as a main issue for stakeholders, and is reflected in the FCM, but when comparing the behavior of the system back to the text, trust's role in the success of the framework seems almost understated. Fairbrother documents their findings on how political trust, and the belief that the public sector's actions are benevolent and not corrupt, is a major indicator of support for environmental protection, on both an individual and country-wide scale, and is even more pronounced than correlations between income or political ideology and support for environmental protection (Fairbrother, 2016). If the EU can prioritize trust building attributes like quality (C31), transparency (C4), and harmonisation (C24), it bodes well for long-term environmental integrity.

6.4 Limitations and Strengths

FCM production based solely from policy documents with no participatory research is very uncommon. This is because the methodology is typically used for solution generation and knowledge sharing. An FCM was the best tool for this research because it allowed for a comprehensive understanding of a complex system, qualitative input data, and possibility to uncover thresholds in the system with the sensitivity analysis. However, when mapping a system as described in documents, especially of a political nature, it is important to understand the intention of said document. With public documents the primary intention is to convey information, and with these documents, the secondary intention is to persuade the reader and justify the choices made (Axelrod, 1976). Consequently, the validity of inferences I made could be questioned. Given more time, I would have checked my map with unbiased experts on the topic to determine if my system matches or if I missed anything.

Another limitation I encountered was the pervasive ambiguity throughout the two analysed documents. There were multiple instances in the impact assessment where a problem was brought up that the EU stated would be fixed by 'specific methodologies' or something along those lines, which does not contain the specificity needed for more accurate mapping. With more time I would have done this by meeting with the EU ENVI Committee to clarify any questions I had. In its current form it is still valuable and interesting, in my opinion, as policy documents can be confusing for the public and this method allowed for a comprehensive understanding of what the EU is really stating. If this methodology is repeated, I recommend starting with a smaller system or allowing yourself more time for creating the map. A smaller system could let the researcher increase the number of documents analysed to get a better understanding without increasing the complexity. If a smaller system is not possible or preferred, then increase the amount of time allowed. I started reading the documents and identifying potential concepts while I still had a suboptimal comprehension of the policy, and with more time I would have gone back and re-read both documents to double check my work in the beginning.

Using a systemic perspective and system dynamics to analyse this policy also had limitations tied to scope. Due to the complexity of the policy, I chose to focus on just one of the specific avenues of carbon removals, carbon farming. As mentioned in the methods section, 20 concepts are ideal, but do to the enormity of the documents analysed this was the simplest portrayal of the system while still including important, but small interactions. However, there are some aspects of this system that are also important in the other avenues of carbon removal, or just outside the carbon farming scope in general, and the boundaries drawn meant that I could not model all concepts as accurately as I would have liked. An example being GHG emissions- that concept in my map represents GHG emissions only within this system, and I think that is a level of rigidity that is hard to comprehend when using a systemic perspective. In the case of policy specifically, it is also difficult to have a clearly defined system, since there are many instances where multiple policies supplement each other but that very quickly becomes too complex to model. The FCM produced was much more complex than the recommended 15-20 concepts, and this is after substantial simplification of certain aspects. This indicates that the documents themselves are too complex.

The strict boundaries of the system, put in place to make the workload feasible for myself, also added difficulty to the mapping of complicated concepts like food security and emissions, which go far beyond the scope of this paper. Also given the volume of work done, with nearly 1,000 coded segments across two documents, it is possible that subtle relationships might have been missed. However, in conformity with the methodology stated for concept identification, I would have excluded those relationships anyway.

Finally, the subjectivity and potential bias of the researcher is always a limitation in FCM production, as it is relatively impossible to perfectly recreate any system, only one's perception of it. My personal opinions and experiences may have unintentionally played a role when determining relationship strength, although the methodology played a role in ensuring the map reflects the information in document, and not my opinion on the matter.

