THE CHEMICAL IDENTITY OF SCOTTISH HONEY

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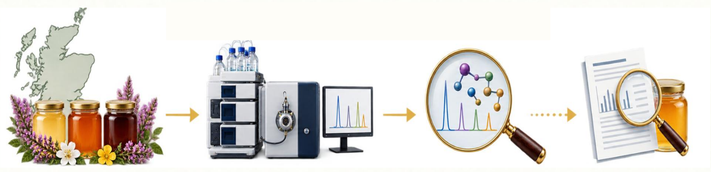
Protecting Scottish honey's authenticity starts with understanding its natural seasonal variation.

Introduction & Aim



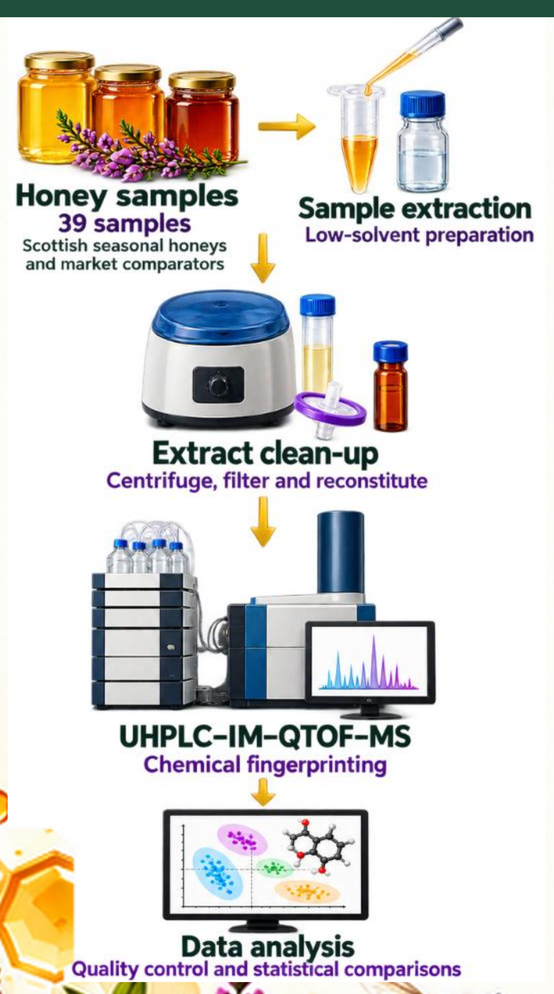
Floral sources, location and harvest season influence honey's chemical composition.

Mislabelled origin and undeclared additions can undermine consumer trust and disadvantage Scottish producers.



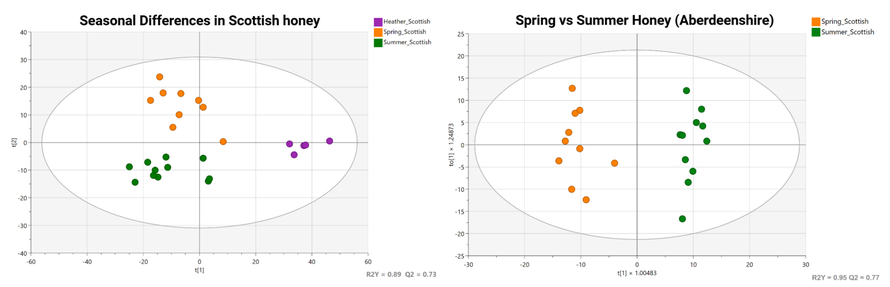
Characterise the chemical identity of Scottish honey using liquid chromatography mass spectrometry (LC-MS) to identify candidate chemical markers for future authenticity testing.

Methods

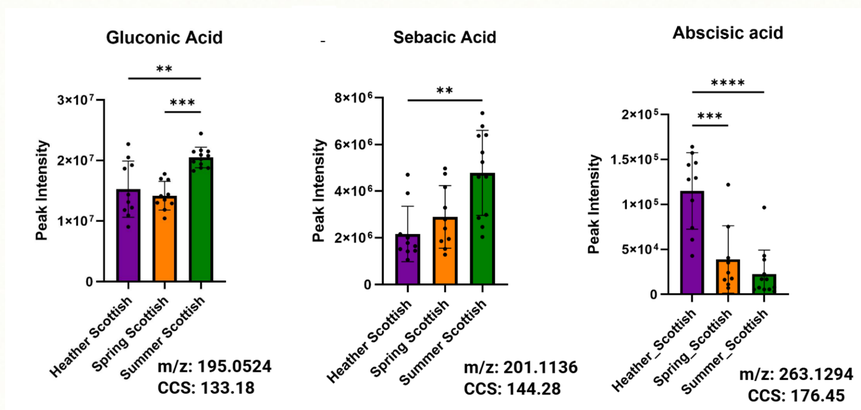


Results

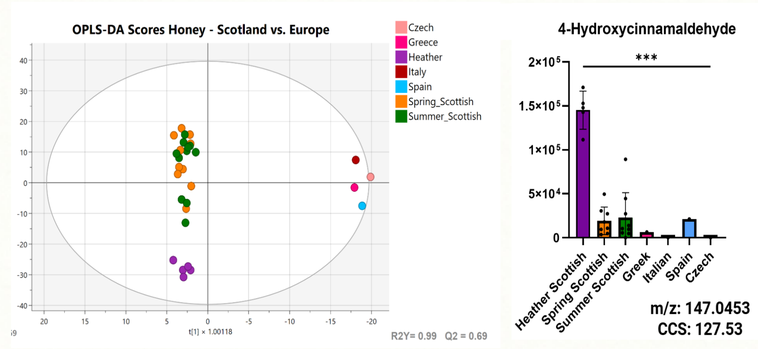
1. Seasonal fingerprints differ

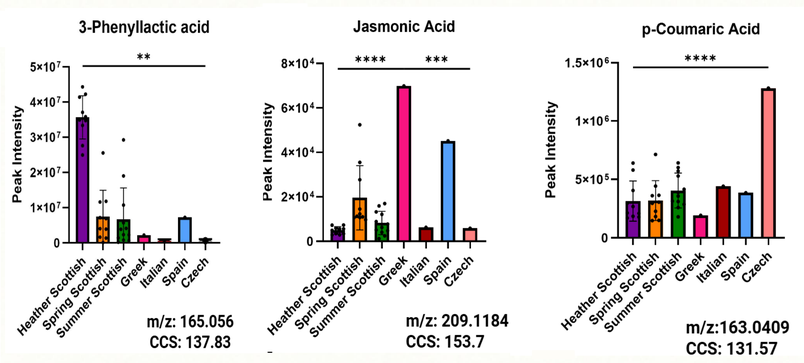


Spring and summer honeys from the same apiaries showed distinct chemical profiles.



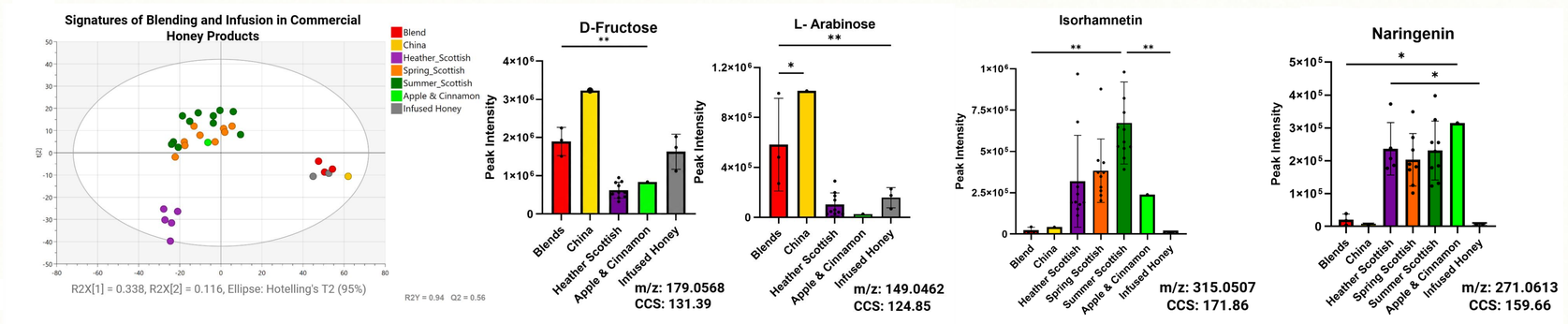
2. Scottish vs. European Honey





Scottish and European honeys showed different chemical profiles These preliminary differences require validation across more producers and regions.

3. Scottish vs. Blends and Infusions



Blended and infused products showed contrasting chemical profiles. These exploratory findings require broader validation.

Scottish Relevance

- **Inform evidence-based food authenticity policy**
- **Support government priorities for traceability and consumer protection**
- **Protect the identity and value of Scottish honey**
- **Strengthen collaboration between researchers, regulators and producers**

Conclusion

Scottish honeys showed distinct seasonal chemical fingerprints, including a characteristic heather profile. LC–MS profiling identified candidate markers that, following wider validation, could support authenticity testing and help protect Scottish honey's identity.

SCAN ME

Read the paper: Duft & Griffin, Food Chemistry (2026)

Acknowledgements

We thank the Aberdeen and District Beekeepers' Association (SCIO) for providing samples.

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A natural capital valuation toolkit for aiding participatory landscape scale decision-making

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Explore our toolkit guidance

toolkit guidance

Introduction

The project "Bringing in participatory approaches to widen the scope of Natural Capital Valuation" explores participatory methods for eliciting natural capital (NC) values. By integrating spatial, qualitative and participatory approaches this research supports NC valuation to:

- highlight governance adaptations for implementing Multi-Functional Forestry, internationally (Nijnik et al., 2026);
- facilitate decision-making processes at the local level.

In this poster we show how we contribute to practice by:

- Exploring values and why they are important;
- Defining a valuation toolkit to inform local decision making.

We tested a valuation *toolkit* (Martino et al., 2025), and published a *toolkit guidance (*Poskitt et al., 2026), to elicit intrinsic, relational and instrumental values (Himes et al., 2024) and facilitate collaboration between stakeholders in finding solutions that minimize conflicts in land use management. During the pilot test carried out at Glensaugh farm with Hutton farmers, local anglers, Scottish Woodlands, NaureScot and the Scottish Government, we implemented:

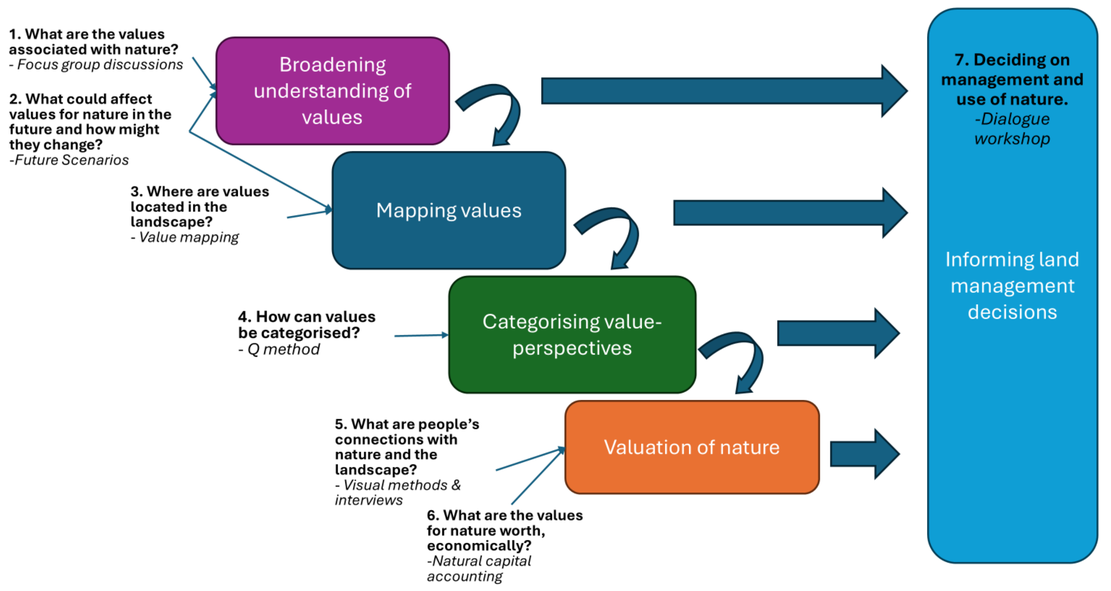
1. participatory GIS mapping;
2. Scenario-based discussions;
3. Q method;
4. Photo-choice & interviews;
5. Natural capital accounting;

Finally, through an interactive event to which we invited the Aberdeen Council, the Scottish Government, Scottish Woodlands, Nature Scot, land managers, and NGOs, we showed how the identified NC values could be used to define farm management strategies that support those NC values deemed to be priorities.

