Exploring industrial hemp for carbon sequestration in Ireland (WIP)

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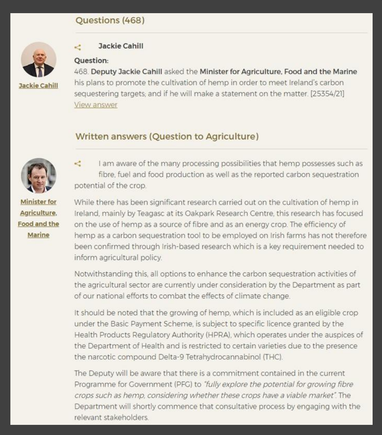
Research Problem

- This dissertation examines the environmental effects of industrial hemp as a carbon sequestration tool on farms in Ireland.
- This is an important topic in light of the country's high carbon emissions from agriculture. According to recent estimates, carbon emissions will increase in most sectors in Ireland by 2040, but mainly in agriculture due to economic growth and expansion of the dairy sector.



Questions (468)

Jackie Cahill

Question:
468. **Deputy Jackie Cahill** asked the **Minister for Agriculture, Food and the Marine** his plans to promote the cultivation of hemp in order to meet Ireland's carbon sequestering targets, and if he will make a statement on the matter. [25354/21]
View answer

Written answers (Question to Agriculture)

Minister for Agriculture, Food and the Marine

I am aware of the many processing possibilities that hemp possesses such as fibre, fuel and food production as well as the reported carbon sequestration potential of the crop.

While there has been significant research carried out on the cultivation of hemp in Ireland, mainly by Teagasc at its Oakpark Research Centre, this research has focused on the use of hemp as a source of fibre and as an energy crop. The efficiency of hemp as a carbon sequestration tool to be employed on Irish farms has not therefore been confirmed through Irish-based research which is a key requirement needed to inform agricultural policy.

Notwithstanding this, all options to enhance the carbon sequestration activities of the agricultural sector are currently under consideration by the Department as part of our national efforts to combat the effects of climate change.

It should be noted that the growing of hemp, which is included as an eligible crop under the Basic Payment Scheme, is subject to specific licence granted by the Health Products Regulatory Authority (HPRA), which operates under the auspices of the Department of Health and is restricted to certain varieties due to the presence the narcotic compound Delta-9 Tetrahydrocannabinol (THC).

The Deputy will be aware that there is a commitment contained in the current Programme for Government (PFG) to *"fully explore the potential for growing fibre crops such as hemp, considering whether these crops have a viable market"*. The Department will shortly commence that consultative process by engaging with the relevant stakeholders.

Summary

- The two reviews that answered RQ1 and RQ2 resulted in a framework for a multimethod modelling approach to hemp in agriculture.
- The quantitative results to answer RQ3 show that in the year of the largest harvest of hemp in 2019 and based on a sequestration rate of between 10 and 22 tonnes (t) of CO2, hemp could sequester between 5,470 and 24,068 t of CO2. The total amount of CO2 sequestrated between 2017 and 2021 is estimated to be between 14,660 and 64,504 t CO2.
- The estimated minimum and maximum financial contributions were between €348,805 and €1,534,742, equivalent to a carbon tax. The results inform RQ4 and the development of the Hemp in Agriculture for Carbon Emissions (HACS) simulation to ascertain future scenarios to 2030 (WIP).
- A qualitative Causal Loop Diagram (CLD) is created from media analyses that help build a hypothesis and answer RQ5. The research demonstrates that it is possible to gain insight into the complexity of Ireland's hemp market by using retrospective analysis of purposive data from publicly available transcripts to develop a CLD that reasonably captures the system.

Purpose

- This study's scope of research is focused on industrial hemp as a means of carbon sequestration within Ireland's agricultural system, using a mixed-methods approach.

LITERATURE REVIEWs

RQ 1

What modelling methods do decision-makers use for GHG emissions within Ireland's agriculture system?