Regardless of the limitations, I do think there are several strengths to using this model for policy analysis as well. Policy documents, including the two analysed, are often needlessly complicated. While building the model was also complex, this method is well-suited to handle complexity and uncertainty, and the result offers a comprehensive view of the policy (Özesmi & Özesmi, 2004). The FCM also allows for human perception to be incorporated into the system, which is important when analysing potential policy impacts. The semi quantitative nature of the FCM is another advantage, as it captures the nuances of human behaviour and can include concepts that are hard to quantify. Human perception and social concepts are crucial to fully analysing policy impacts, as shown in sections 6.2 and 6.3. The identification of unwanted consequences solely through EU documents added validity to several fears brought up by climate experts.

Additionally, the identification of feedback mechanisms and complex interactions also helped uncover the structure of the policy and its system, again allowing for an understanding that is more similar to real-world behaviour. The sensitivity analysis is a crucial aspect of this, simulating different futures to find more unwanted consequences. Overall, while the FCM can lack precision due to the nature of the system boundaries, it is a necessary tool to map human-environment relationships, uncertainties, and the diverse social impacts accompanying climate policy (Kok, 2009; Özesmi & Özesmi, 2004).

6.5 Further Research

FCMs have proven their value in policy analysis as discussed in the strengths and is a promising line of research. One could argue that important concepts are missing from the model and do further research on potential inaccurate representations in the policy, and the consequences of that. Further research could be done on this thesis's findings specifically, and the identified possible side effects, such as determining if a nationwide push for carbon removal, with specific regard to carbon farming, can lead to issues with land competition or food insecurity. From a methodology perspective, one could adjust the methods shown, for example adding interviews with the relevant committee or meeting transcripts from the creation of the document to get an even better understanding or use the model to facilitate a better understanding of historically complex documents for the public. More research needs to be done to determine the best combinations of knowledge sources for FCM production, as well the best uses for the model after its creation, but FCMs can add major value to the field.

7. Conclusion

This research set out is to map the EU's conceptualization of the Carbon Removal Certification Framework and identify potential systemic side-effects, as well as assess the use of fuzzy cognitive mapping as a tool to analyse policy documents without supplemental co-production, interviews, or outside literature.

The use of FCMs as a tool for policy analysis, solely through the analysis of documents, is very useful for the comprehension of complex policy and the discovery of potential impacts and complex interactions. It must be said that the usefulness of FCMs depends on how well they can be understood, and since they are representations of systems, they will inevitably match the complexity of the policy. This adds some limitations, but overall FCMs are best equipped to handle the uncertainty in policy. There are also other methods that can supplement its analysis, such as interviews or scenarios, that can expand on the usefulness of the tool and allow for even more possibilities, as mentioned in section 6.5.

To address the first objective: The EU, while acknowledging multiple problems for stakeholders in the framework regulation and impact assessment, conceptualizes a successful implementation of the framework, with trust and revenue for operators as the top concepts and GHG emissions and perceived risk of failure the bottom two. There is a possibility for issues and pitfalls in the actual implementation, but the dynamic output of the system described in the documents shows a relatively positive system state that is strong enough to overcome previously undiscovered side effects, which revolve around trade-offs between quantity and quality, a potential for unstable growth, and decreased food security that would disproportionately affect smaller farmers. Careful monitoring is needed for these aspects; however, the entire system is sensitive and needs thoughtful and deliberate calibration.

It could be said that the success of the system, as determined by the dynamic output, is partially due to underrepresentation and slight neglect of the priorities and needs of smaller carbon farmers. A re-occurring theme in the documents is vague promises of solutions for problems that would marginally affect rural areas and the farmers within, an example being the response to potential issues with food security and land competition, discussed in section 6.3.1. The documents state the importance of small and medium enterprises but that is a widely encompassing term and there is no regard stated for truly local farming and foresting operations. Even with the solutions being accounted for in the system, innovation of agricultural communities, economic diversification in rural areas, simplified MRV procedures for small scale activities, and stakeholder are all weak in the system, again representing a future brought on by ingenuine climate policy that prioritizes growth. The book *Small Farmers, Big Change* expands beyond just environmental policy, but still includes several case studies showing how a better incorporation of "smallholder" farms is critical for long term change (Wilson et al., 2011). The success of the system is also partly due to the exclusion of topics in the CRCF and impact assessment. Issues like greenwashing, mitigation deterrence, and conflicting interests between large and small scall farming operations will affect the real-world implementation of this framework but were not able to be analysed within the dynamics of the system.