Acknowledgements
This research is supported by the SRP 2022-2027, RESAS project JHI-D5-1 *Bringing in participatory approaches to widen the scope of natural capital valuation*.

References
Himes, A. et al. (2024). Why nature matters: A systematic review of intrinsic, instrumental, and relational values. *BioScience,* biad109. https://academic.oup.com/bioscience/article/74/1/25/7499505
Martino et al (2025). A toolkit supporting the participatory natural capital valuation framework. Deliverable D2.2 project JHI-D5-1 "Bringing in participatory approaches to widen the scope of Natural Capital Valuation". doi: 10.5281/zenodo.18629949 .
Nijnik et al (2026). A mixed methods approach to better understand and steer multifunctional forestry in mountain regions of Europe. Forest Policy and Economics, 190, p.103859.
Poskitt et al. (2026). Using the Natural Capital Valuation Toolkit: A Practice Guide for land managers for gathering holistic, on-the ground values. doi. 10.5281/zenodo.21351513.

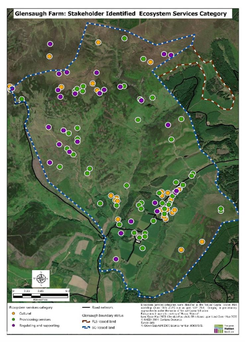
Methods



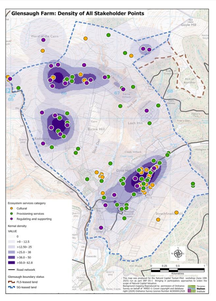
A cascade of methods is proposed in the toolkit guidance to answer several questions related to NC values and to elicit and assign intrinsic, instrumental, and relational values to NC assets under the current and future scenarios.

The proposed methods can be used in a combined approach or individually depending on need.

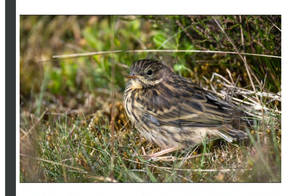
Results



Map of points representing values as ecosystem services



Cultural and relational values emerging from photo-choice and interviews



'It's those, it's those little unexpected encounters that are kind of just little, little moments of, of joy... The beginning of my research career was...working with birds... And so, yeah, so I guess I've got. There's always a little, kind of, particular soft-spot in my heart for, for little juvenile birds'

'It just makes us feel a little bit nostalgic, thinking back into... Members that we've lost, they, actually, the table that we've got there, out there, just at the centre there... over the years, we now have probably about six or seven plaques on there of members that have passed away and just so, [it's a] memorial to them as well.'



Valuation approaches implemented at Glensaugh farm elicited benefits in terms of ecosystem services using participatory GIS, described relational aspects with nature (photo-choice & interviews), and categorised NC values (Q method) to discuss and rank preferred farm management strategies

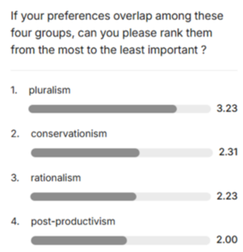
CONSERVATIONISM

1. Improve woodlands.
2. Diversify tree species against climate risk
3. Farm production is not the most important reason for managing NC.
4. Develop community wellbeing.

RATIONALISM

1. Production planned in terms of climate change (CC) impacts.
2. NC may generate income to protect it against CC.
3. Collaboration between investors and land mangers
4. NC support wellbeing

Natural Capital views emerging from Q analysis



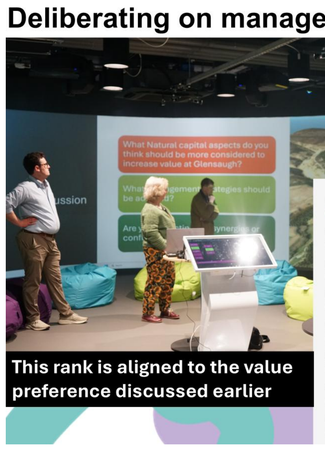
PLURALISM

1. Consider plural values of NC, beyond economic benefits.
2. Connecting with nature: sense of closeness with heritage
3. NC support wellbeing

POST-PRODUCTIVISM

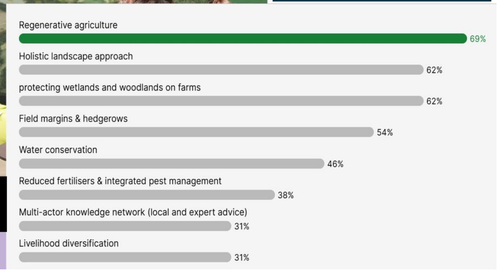
1. Profitability of timber and food but not at the expenses of environmental services.
2. No focus on relational values but on physical and mental wellbeing
3. Decisions mainly driven by experts

Deliberating on management preferences



This rank is aligned to the value preference discussed earlier

Regenerative agriculture is a holistic farming approach that rehabilitates ecosystems by focusing on soil health, biodiversity, and water management.



Outcomes

- Methods and tools for engagement and facilitation are considered by stakeholders to:
  - Improve consultation and conflict resolution in land use decisions
  - Define values informing NC policies
- Tools are expected to support **Local Authorities, NGOs, NC Community Partnerships, estate managers, RLUPs, policy makers,** in making decisions about management of natural capital.

Next steps

- Test the approach in different estates and rural contexts
  - Multiple scales of implementation
- Improve the toolkit guidance
  - Advise on support for analysis
  - Suggest templates to support presentation of results

JHI-B1-6: Monitoring the environmental impact of controlled environment agriculture

Frances Sandison[1], Martina Pičmanová [2], Gordon McDougall[2], Nick Bennett[3], Derek Stewart[2]

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The Background

Food supply chains contribute approximately 30% of global greenhouse gas emissions (Crippa *et al.* 2021), making decarbonisation a priority. Vertical farming enables year-round production under controlled conditions, but its carbon footprint depends strongly on energy use and electricity source.

Understanding both environmental performance and crop characteristics can help growers meet commercial requirements while reducing emissions. This study assessed the carbon footprint and volatile profiles of four basil varieties grown in a Scottish vertical farm, providing evidence to inform electricity sourcing and variety selection.

The Research



Figure 1: Basil grown in vertical farm

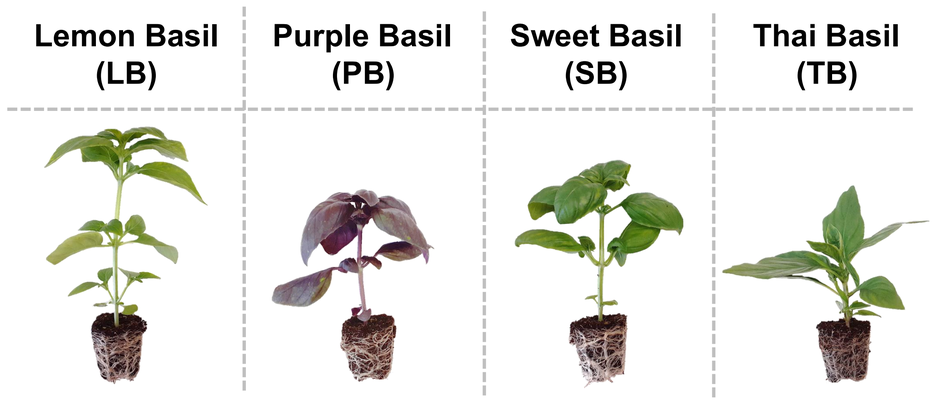
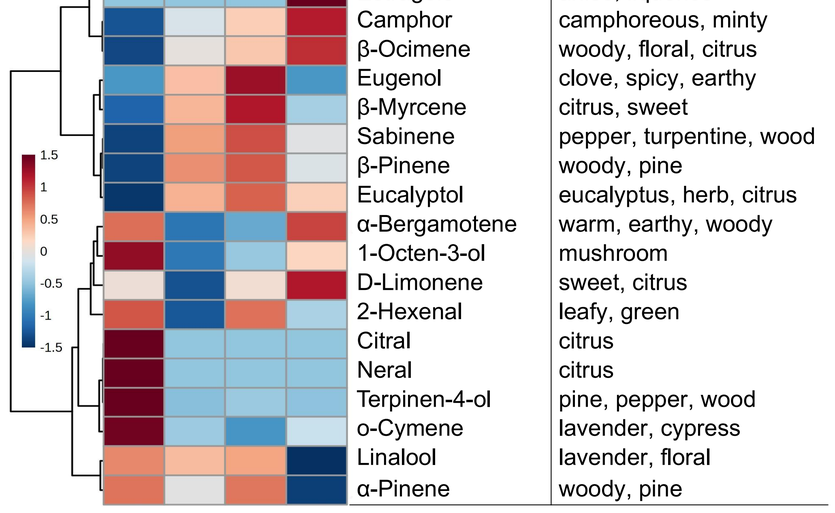


Figure 2: Varieties of basil explored in study

Methods

Lemon (LB), purple (PB), sweet (SB) and Thai basil (TB) were grown under controlled conditions in a vertical farm (Figures 1–2). Production inputs were recorded within the system boundary shown in Figure 3.

Life cycle assessment (LCA), conducted using SimaPro 9.6.0.1, quantified the carbon footprint (CF) of producing 1 kg of basil, identified emission hotspots and compared electricity-source scenarios. Volatile compounds were analysed using SPME-GC-MS to characterise variety-specific aroma profiles.