Table 2.3: Carbon emission models used in agriculture in Ireland

Name	Description
JRC-EU-TIMES	Joint Research Council-EU-The Integrated MARKAL-EFOM System, a linear optimisation bottom-up technology model. **Source:** (Nijs and Ruiz, 2019)
The EU-TIMES	The Integrated MARKAL-EFOM System partial equilibrium energy system model. **Source:** (Loulou et al., 2005)
The POLES	Prospective Outlook on Long term Energy Systems, a partial equilibrium energy system simulation model. **Source:** (Després et al., 2018)
The PRIMES	Price-Induced market partial equilibrium modelling system. **Source:**(EMLab, 2018)
The GEM-E3	General Equilibrium Model. **Source:** (Capros et al., 2013)
Irish TIMES	Irish The Integrated MARKAL-EFOM System analyses energy usage, emissions, and natural resources. **Source:** (Ó Gallachóir et al., 2012)
EU GAINS	EU Greenhouse gas and Air Pollution Information and Simulation, multi-sectoral integrated model. **Source:** (International Institute for Applied Systems Analysis (IIASA), 2016)
Irish GAINS	Irish Greenhouse gas and Air Pollution Information and Simulation, multi-sectoral integrated model. **Source:** (Envecon, 2015b)
Integrated Modelling Project	GAINS and TIMES. **Source:** (Envecon, 2015a; Kelly, 2013)
ENV-Linkages	Computable General Equilibrium (CGE). **Source:** (Burniaux and Château, 2008; Château et al., 2014)

RQ2

How is SD research applied to complex real-life problems in Ireland?

Table 2.4: System dynamics research in Ireland (continued)

Year	Research Area	Authors
System dynamics research in healthcare		
2020	Bio-medical modelling	(Karanfil et al., 2020)
2020	Policy analysis for sustainable healthcare	(Lane and Duggan, 2020)
2017	Acute bed blockage problem	(Liston et al., 2017)
2017	Healthcare worker flu vaccination	(Domegan et al., 2017)
2016	The economic burden of hip fractures	(Elbattah and Molloy, 2016)
2015	Implementing large-scale spatial models of infectious disease	(Curran et al., 2016)
2015	Illustrating two complementary applications of SD	(Lyons and Duggan, 2015)
2013	Improve elderly care	(Rashwan et al., 2013)
2001	Modelling the effect information feedback, spread of Ebola	(O'Regan and Moles, 2001)
System dynamics research in urban and environment		
2020	Modelling society-wide climate change mitigation scenarios	(McMullin and Price, 2020)
2020	Sustainability education	(Brennan et al., 2020)
2019	Increasing ocean literacy	(Brennan et al., 2019)
2015	Rooftop solar and the utilities death spirali	(Meehan and Arango, 2015)

Continued on next page

Table 2.4: System dynamics research in Ireland (continued)

Year	Research Area	Authors
2011	Woody debris in managed Sitka spruce forests	(Olajuyigbe et al., 2011)
2009	The role of the private sector in urban regeneration	(Rhodes, 2009)
2009	Using SD to model the interaction between environmental and economic factors in the mining industry	(O'Regan and Moles, 2006)
2005	SD modelling: a more effective tool for assessing the impact of sustainable development policies on the mining	(O'Regan and Moles, 2005)
2001	Insight into the SD method: a case study in the dynamics of international minerals investment	(O'Regan and Moles, 2001a)
2001	A SD model of mining industry investment decisions within the context of environmental policy	(O'Regan and Moles, 2001b)
2001	Modelling to Learn, a case study in international minerals	(O'Regan and Moles, 2001)
1997	Applying a systems perspective to environmental policy	(O'Regan and Moles, 1997)
System dynamics research in energy		
2018	European power system	(Brinkerink and Shivakumar, 2018)
2010	Sequential development of Wave energy converter	(Weber et al., 2010)
2009	Co-simulation of HVAC systems in buildings.	(Trčka et al., 2009)
System dynamics research in methodology		
2020	Stock-flow thinking	(Curran et al., 2020)
2020	Optimisation of SD models	(Dangerfield and Duggan, 2020)
2020	Sustainability education: a study design	(Brennan et al., 2019)
2020	Hybrid modelling in Ireland	(Madden et al., 1997)
2019	Further demonstrates R's potential as a tool for analysts	(Duggan, 2019)
2019	SD and agent-based models in health	(Cassidy et al., 2019)