While climate policy is necessary for systemic change, and this framework has potential, it fails to fully address the challenges that brought about its creation in the first place. The change needed to reach carbon neutrality by 2050 must have inclusive action and solutions, and not addressing these complex issues only perpetuates the fears it was designed to assuage. This represents a broader issue among all climate policy- ultimately appealing to corporate needs at the expense of climate integrity, which is exactly what climate experts like the ones at the Institute of Agriculture and Trade Policy are worried about. These economically favourable solutions fail the environment by ignoring its complexity and abstaining accountability.

As it stands now, the CRCF is insufficient in in contributing towards its goals and a cleaner environment. More so, it is at risk of contributing further harm to the environment through reinforced inequities between small- and large-scale farming systems and superficial solutions. For true environmental integrity and a net climate benefit, these oversights must be corrected and properly accounted for. This policy is a step in the right direction, and represents a slow path towards sustainability, but one that needs to be revised. The EU still has a chance to adjust this framework, as the specific certification methodologies are not to be finalized until 2026 and can remake this policy into one that is inclusive, equitable, and scientifically sound to bring about systemic change that will foster resilience and long-term climate health for the future.

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9. Appendix

Table 1: Concepts and what they have been merged with.

Concept Name:	Merged With:
★ C1 Implementation of a Policy Baseline (Other Supplemental Policy)	• Public Funding • LULUCF • CAP Funding
★ C2 Long Term Storage Criteria	
★ C3 Quantification Actions	• Climate Benefit Assessment, • Comprehensive Monitoring Plan, • Comprehensive Project Boundaries
★ C4 Transparency Actions	• Reliable Rules and Procedures, • Robust Registries, • Registries, • Tailored Certification Methodologies, • Third-Party Verification and Certification, • Independent Third-Party Auditing, • Transparency
C5 Accuracy of Quantification and MRV	• MRV Accuracy • Quantification
C6 Access to Knowledge	• Access To Reliable Info on Quality on Removals, • "Wealth of Accurate Information", • Users' Ability to Assess Value of Carbon Removals, • Data Availability, • Data on Carbon Removals, • Advisory Services, • Knowledge Exchange
C7 Additionality	• Highly Representative Baseline • Highly Representative Standardized Baseline • Recognition of Net Climate Benefits of Activities Compared to Current Practices
C8 Administrative Burden	
C9 Afforestation Activity	
C10 Agroforestry Activity	
C11 Business Opportunities	• Business Case for Investment in CR Tech • Strength of Market • Diversity of Business Models
C12 Carbon Removal Quantity	• Carbon Removal Efforts • Efforts to Decrease Emissions

	• Uptake of Carbon Removal Solutions
C13 Carbon Sinks (Via Carbon Farming Activities)	
C14 Co-Benefits	• Reputational Benefit from Investing in High Quality Carbon Removals
C15 Comparability and Competition for Certifications	
C16 Competition for Land	
C17 Demand for Land-Based Carbon Sequestration for Afforestation Activity	
C18 Demand for Removal Certificates	• Pressure To Buy High Quality Certificates • Support for Carbon Removal
C19 Diversity of Certification Approaches	• Diversity of Uses for Removal Certification
C20 Economic Diversification in Rural Areas	
C21 First Movers	
C22 Framework Effectiveness (As a Policy)	
C23 GHG Emissions (Including Leakage)	• Carbon Leakage Due to Anthropogenic Events • Carbon Leakage Due to Natural Events • Liability Management
C24 Harmonisation	• Strength of EU Governance Process
C25 Implementation and MRV Costs	• Overall Cost • Transaction • Carbon Removal Providers Access to Finance
C26 Incentivization	• Incentivization for First Movers • Disclosure of Co-Benefits • Possibility for Land Managers to Commit to Short Time Periods
C27 Innovation in Agricultural Communities	
C28 Long-Term Food Security	
C29 Operators Seeking Certification (Participation)	• Renewing/Continuation
C30 Perceived Risk of Failure	• Risk of Being Associated with Greenwashing Accusations • Uncertainty and Risk Aversion • Legal Certainty • Public Guarantees
C31 Quality of Certified Carbon Removals Compared to Policy Baseline	• Quality of Carbon Removals • Likelihood of Low-Quality Removals • Reliability and Efficiency in Land-Based Sequestration Solutions • Level of Standard for Development of Methodologies