Volatile	Odour
Methyleugenol	clove, spicy, earthy
Estragole	anise, liquorice
Camphor	camphoreous, minty
β-Ocimene	woody, floral, citrus
Eugenol	clove, spicy, earthy
β-Myrcene	citrus, sweet
Sabinene	pepper, turpentine, wood
β-Pinene	woody, pine
Eucalyptol	eucalyptus, herb, citrus
α-Bergamotene	warm, earthy, woody
1-Octen-3-ol	mushroom
D-Limonene	sweet, citrus
2-Hexenal	leafy, green
Citral	citrus
Neral	citrus
Terpinen-4-ol	pine, pepper, wood
o-Cymene	lavender, cypress
Linalool	lavender, floral
α-Pinene	woody, pine

Figure 6: Heatmap and description table of volatiles associated with each basil variety

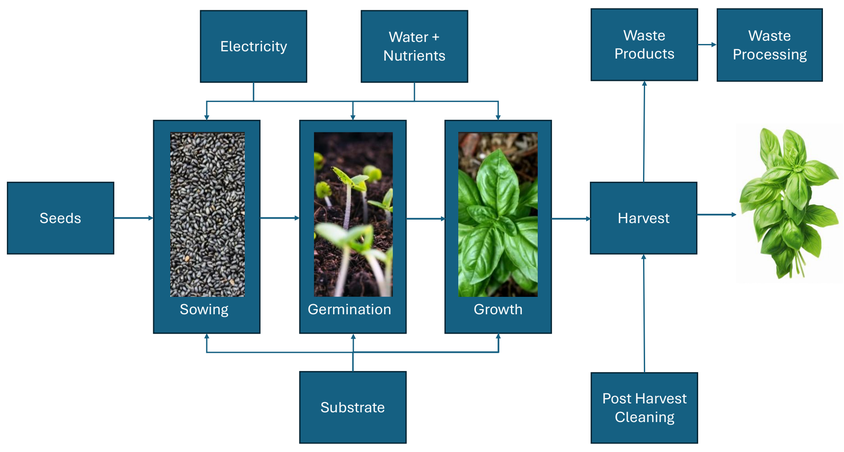


Figure 3: LCA boundaries used in study

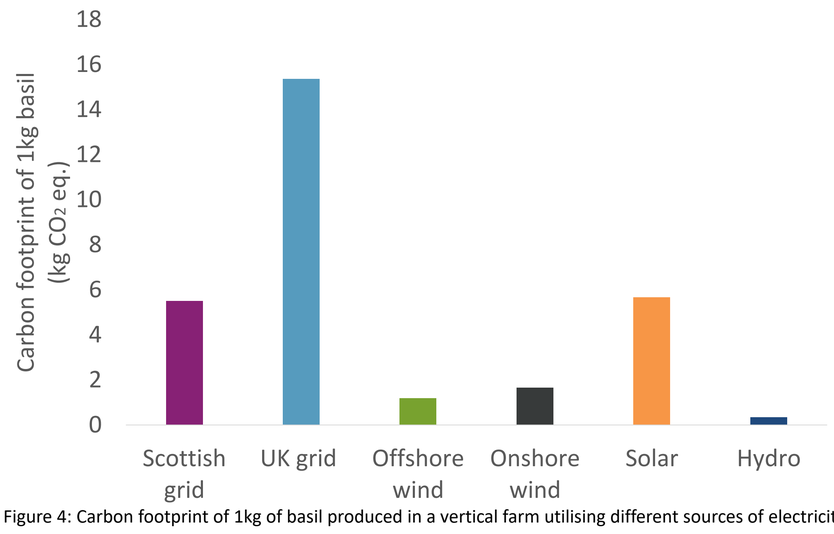


Figure 4: Carbon footprint of 1kg of basil produced in a vertical farm utilising different sources of electricity

Basil Aroma Profile Results

Volatile profiles differed between varieties (Figure 6). Lemon basil was characterised by citral-related compounds associated with citrus aromas, alongside linalool (floral/lavender). Sweet and purple basil showed profiles characterised by eucalyptol (eucalyptus) and linalool, while Thai basil contained a high proportion of phenylpropanoids, particularly estragole (anise).

These differences offer opportunities for growers and buyers to select varieties for specific aroma requirements.

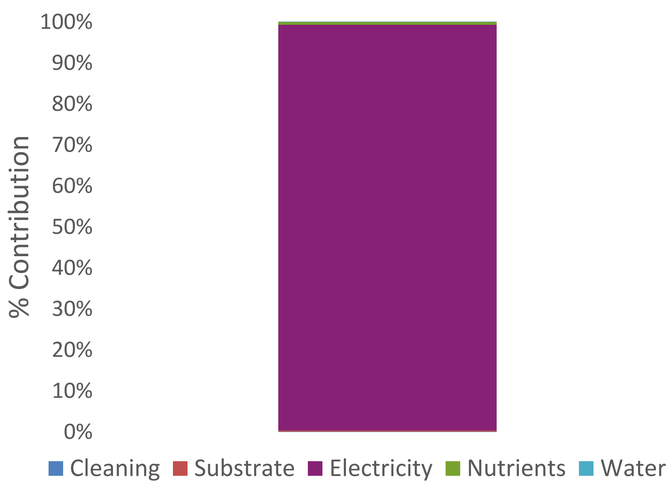


Figure 5: Hotspot analysis of 1 kg of basil produced in a vertical farm in Scotland

Electricity and Carbon Footprint Results

Electricity accounted for approximately 99% of the modelled CF using Scottish grid electricity (Figure 5), identifying it as the principal target for emissions reduction.

The modelled CF was 5.49 kg CO_2eq. per kg of basil using Scottish grid electricity, compared with 15.37 kg CO_2eq. using the UK grid mix (Figure 4). This difference reflects the higher proportion of low-carbon electricity in the Scottish mix at 90% to 65% for the UK as a whole, and 63% for England (DESNZ, 2025). See Table 1 for electricity CF comparisons. This highlights the importance of geographically appropriate electricity data in LCA.

All renewable electricity scenarios assessed had lower footprints than the UK grid scenario. Most also improved on the Scottish grid scenario, while solar produced a comparable footprint. Hydroelectricity gave the lowest modelled CF at 0.35 kg CO_2eq. per kg of basil, followed by offshore wind at 1.19 kg CO_2eq.

Table 1: Carbon footprint of 1kWh of electricity produced by selected methods

Impact category	UK 2025	Scotland 2025	Oil	Gas	Nuclear	Hydro	Onshore Wind	Offshore Wind	Solar
Carbon Footprint	0.225	0.080	1.415	0.544	0.007	0.004	0.023	0.017	0.083

References

Crippa, M., Solazzo, E., Guizzardi, D. *et al.* (2021) Food systems are responsible for a third of global anthropogenic GHG emissions. *Nat Food* **2**, 198–209. https://doi.org/10.1038/s43016-021-00225-9

DESNZ (2025) Electricity generation and supply in Scotland, Wales, Norther Ireland and England 2004-2024 – data tables. Published 18/12/2025 Accessed 25/10/2026. Available at: Energy Trends: December 2025, special feature article - Electricity generation and supply in Scotland, Wales, Northern Ireland and England, 2020 to 2024 - GOV.UK

The Outcomes

- This research can support vertical farmers and farm developers in making informed electricity-sourcing decisions to reduce production carbon footprints. The volatile analysis can also help growers and commercial herb buyers select varieties suited to specific product requirements.
- Together, these findings inform the development of lower-carbon, year-round food production, relevant to wider efforts to strengthen food security. They highlight the importance of considering electricity supply alongside crop selection when developing vertical farming systems that meet both environmental and commercial objectives.

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SEFARI

Towards a digital twin of Scottish Agriculture

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The James Hutton Institute

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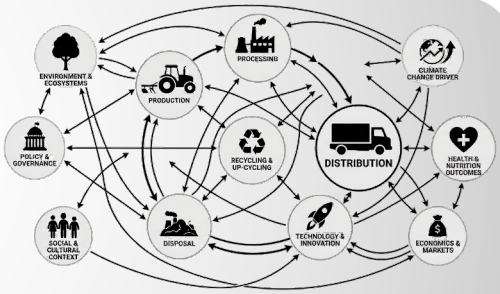
Introduction

The Scottish food system is a complex mix of the environment, economy, and society. These interactions create feedback and cascading effects that cannot be readily understood from isolated instances of disruption or perturbation.

Policymakers require tools capable of evaluating how interventions affect complex systems. One such tool could be a digital twin.

We are working with RESAS to define and explore agricultural policy scenario.



Real inputs

Farms are already scrutinised with detailed census data on what they have and produce, farm budgeting tools for inputs and outputs, and life-cycle analyses of emissions.
There is also good data on climate and environmental drivers of production.



Modelling

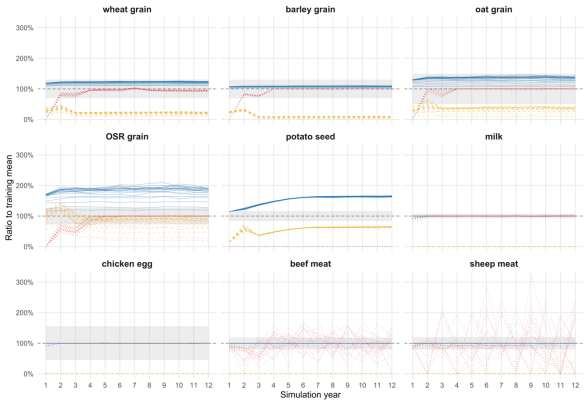
The STRAVVS model represents agriculture as a dynamic metabolic network that captures key features – inputs, movement along value chains, processing and production. It places farms in space and includes constraints on when and where things can happen.



Towards a digital twin

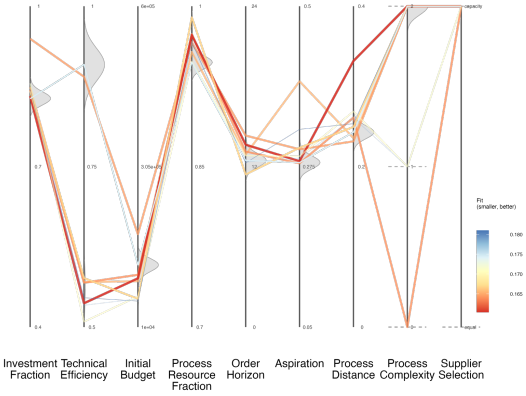
We are testing scenarios around subsidy reform, novel production methods, climate change and trade disruptions.
With live data updates, a digital twin could inform and update interventions in real time.





LEFT
Selected modeled goods (Ordered, Produced, Imported) were compared to the annual Economic Report for Scottish Agriculture (---- 5y mean ±95% prediction interval).

RIGHT
Distribution of parameter values that best describe observed economic data. Lines show the best matching model runs



Conclusions

By integrating farm-level economic budgets, supply chain relationships and bio-climatic land capability we have set out a pathway to developing a realistic simulation tool that can explore *what if?* questions, assessing resilience, adaptation and future policy scenarios.

STRAVVS can represent the production and supply of goods. By changing inputs, it can support policy analysis of agricultural transitions, resilience and food security from individual farm decision-making through to impacts for consumers.

Acknowledgements
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Supporting the resilience of Private Water Supplies in Scotland

Emerging Water Futures

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Introduction

In Scotland, while Scottish Water provides water to most people, **around 3.5% of the population** depend on small decentralised supplies serving single dwellings or small communities and are managed by their owners and users. These are known as "private water supplies" (PWS).

There are **more than 23,000 PWS across Scotland**, particularly in rural areas.

Rural drinking water is significantly impacted by the emerging threats to Scotland's water resources that are posed by pollution and contamination and climate change impacts. Users and managers of PWS must contend with the increasing regularity of low flow conditions and drought, health and social impacts of poor drinking water quality. Although these impacts play out across multiple scales, rural households dependent on PWS experience these challenges in very material ways and often find themselves tasked with developing coping strategies and innovating in the face of growing uncertainty.

The project 'Emerging Water Futures' has looked into rural PWS as an appropriate case study for examining vulnerability to water insecurity (water shortages and water quality issues in particular) and options to support increasing their resilience.

In addition to enhancing the understanding of PWS water insecurity, building on evidence from users and stakeholders we have developed two outputs oriented to support changes that might support resilience:

1. stakeholder recommendations for policy and organisational improvements;
2. an accessible guide to PWS management from source to tap, covering water quality, scarcity, maintenance and affordability.

Methods

This research builds on the integration and triangulation of social science insights about PWS in Scotland gathered during the last 4 years of research. The outputs presented in this poster were particularly informed by evidence on PWS users' practice and information needs and gaps collected in interviews with PWS users and a series of participatory workshops with users and stakeholders.