Continued on next page

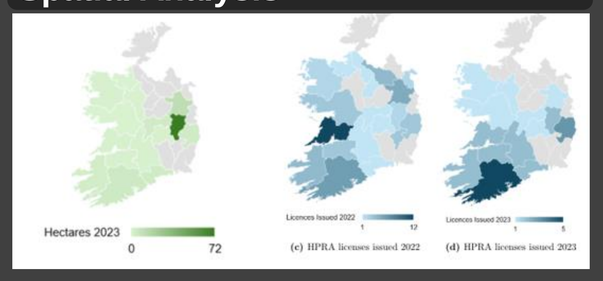
Table 2.4: System dynamics research in Ireland (continued)

Year	Research Area	Authors
2016	Introduction to SD	(Duggan, 2016a)
2016	How R can benefit system SD	(Duggan, 2016b)
2012	Observations shortest independent loop set algorithm	(Huang and J., 2012)
2008	SD & multiple objective optimisations for policy analysis	(Duggan, 2008b)
2008	Optimisation for agent-oriented SD models	(Duggan, 2008a)
2007	Cellular Automata with Systems Dynamics	(Leonard, 2007)
1999	Local models, blended multiple model structures	(Shorten et al., 1999)
System dynamics research in marketing		
2020	Systems and macro-social marketing	(Flaherty et al., 2020)
2020	Marketing systems a listen, learn, leverage framework	(Domegan et al., 2020)
2019	Social marketing theory Galway cycling system	(Brychkov, 2019)
2009	Advertising effectiveness and spillover	(Brady, 2009)
System dynamics research in economics		
2019	Integrated economy-demography	(Dural-Selcuk et al., 2019)
2019	Indicators before, during & after the 2007/08 recession	(Bahaddin et al., 2019)
System dynamics research in operations research		
2018	Policy incentives and the organic value chain in Ireland	(Cathal et al., 2018)
2017	Integrated retail supply chain risk management framework	(Crowe, 2017)
2015	Dynamic behaviour of three echelon retail supply chain disruptions	(Crowe et al., 2015)
2008	Centre of gravity positions automotive vehicles	(Solmaz et al., 2008)
2005	Growth and yield of conifer species in Ireland	(Purser et al., 2005)

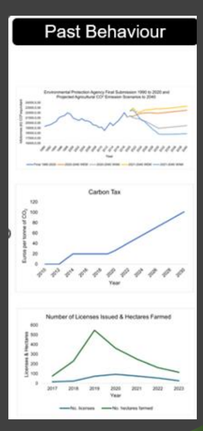
RQ3

Historically, how has hemp impacted land use & Agricultural C02 emissions?

Spatial Analysis



Trends



QUANT

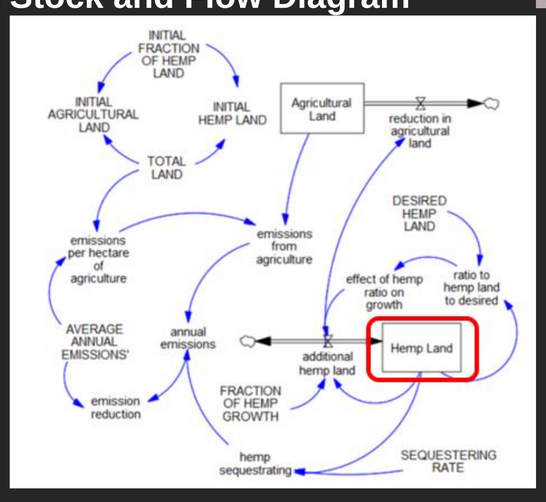
RQ4 (WIP)

How does hemp impact agricultural CO2 emissions?