	• False Claims • Double Counting
C32 Revenue	• Economic Benefits for Certification Actors • Investments in High Quality Carbon Removals • Revenue for Certification Schemes
C33 Simplified MRV Procedures for Small Scale Activities	
C34 Small or Micro Sized Enterprises	
C35 Soil Carbon Activity	
C36 Soil Health (Quality and Resilience)	• Soil Quality • Soil Resilience
C37 Stakeholder Involvement	• Stakeholder Consultation
C38 Sustainable Criteria	• Sustainability • Sustainable Development • Climate Friendly Management Practices • Minimum Sustainability Requirements • Safeguards
C39 Technology Innovation	• Adoption/Use of Digital (Monitoring) Technology • Remote Sensing • Innovation
C40 Trust	• Operators Trust in Framework • Stakeholder Trust • Stakeholders Trust in Carbon Removal Certificates

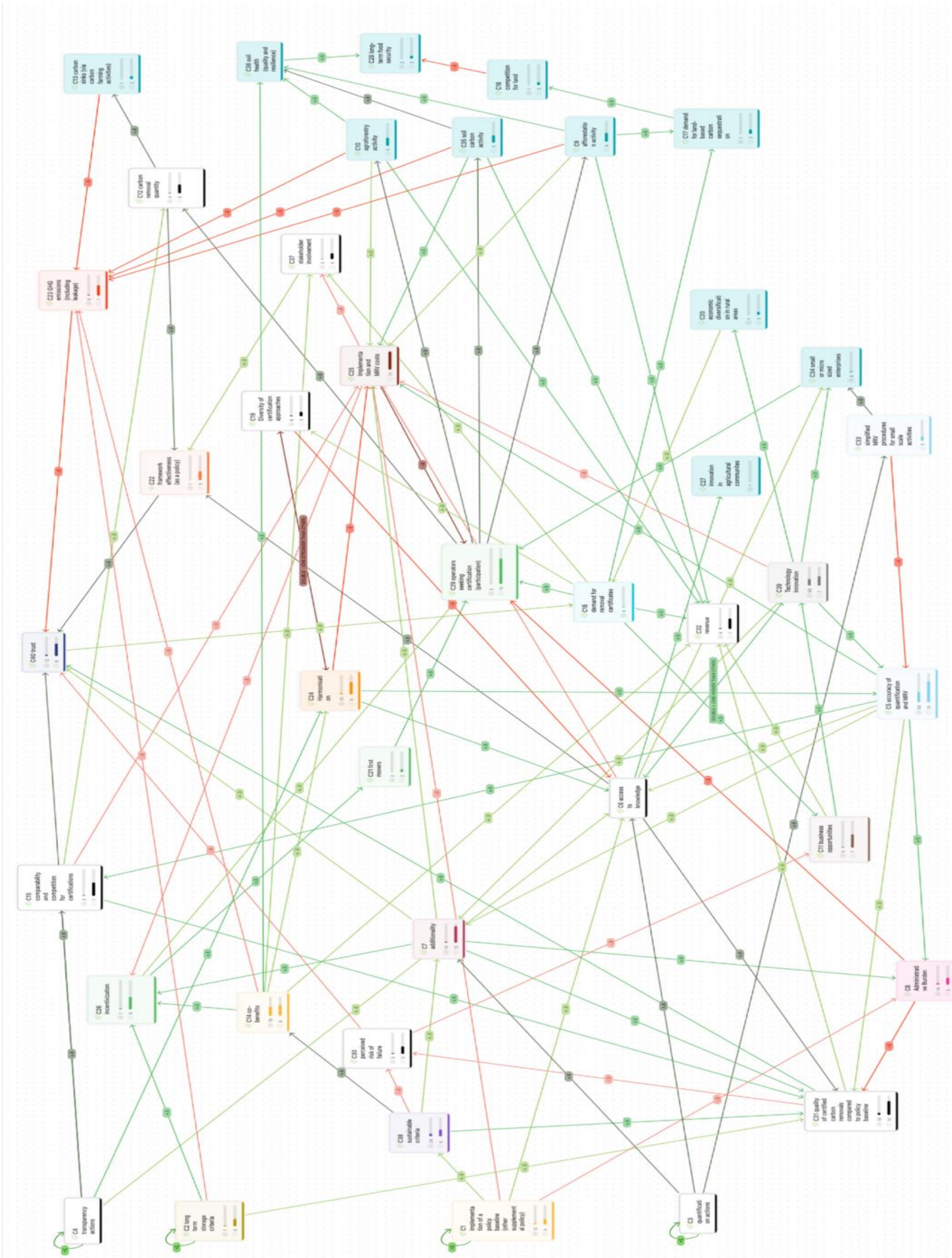

Figure 1: The final FCM, enlarged for better comprehension.