Evidence Review 2022-2023 → Survey of PWS Users 2023-2024 → In-Depth Interviews with PWS Users 2024-2025 → Participatory Workshops with Stakeholders 2025

PWS Issues

PWS households face growing challenges:

- **Water scarcity** due to climate change, drought and land use change. Resilience can be improved with better technical responses, user knowledge and capacity, and financial support.
- **Water quality** issues, influenced by inadequate set-ups, land use, and PWS management practices (lack of testing, treatment, maintenance). Resilience may be built by stopping contamination at source, via maintenance and PWS upgrades.
- **Lack of reliability** (e.g. due to **leaks or power cuts)** is more likely in surface supplies and older systems. Prompt repairs, maintenance and back up equipment can build resilience.
- **Affordability**, as **high costs** can be a barrier to testing, to maintenance and upgrading systems, and funding options are limited.

Key Findings

- There is **no unique model of PWS water insecurity.** The vulnerability of PWS features multiple interacting dimensions.
- **Upgrading PWS** seems to hold the key to PWS resilience but is costly.
- **Governance of PWS** is not always straightforward, impacting management and maintenance.
- PWS management also depends on **risk-perceptions** linked to users' experience, beliefs & knowledge.
- **Capacity-building** about PWS is critical for improving management & decision-making over PWS.
- **Local Authorities** are the **key players** supporting PWS effectiveness but their **double-edged role**, and **resource constraints**, hinder their effectiveness.

1. Stakeholder Recommendations for Supporting PWS Resilience

We held a series of participatory workshops with PWS users and stakeholders (including Local Authorities, DWQR, SEPA, Consumer Scotland and service providers), with special attention paid to diverse situations in the South-West and North-East of Scotland. The aim of the workshops was to collect information on support needed to increase the resilience of PWS and consider how to make this support possible. The support strategies emerging from the evidence outline clear, practical, and potentially high impact policy related actions for Scottish Government to consider. The table below summarises the strategies identified and aspects that should be considered along their design.

Strategy or Measure	Benefits	Challenges and Considerations
Establish a National PWS Coordinating Body	• Central point of contact (coherent messaging). • Alignment of policy implementation. • Consistent delivery of PWS support. • Supports transparency, trust, strategic planning.	• Requires resourcing and capacity to adapt & careful coordination across Government. • May duplicate existing roles. • Risk of poor implementation.
Create an online PWS Info Repository for Scotland	• Users / stakeholders directed to a single, easily accessible, coherent source of info / advice.	• Requires body responsible for oversight. • Requires agreement on what to include. • Digital-only formats may exclude some users.
Improve users' knowledge of PWS	• Useful info on practice / responsibilities/ advice / sources of financial support. • Improves behaviour, (i.e. system maintenance). • Reduces long-term risk / emergency interventions. • Reaches both current and future generations. • Cultural change re water use / resilience.	• Behaviour change can be slow and uneven. • Requires ongoing investment in communication. • Effectiveness depends on message format and clarity, delivery channels, trust in info provider. • Will not capture every detail. • Associated costs.
Accreditation scheme for PWS service contractors	• Improves quality / reliability of installations / servicing. • Identifies accountable / trusted professionals. • Workforce development / pro standards. • Reduces risk of poor-quality / unsafe work.	• Requires regulatory framework / oversight body. • Requires training programme / provider. • May increase costs for users. • May temporarily reduce pool of contractors. • Research needed to establish costs / benefits.
Expand financial support	• Improves safety / reliability, supports public health. • Helps vulnerable / low-income households. • Encourages proactive upgrades. • Supports climate adaptation / resilience.	• May require significant public investment. • Risk of uneven uptake if not well-targeted. • May create grant dependency. • Cost to other taxpayers (already paying water rates).
Clarify legal position of PWS in relation to land-use change & development planning	• Enables better risk assessment / development planning. • Supports climate modelling / drought preparedness. • Helps identify high-risk or vulnerable supplies. • Improves transparency for buyers / planners.	• Mapping PWS may face resistance from landowners. • Requires regular updates to remain accurate. • Data-sharing must be carefully managed.
Enhance support for water scarcity	• Consistent with other Scottish Government climate change adaptation initiatives. • Encourages sustainable water use.	• PWS sources differ re. risks to water scarcity. • Not all properties can accommodate water storage alternatives.
Transforming PWS	• Knowledge of PWS infrastructure locations will help stakeholders make better decisions. • Affordable technology may improve reliability, effectiveness, ease of managing PWS.	• Availability of affordable and useful technology. • Variable uptake by users. • Establish availability of funding to cover costs.
Facilitate establishment of PWS stakeholder support network	• Offers PWS users collective agency. • PWS community gain visibility. • Builds trust / facilitates learning / innovation.	• Logistics difficult in rural locations. • Who would lead at regional and national levels?

Table 1 Summary of stakeholders' recommendations for enhancing the resilience of PWS.

2. Guidance for PWS users

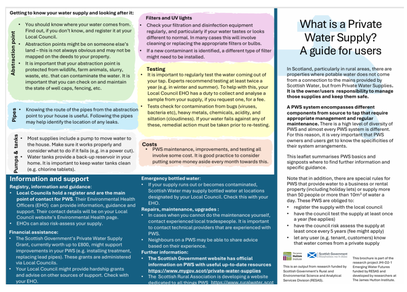

Figure 1 Snapshot of the side of the leaflet containing basic information for PWS users.

Stakeholders had long identified the need for improving PWS users' knowledge about PWS practice as an important enabler for resilience (Ash 2023, Geris et al. 2024, Valero et al. forthcoming). We developed a leaflet aimed to contribute to such capacity building (*Figs. 1 & 2*). Building on evidence collected on users' and stakeholder's experiences, the guide explains basics about PWS maintenance and signpost where users could access further resources.

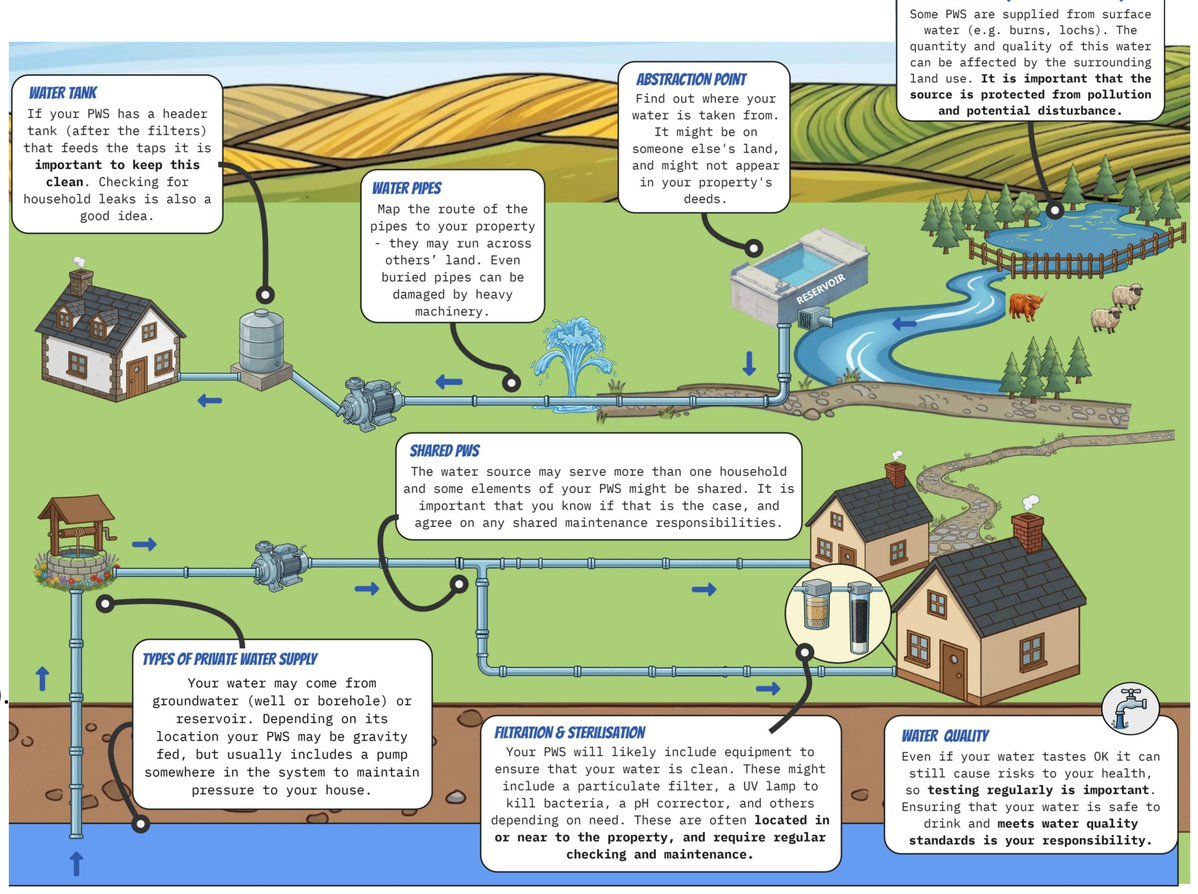

Figure 2 Detail of the infographic included in the leaflet describing components of PWS systems and signposting users to basic maintenance aspects.

Acknowledgements

Special thanks go to all PWS users and stakeholders who participated in the different stages of this research. This research is funded by the Rural and Environment Science and Analytical Services Division of the Scottish Government through the Strategic Research Programme 2022-2027, as part of project JHI-D2-1 Emerging Water Futures.

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More information and materials:

https://www.hutton.ac.uk/PWS

Drought risk modelling and forecasting framework to inform the implementation of the National Water Scarcity Policy Plan in Scotland



Stevenson[1], J.L., Schurch[2], N., Adams[1], K., Gagkas[1], Z., Jabloun, M[1]., Naha, S[3]., Frantsuzova, A.[2], & Glendell, M[1].

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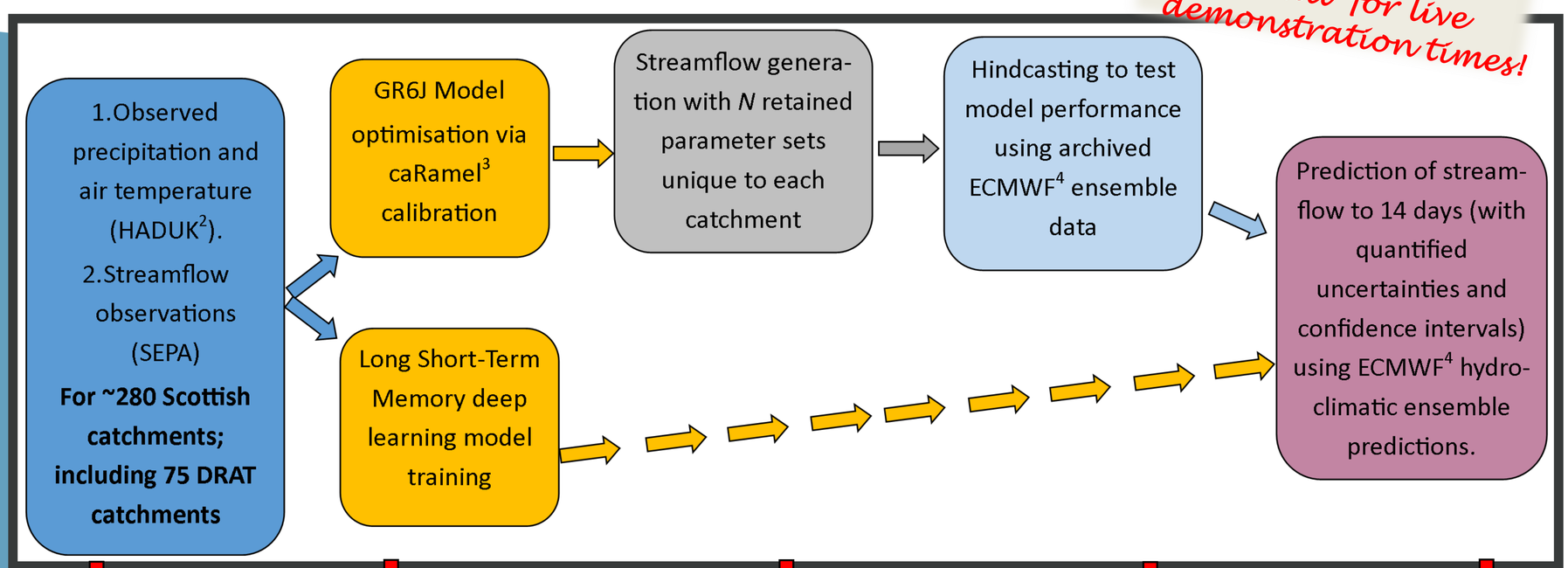
Email for live demonstration times!