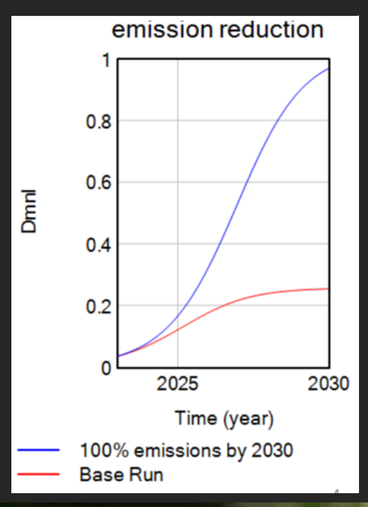
Variable Names & Units

Variable Name	Unit of measurement
Desired corporations goals	euros per year
History	papers published per year
Regulations	euros per year
Food	euros per year
Health	microgram per kilogram of body weight
Supply	euros per year
Environmental	tonnes of CO_2 per year
Subsidies	euros per year
Hemp research	papers published per year
Knowledge of crop	papers published per year
Profits	euros per year
Demand	euros per year
Sustainability	euros per year
Perception	% changes in regulations per year
Prohibition	% changes in regulations per year
Industry credibility	euros per year
Communication	broadcasts per year
Unsubstantiated claims	broadcasts per year
Policies	% changes in legislation per year
Economic competitiveness	euros per year

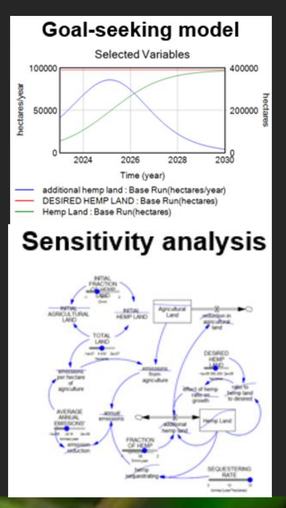
Stock and Flow Diagram



Runs to 2030 & 2050



Validation



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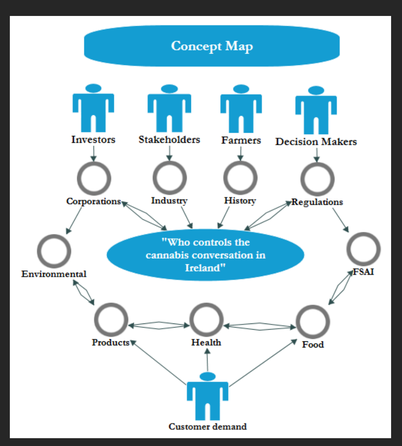
RQ5

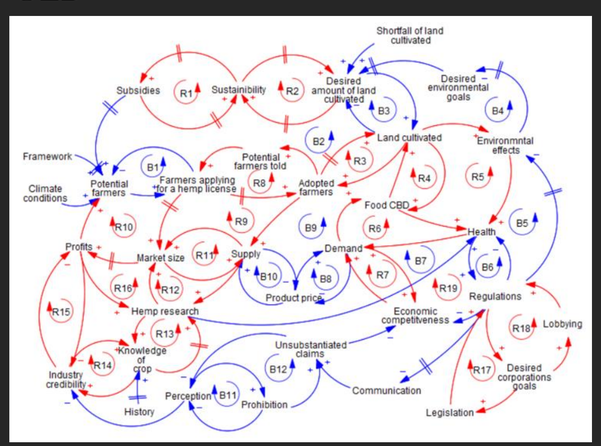
What drivers and barriers affect the industrial hemp market in Ireland?