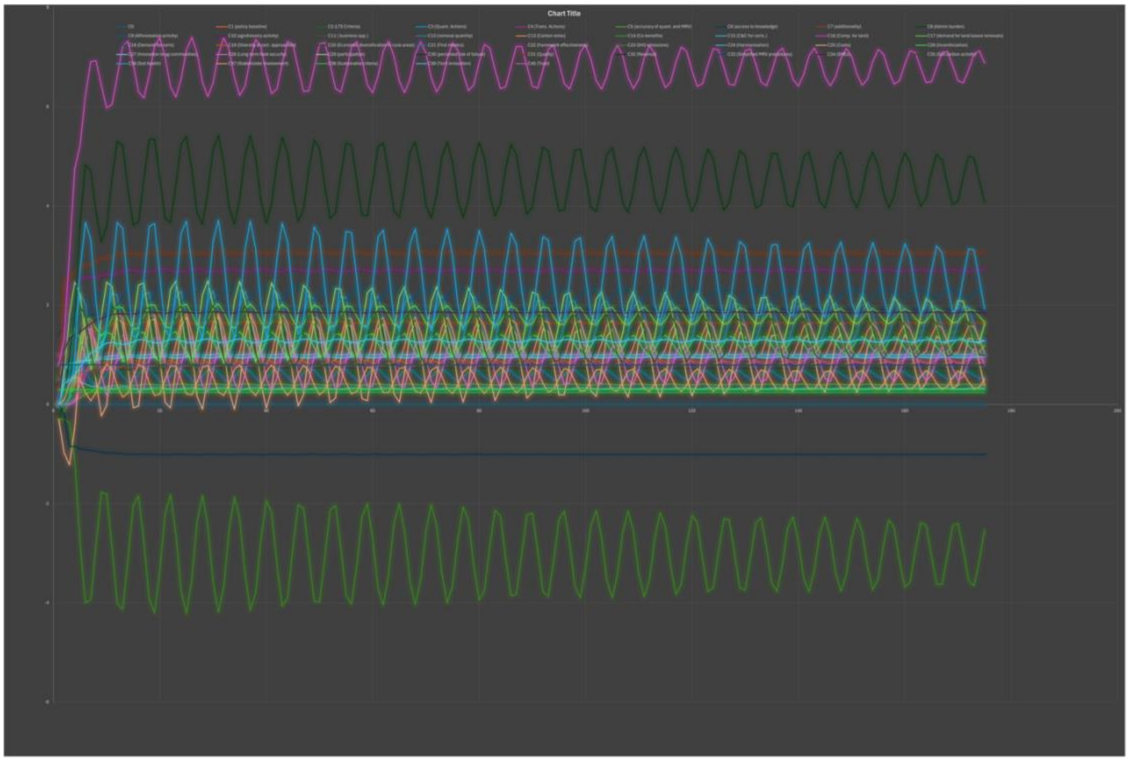

Figure 2: The dynamic output after a .2 increase in relationship between agroforestry activity (C9) and costs (C35). The small change caused substantial oscillation, which is also visible after a .2 increase between costs and afforestry activity (C10) and costs, and soli carbon activity (C35).