Introduction

By 2050 droughts may almost double in parts of Scotland[1], impacting a range of water users. Here, we showcase tools to inform future adaptation responses over both the short- and long-term:

- An open-source R package (*wscall*) which combines a multi-window rolling average smoothing approach with a history-matching framework and a lumped process based hydrological model (GR6J) to predict streamflows to 14 days in near-real-time.
- A probabilistic catchment-scale water resources decision-support tool to evaluate drought risk to 2050.
- Collectively, these help inform water resource planning by SEPA.



R Package wscall: Probabilistic modelling of Scottish drought periods.

- *Water resource decision support tool for SEPA.*
- Coupled machine learning and process-based modelling.
- Focussed on low-flow predictions.
- User friendly, with automatic daily .pdf summary generation.
- Demonstrates impact of different statistical smoothing approaches in determining start & end of water scarcity periods.

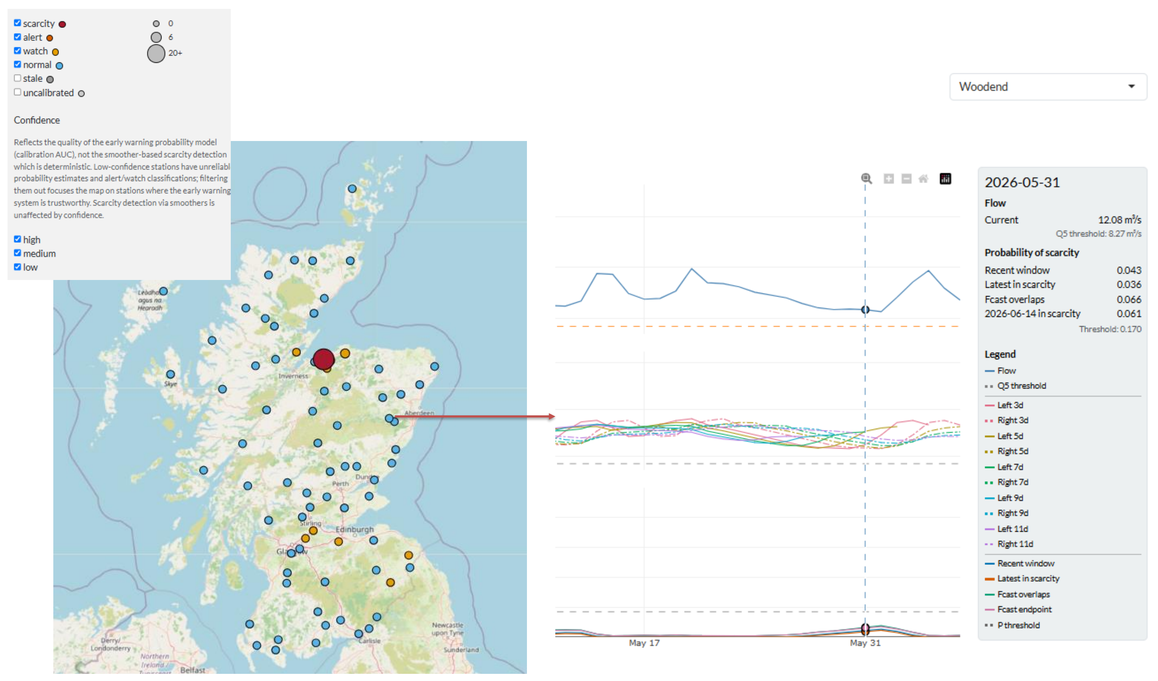


Figure 1 *wscall* user interface showing the home page for catchment filtering (left) and multi-timescale smoothing for the River Dee (Woodend; right).

Probabilistic catchment scale water resources management decision-support tool.

- Leverages meteorological, hydrological, agricultural and socioeconomic indicators of drought across future scenarios to understand sectoral vulnerabilities.
- Investigates adaptation measures to support decision-making.

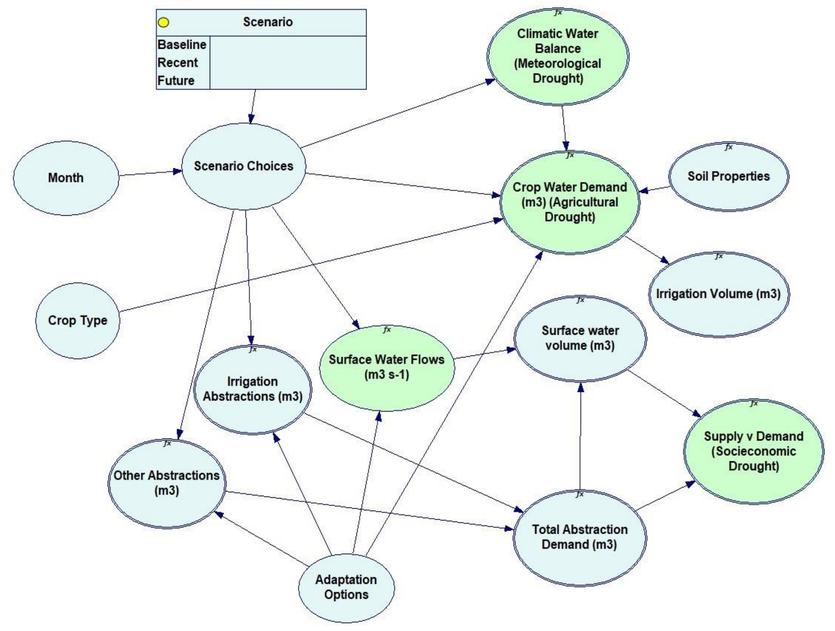


Figure 2 Schematic of catchment-scale water resources decision-making support tool.

Outlook:

- **Inclusion of semi-distributed process-based model (HYPE) into *wscall*, so directly accounting for catchment characteristics in streamflow simulations.**
- **Upscaling of Bayesian network-based decision support tool for water resources management to catchments across Scotland.**

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1. Naha *et al.* (2025). https://dx.doi.org/10.2139/ssrn.5214283
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From Co-production to Practice: Embedding Dietary Behaviour Change Support within Social Prescribing

RESAS
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The Rowett Institute

Oana Petre [1], Julia Allan[2], Leone Craig[1], Flora Douglas[3], Janet Kyle[1], Abigail Stephen [1], Frank Thies [1]

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Background

- Diet-related ill health disproportionately affects low-income communities in Scotland, where practical, emotional, and systemic barriers limit engagement with conventional dietary interventions.
- Social prescribing is a person-centred approach that connects people, through Link Practitioners (LPs) in primary care, with non-clinical community services that address the wider determinants of health and wellbeing.
- By building trusted relationships and creating space for meaningful conversations, LPs are well-placed to support dietary behaviour change in ways conventional services cannot.
- Despite this potential, dietary support remains underdeveloped within routine social prescribing, highlighting the need for practical, evidence-informed interventions.

Aim

SPICE
Social Prescribing for Improving Communities Eating practices

To translate behavioural and nutrition evidence into practical, person-centred dietary support that fits routine social prescribing practice.

Methods

- Participatory co-production involving 16 semi-structured interviews, two co-design workshops (n = 11; n = 9), and consultation discussions with senior LPs and service leads. Thematic analysis informed iterative co-design and intervention development.

Overview of the SPICE intervention



National Link Practitioner Workshop

Scottish Community Link Worker Network Annual Conference, Edinburgh, September 2026

18 practitioners explored the MAP-informed SPICE tool and how it could be adapted in their own settings.



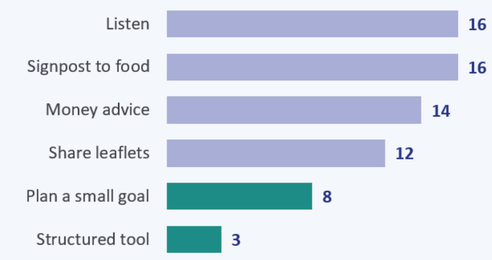
17/18
have food and eating conversations sometimes or often

1. Practice before the workshop

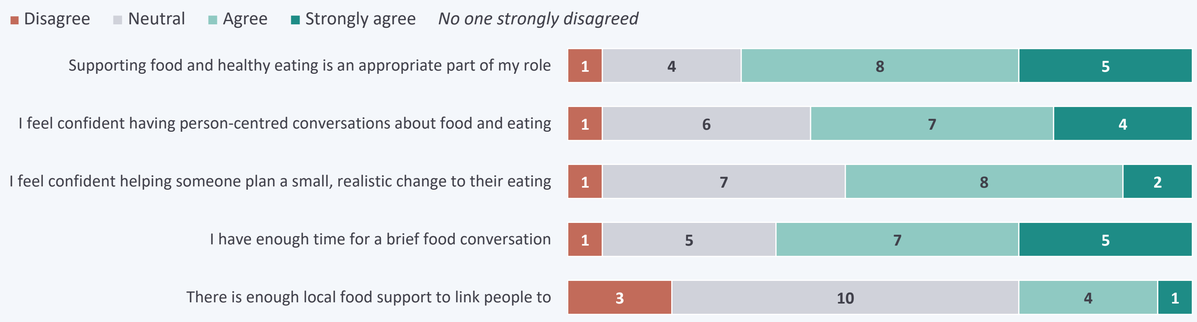
Food came up alongside

14/18	benefits, debt or fuel costs
13/18	low mood, grief or appetite changes
13/18	a long-term health condition

How they respond



Readiness *(n = 18)*



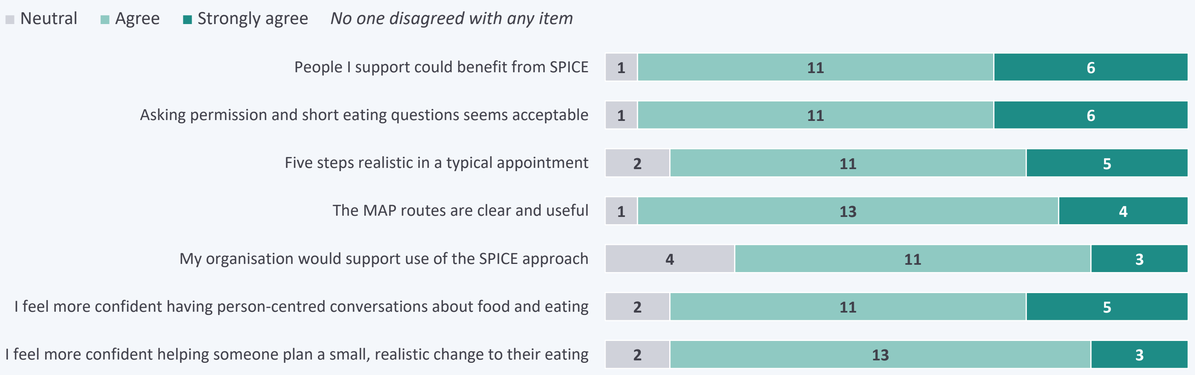
2. Views about SPICE

18/18
SPICE could fit their practice
(13 as is, 5 with changes)

13/18
likely to use SPICE in the next 3 months

Most requested supports
Short training session (13/15)
One-page quick guide (7/15)
Local food directory (5/15)

First impressions of SPICE *(n = 18)*



Impact & Ongoing Work

- A practical, MAP-informed intervention built on LPs' existing skills.
- Feasibility and acceptability testing is underway in Aberdeen Links.
- Feedback from practitioners and clients will guide refinement and scale-up.