Word Cloud

Concept Map



CLD



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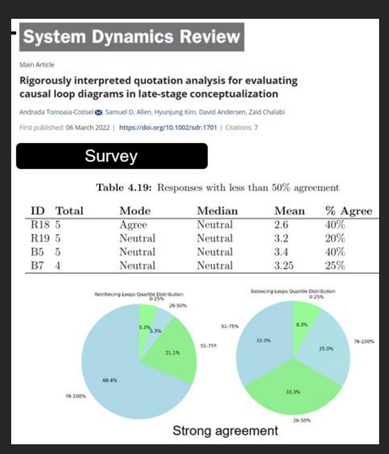
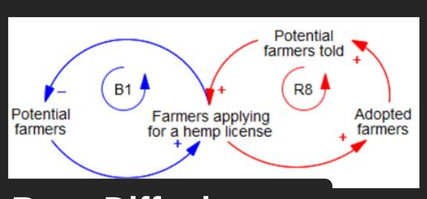


Future Work



Bass Diffusion

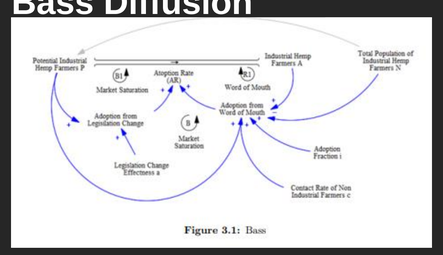


Figure 3.1: Bass

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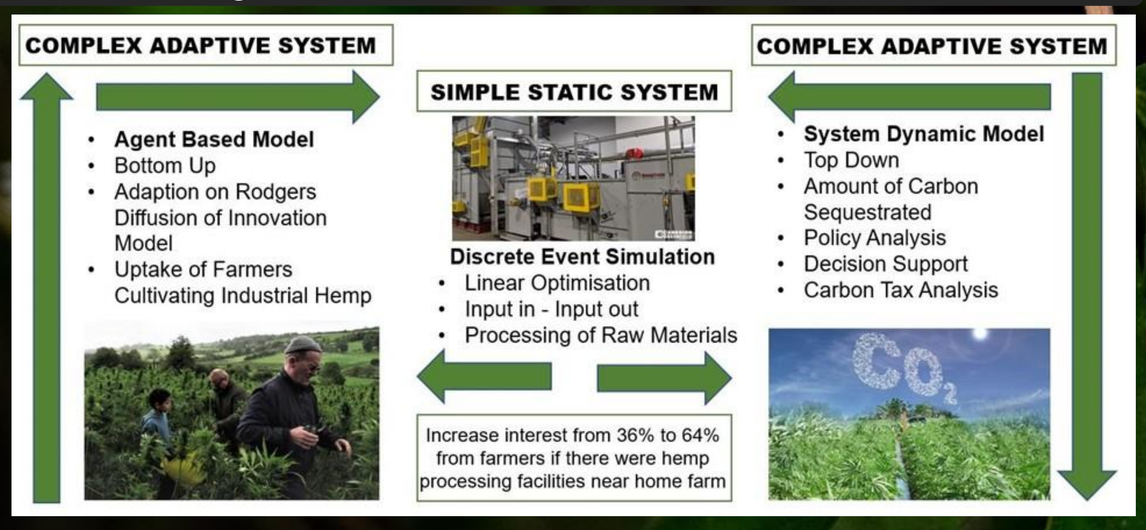
Multi-Modelling Framework



Publications relating to work

- Madden, S.M., Walsh, P. and Ryan, A., 1997. A State-of-the-Art Review: Ireland, a Model State?. Pat, 94, p.T9PX.
- Madden, S.M., Ryan, A. and Walsh, P., 2021. Exploratory study on modelling agricultural carbon emissions in Ireland. Agriculture, 12(1), p.34.
- Madden, S.M., Ryan, A. and Walsh, P., 2022. A Systems Thinking Approach Investigating the Estimated Environmental and Economic Benefits and Limitations of Industrial Hemp Cultivation in Ireland from 2017–2021. Sustainability, 14(7), p.4159.

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