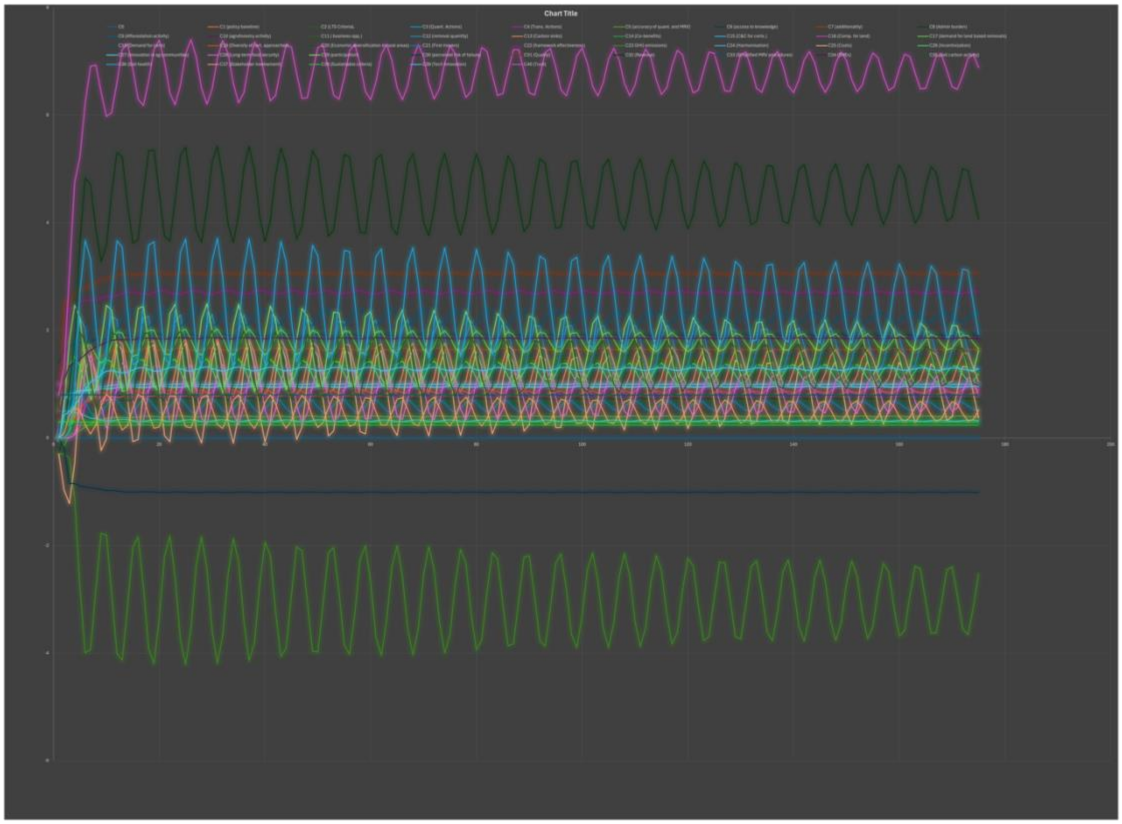

Figure 3: The dynamic output after a .2 increase in relationship between soil carbon activity (C9) and costs (C35). The small change caused substantial oscillation, which is also visible after a .2 increase between costs and agroforestry activity (C10) and costs and afforestry activity (C35).