Acknowledgements

- This work is funded by RESAS (Rural and Environmental Science and Analytical Services) of the Scottish government. Work is carried out in collaboration with the local authority and third sector partners.

Scottish Government Riaghaltas na h-Alba
SPICE Social Prescribing for Improving Communities Eating practices
ROBERT GORDON UNIVERSITY ABERDEEN
UNIVERSITY of STIRLING
Aberdeen Links Connecting local communities
Aberdeen City Health & Social Care Partnership A caring partnership

A food swap tool to improve diet quality

Zhou Fang, Bram Boskamp, Graham Horgan
Biomathematics & Statistics Scotland

Scottish Government
Riaghaltas na h-Alba

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BioSS

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- Most of us consume diets which don't meet all the **recommendations** for health. **Targets** for fibre, sugar, saturated fat and sodium in particular are missed by a large proportion of adults. Eating less meat may also reduce the environmental impact of food production.

- In collaboration with scientists at the Rowett Institute we have developed an **online tool** which takes **diet records** entered by participants and suggests personalised food changes that will improve their diet.

- The tool uses a large database of food item compositions, and linear programming methods to find **optimal changes**. Participants can **interact** with the software, accepting or rejecting the suggestions until a set of better diet choices is found. Environmental impact and cost can also be accounted for.

- **A trial** currently being conducted at the Rowett Institute will test how well volunteers are able to follow the diet improvements which are suggested to them by this tool.



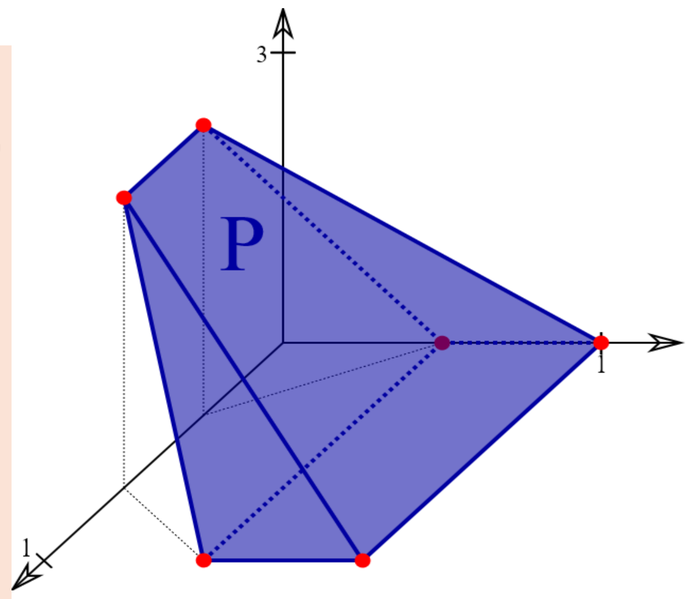


The mathematics of diet modelling

There are many aspects to diet: ● energy, ● protein, ● macronutrients, ● micronutrients, ● environmental impact, ● cost.

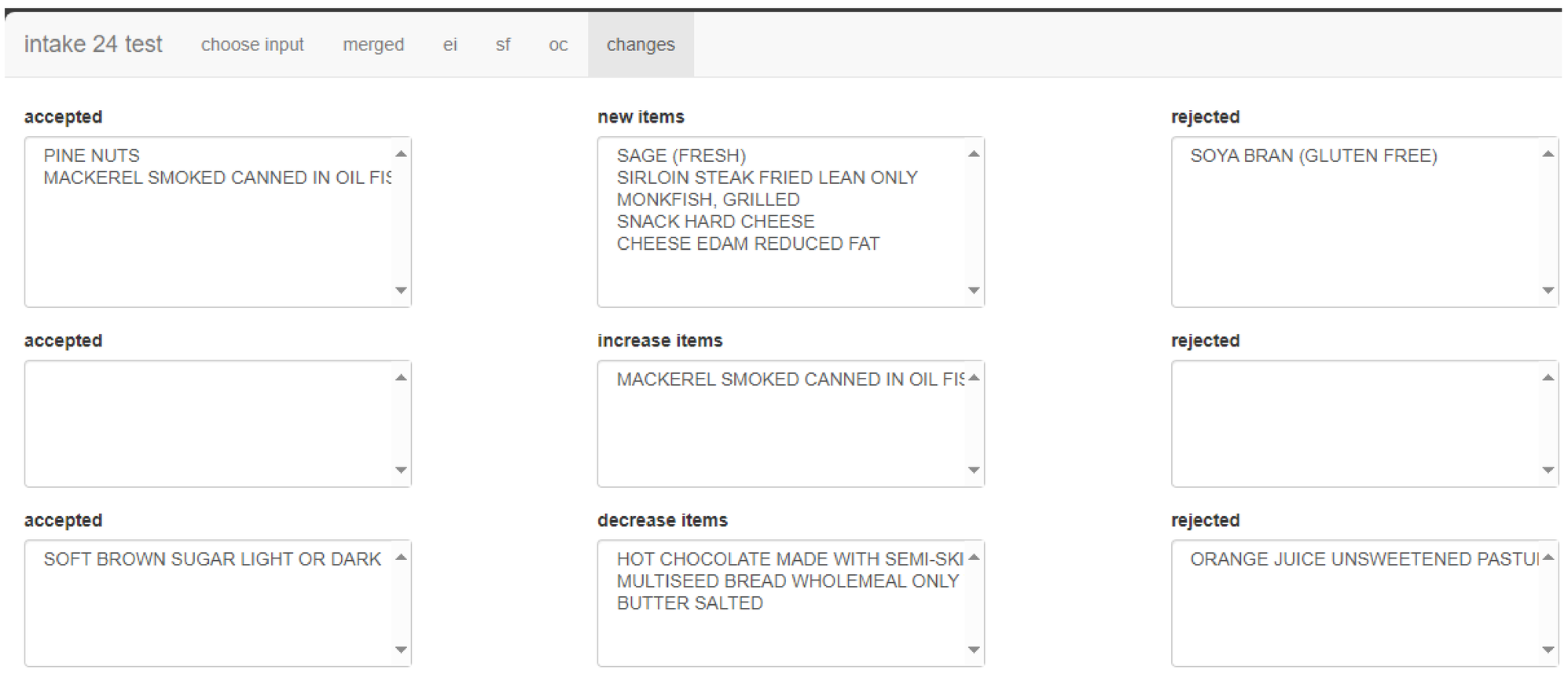
Trying to balance requirements for all of these can be framed as a mathematical question: what **combinations** of foods meet these conditions?
We then ask what are the least **changes from a current diet** that satisfy a set of specifications.

We also need to account for **diet appeal**. This is much more difficult! It's **very nonlinear**, and **varies between individuals**.



Choosing amounts of many foods on a shopping list or menu is equivalent to finding points in very many dimensions.

Requirements and constraints limit the region in which the tool can search



The hidden cost of frequent worming

Benedict E. Karani[1], Jennifer McIntyre[1], Stephen R. Doyle[2], Roz Laing[1], James A Cotton[1], Fiona Kenyon[3]

[1]University of Glasgow, [2]Wellcome Sanger Institute, [3]Moredun Research Institute



Background

- Parasitic roundworms can affect animal health, growth and productivity
- Wormers are an important tool for controlling these parasites
- However, resistance to many wormers is widespread
- Resistance is heritable - worms that survive treatment reproduce and pass on the resistance to offspring

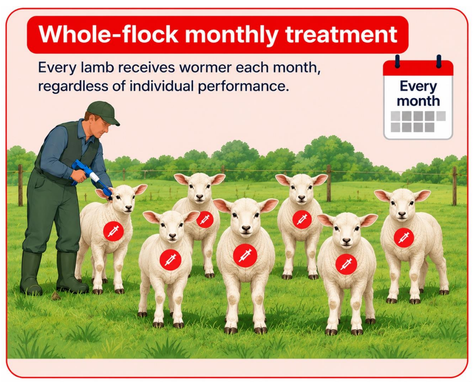


Could changing how we use wormers help slow the development and spread of resistance?

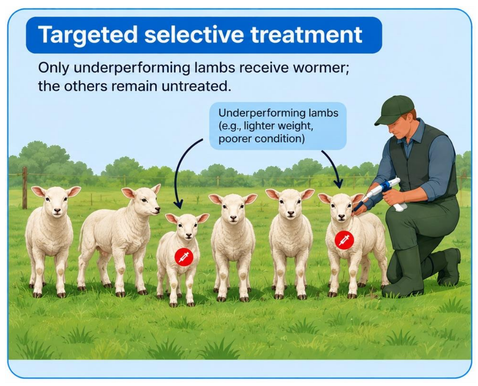
Methods

A RESAS-funded field trial (2006-2012) compared two contrasting wormer treatment strategies in lambs (A and B)

A



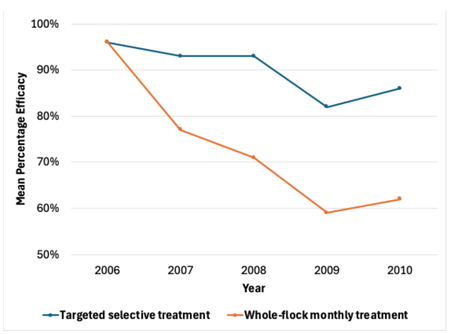
B



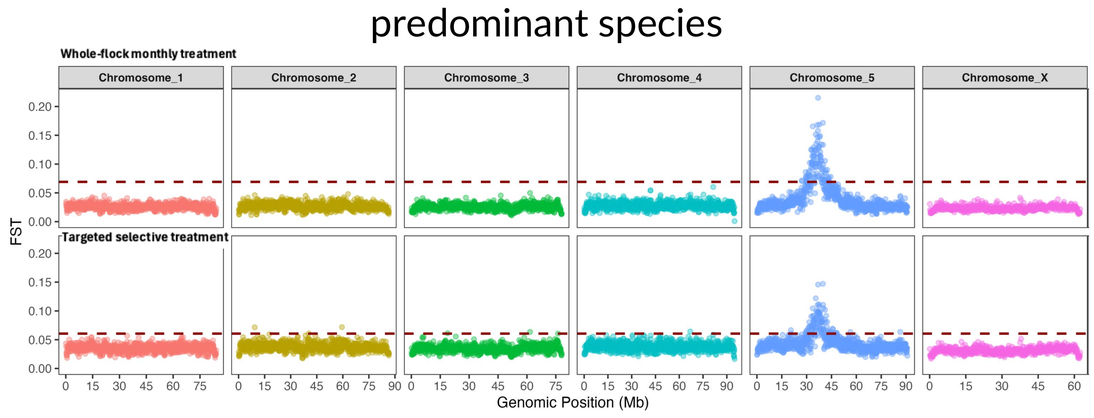
- Aim - To investigate how the treatment strategies influenced the evolution of wormer resistance
- Wormer efficacy and genomic analyses were assessed in the worm populations

Results

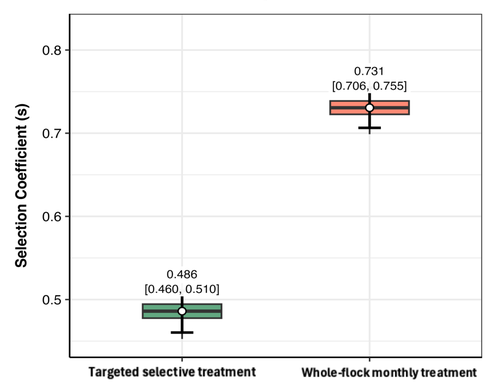
Rapid decline of wormer efficacy in whole-flock monthly treatment



Genomic analysis identified a single region of the genome associated with wormer (ivermectin) resistance in the predominant species



Stronger selection under whole-flock monthly treatment



What does this mean for farmers?

- Treating all sheep regularly removes susceptible worms while resistant worm population increases
- Targeted selective treatment reduces selection pressure by limiting treatment exposure while preserving susceptible worms and genetic diversity within the parasite population
- The genomic region identified here could help inform the development of future genetic tools for monitoring resistance ensuring early detection

Impact

This research has informed policy briefs and peer-reviewed publications, fostered extensive engagement with farmers and commercial partners and helped secure additional funding to further develop and refine the tools. **Scan the QR codes below to learn more**

Conclusion

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Frequent worming not only increases unnecessary wormer use and treatment costs but also increases the selection pressure for resistance

IT IS THEREFORE NOT JUST WHICH WORMER WE USE, BUT HOW WE USE IT

Predicting Wildfire Danger for Natural Capital Protection

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The James Hutton Institute

Introduction

Recent years have seen increased wildfire activity, with significant impacts on natural capital (NC) assets. The Scottish Government's *Wildfires: Strategic Action Plan* identifies developing effective wildfire danger assessments as a key action to support the efforts of the Scottish Fire and Rescue Service, National Park Authorities, and land managers in wildfire prevention and the protection of nature and people. Current fire danger predictions rely solely on fire weather indices that were not developed specifically for the Scottish climate and fuel types. Machine learning (ML) models have the potential to improve these predictions by considering the complex, non-linear interactions among multiple factors driving fire occurrence in Scotland.

To test this, we developed a ML model trained on historical fire records and multiple fire drivers to simulate the probability of fire occurrence at a given location. We assessed model performance by simulating probable fire occurrence for an independent set of historical fires and developed a prototype web application to demonstrate the model's utility for fire danger forecasting. The ML model was also used to simulate future (2020–2049) fire danger and respective exposure of NC assets within the Cairngorms National Park.

Methods

Model Development[1]

- Wildfires: Burnt area polygons (2011 – 2019, *n=169*) from the European Forest Fire Information System (EFFIS).
- Covariates: Land Cover (*Fuel Type*), Soils, Terrain, Accessibility, and Fire Weather Indices calculated on fire date.
- Training dataset: Fire presence/absence and covariates at locations of random 'virtual' samples within & outside burnt polygons on each fire date (Figure 1).
- ML (Random Forests) model: Simulates probability of fire occurrence (in %).

Model Performance Assessment[2]

- Historical weather from the European Centre for Medium-Range Weather Forecasts (ECMWF) matching the dates of 70 EFFIS burnt polygons (>100 ha each, total: ~40k ha) from 2020 – 2025.
- Simulation of fire occurrence probabilities at 50m pixels within burnt areas.

Future Fire Danger Spatial Assessment

- Cairngorms National Park (CNP): daily gridded (1km) future climate for 2020 – 2049 from CHESS-SCAPE EM01 RCP 8.5.
- Simulation of fire probabilities at 250m pixel: identify hotspots of future fire occurrence and assess NC asset exposure.

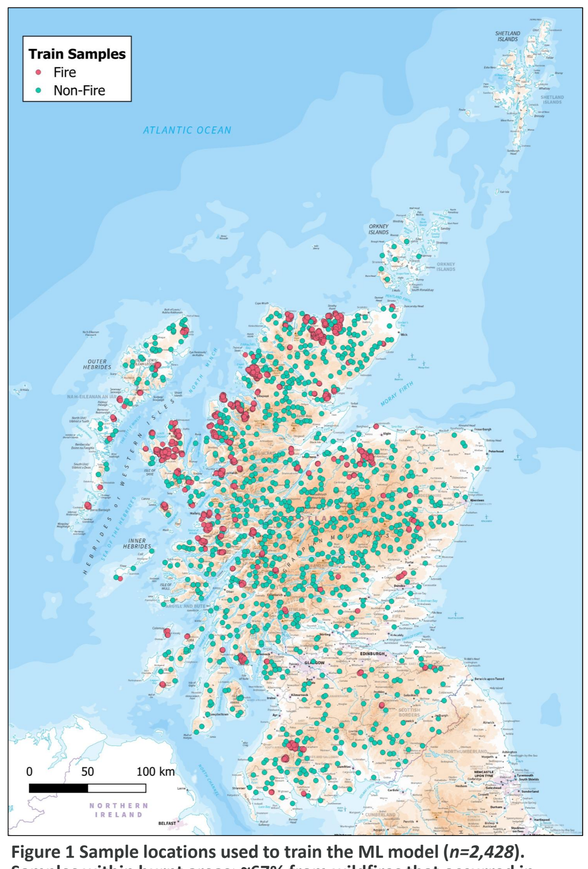


Figure 1 Sample locations used to train the ML model (*n=2,428*). Samples within burnt areas: ~67% from wildfires that occurred in March and April, 30% from wildfires in May to August; 90% on heather moorlands and bogs.

Results

1) Model Performance Assessment

- High (>0.80) model sensitivity and specificity and good inter-annual transferability.
- Fires 2020 – 2025: 40% and 30% of total burnt area predicted to be in High and Moderate fire danger; >65% of Heather and Bog areas with fire probability >45% on fire date.
- Model performs well for spring fires in heather moorlands and adequately for forest fires; however, more training samples are needed to better capture danger of summer fires caused by prolonged warm and dry conditions (Figure 2).

2) CNP Fire Danger Assessment for the 2020 – 2049 period

Table 1 Results of the fire danger assessment in the CNP for the area with >10% of days with simulated fire probability >50% in the 2020 – 2049 period (Figure 3b), given for each specified phenological period (T1, T2 and T3). Areas with >10% days considered here as in high fire danger (i.e., equating on average >3 days a month with simulated fire probability >50%).

Time period	Area (%)	Climatic Driver	Exposed NC assets	Confidence
T1: Jan - Mar	1.5	Mild and wet winter and early spring	Heather; Bog	Moderate to High
T2: May - Sep	5.0	Warm and dry summer	Conifers; Broadleaves; Seminatural grasslands	Moderate
T3: Oct - Dec	12.0	Warm and dry early autumn	Heather; Bog	Low (uncertain extrapolation)

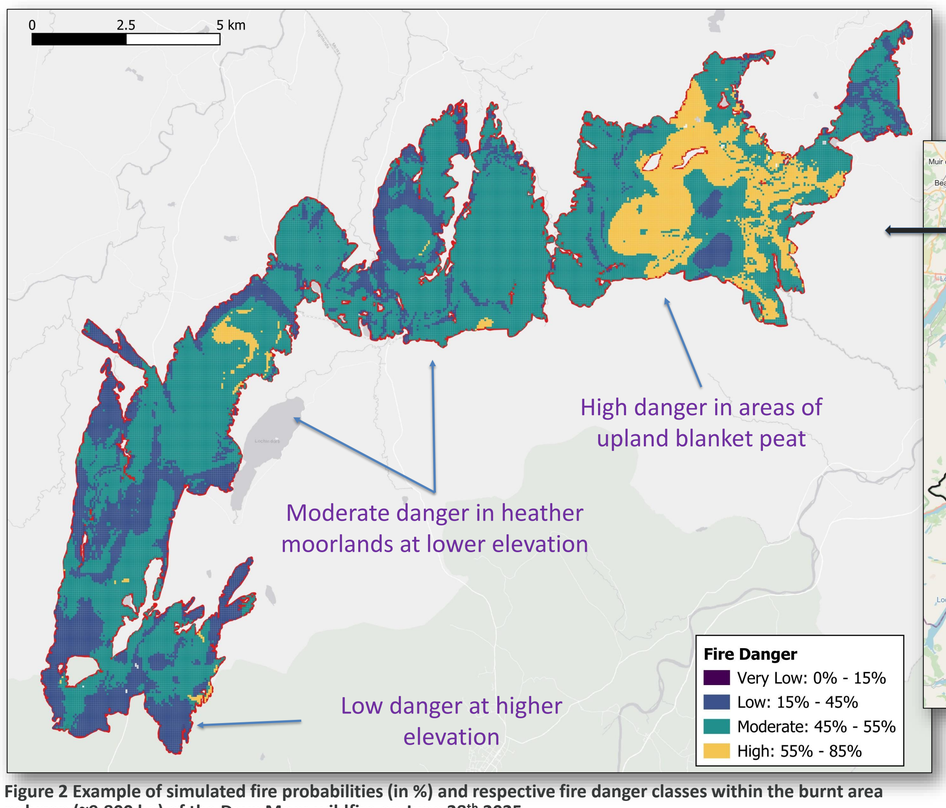
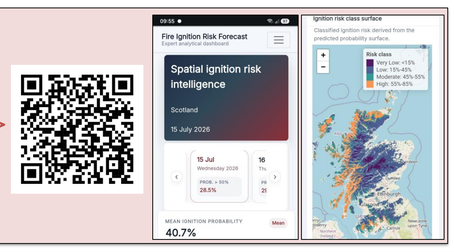


Figure 2 Example of simulated fire probabilities (in %) and respective fire danger classes within the burnt area polygon (~9,800 ha) of the Dava Moor wildfire on June 28th 2025.

Prototype Web Application *(under development):*

- Daily National Forecasting of Wildfire Danger at 1km grid squares.
- Utilises ECMWF 14-day weather forecasts.



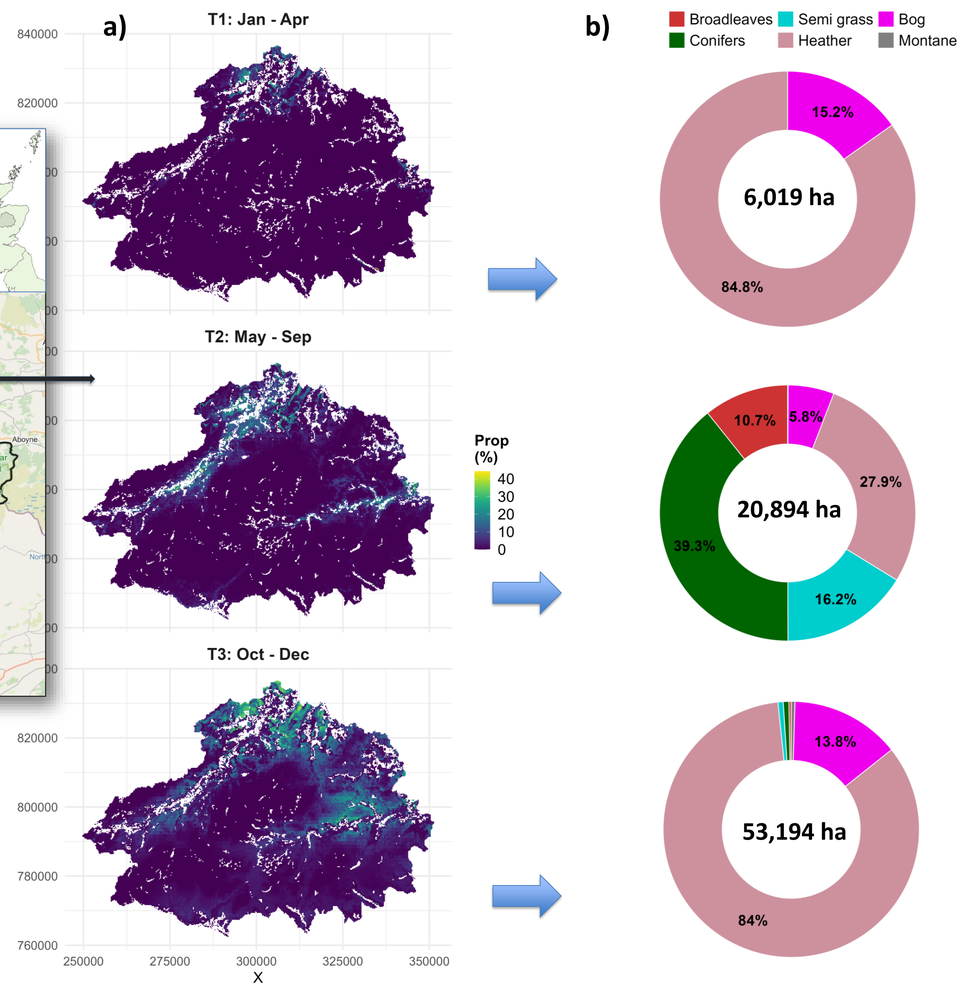


Figure 3 a) Maps of the CNP showing proportions of days (in %) with simulated fire probability >50% at each 250m pixel given for three phenological time periods (T1, T2 and T3) for the 2020 – 2049 period; and b) Coverage by NC assets (in %) of the CNP area (given in doughnut centre in ha) found to have >10% of 2020 – 2049 days with simulated fire probability >50%.

References
[1]Gagkas et al. (2025): https://doi.org/10.5281/zenodo.15794365
[2]Gagkas et al. (2026): https://doi.org/10.5281/zenodo.20344529

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Conclusions

- Good potential of the ML model for predicting wildfire danger and for supporting spatial assessments of NC asset exposure to future fire danger.
- Model utility can be improved by using all available EFFIS burnt polygons (up to 2026) for model re-training to better capture the emerging late spring and summer fire season.
- Model simulations depend heavily on land cover mapping: need for a standardised national fuel type map.

BICI: Toolkit for Large-Scale Data-Driven Process Modelling

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In Partnership With: SEFARI, EPIC Scotland (Centre of Expertise on Animal Disease Outbreaks), The Roslin Institute, University of Edinburgh, DAERA (Department of Agriculture, Environment and Rural Affairs, Northern Ireland), AFBI (Agri-Food and Biosciences Institute, Northern Ireland), Topigs Norsvin, Mowi Scotland, USDA (The United States Department of Agriculture), EEID (Ecology and Evolution of Infectious Diseases, USA-UK consortium)

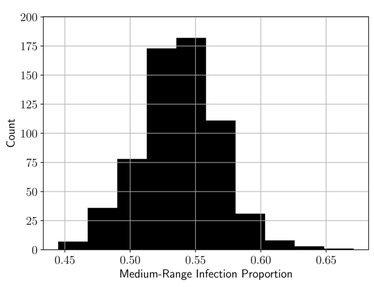
* grant.henderson@bioss.ac.uk

We have developed **BICI (Bayesian individual-based compartmental inference)**, **user-friendly software** that uses state-of-the-art **statistical methods** to combine **real-world, imperfect data** with **expert knowledge** for **cross-sector impact**.

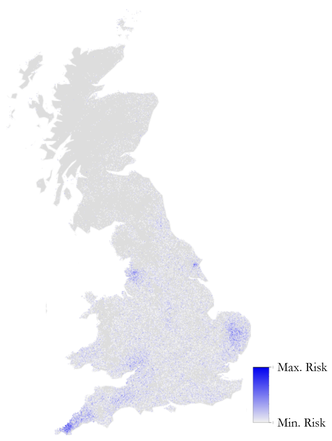
Our toolkit enhances ENRA's ability to provide **data-driven insights** across a wide **range of application areas** from **agriculture** to **ecology** in **policy**, **industrial**, and **educational** settings:

Highly Pathogenic Avian Influenza

- **EPIC**, Scotland's *Centre of Expertise on Animal Disease Outbreaks*, uses BICI to inform **Scottish Government** policy colleagues on threats from:
- HPAI spreads in Scotland via. **long-** *(e.g. migratory birds)* and **medium-range** *(e.g. local reservoir)* **routes**, but their **relative importance** is **unknown**.



- From HPAI **infection reports**, BioSS have **inferred** that **medium-range infections** are **crucial** in GB outbreaks (left).
- The estimation of **control efficacy**, both **locally** (in the environs of infected premises) and **nationally**, becomes possible.
- This analysis **predicts high-risk areas** in the UK (right) and can be used to **quantify** and **target effective policy response**.

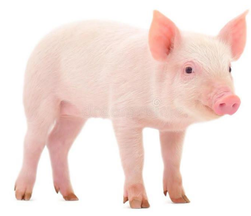


Bovine Tuberculosis

- **Bovine tuberculosis** (bTB) is a chronic, contagious **respiratory disease** in **cattle** that results in **huge economic losses**.
- We are planning to work with colleagues in **AFBI** and **DAERA** to **analyse large-scale datasets** (with skin test results and pathogen genetic data) using BICI to help **identify routes of transmission** within the network.

Industrial Genetic Disease Solutions

- **Selective breeding** of animals for heritable traits has long been used to **increase productivity** in agriculture (*e.g.* milk yield, weight…).
- In principle selective breeding can also be used to **target disease traits** (*e.g.* for reduced susceptibility / infectivity) for **healthier, happier more resilient animals**.
- This is challenging because these **traits** are **not directly observed**.
- BICI, however, can **estimate** them from available **phenotypes**.
- We are working with commercial and other organisations on design/analysis of **disease transmission experiments**:





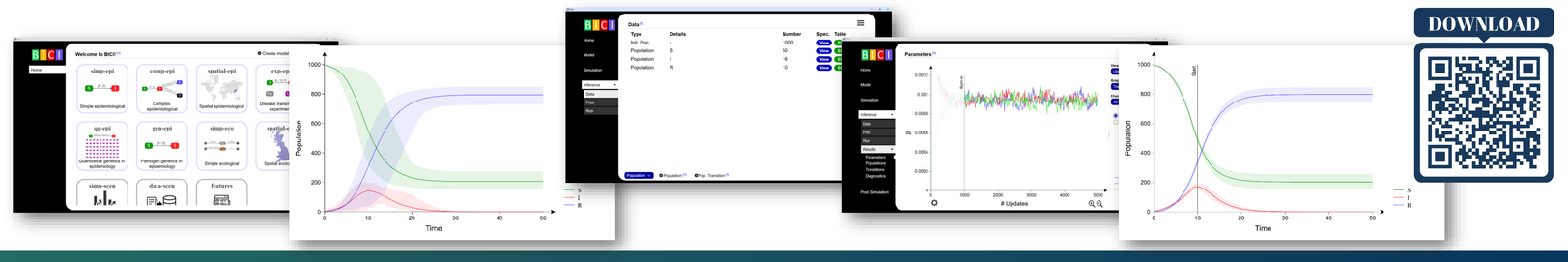


Topigs Norsvin – PRRS in pigs.
MOWI – Salmon and sea bass diseases.
USDA / EEID – Marek's disease in chickens.

Future Directions

- **Incorporate** realistic models of **human behaviour** into epidemiological models.
- Account for **dynamic networks** e.g. due to trade.
- Investigate applications in **ecology** e.g. spread of invasive non-native species and pests and **nature restoration** e.g. natural pest control.

User-friendly software is being developed to **widen access** for non-computational scientific users… including in educational settings



SEFARI | epic Centre of Expertise on Animal Disease Outbreaks | Department of Agriculture, Environment and Rural Affairs | Topigs Norsvin | MOWI SCOTLAND | THE UNIVERSITY of EDINBURGH | RESAS Rural & Environment Science and Analytical Services | Scottish Government Riaghaltas na h-Alba gov.scot

Lung ultrasound scanning for Ovine Pulmonary Adenocarcinoma has the potential to eliminate the disease from flocks



OPA Control
Research & Training Project

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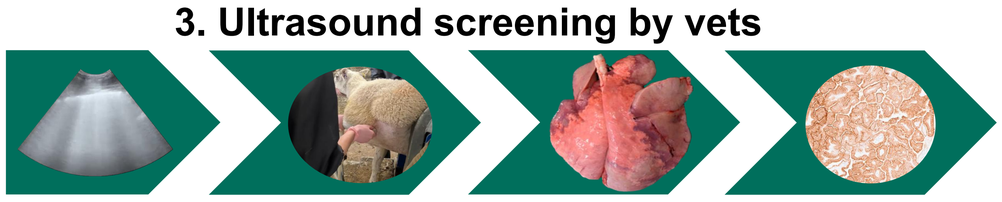
1. Introduction

Ovine pulmonary adenocarcinoma (OPA) is a common infectious and fatal disease of sheep caused by a virus (Jaagsiekte Sheep Retrovirus). Trans-thoracic ultrasound scanning is currently the only ante-mortem test for OPA. It has the potential to be the basis of a control programme for this disease. Here we present two aspects of our work towards that goal; a practical project which trained vets and assessed their efficacy at ultrasound screening for OPA and a project using previously gathered data to mathematically model the impact of test-and-cull based on ultrasound screening.

2. Objectives

- Assess the efficacy of ultrasound screening for OPA by training vets to deliver on-farm screening for OPA and facilitating validation of their work.
- Develop a mathematical model to predict outputs of a flock level test-and-cull programme.
- Increase awareness of OPA and potential control methods.

3. Ultrasound screening by vets



Training at Moredun/on farms. → Vets undertake whole-flock screening. → Postmortem diagnosis of selected cases. → Feedback to vets & Analysis of results.

4. Modelling

A mathematical model of OPA transmission was created under the following assumptions: homogenous mixing with no age structure, expert test Se/Sp (*table 1*), all positive individuals culled, annual restocking with OPA negative ewes, scan sensitivity in exposed stage is half that in the infectious stage.

5. Results

In this study we showed that with training and feedback the vets on the project attained specificity and sensitivity of screening for OPA similar to that of a highly experienced expert (*fig. 1*).

	Expert (published Cousens et al., 2022)	Project vets (n=11)
Specificity	0.998 (0.998–0.999)	0.931 (0.927-0.935)
Sensitivity	0.76 (0.72–0.79)	0.95 (0.85 - 0.99)

(95% credible intervals)



Previously collected data was used to co-develop a mathematical model to test the efficacy of using ultrasound test-and-cull as a method of controlling OPA within individual flocks. The model predicted that scanning twice yearly would eliminate OPA quicker than a single annual scan (*fig.2*).

For example, if a flock of 1500 ewes with an initial prevalence of 1% and an average OPA transmissibility of R_0=1.39, scans twice a year (*fig. 3*):



- Eradication was predicted to occur in 2.5 years (95% prediction interval 0.5- 6.1 years)
- >95% probability of eradication within 10 years

Estimated no. of culls needed to eradicate OPA within a flock that starts with a disease prevalence of 1%. OPA negatives represent the false positives that would be culled. The range is represented in brackets.

OPA Pos	OPA Neg
37 (9-90)	18 (4-43)

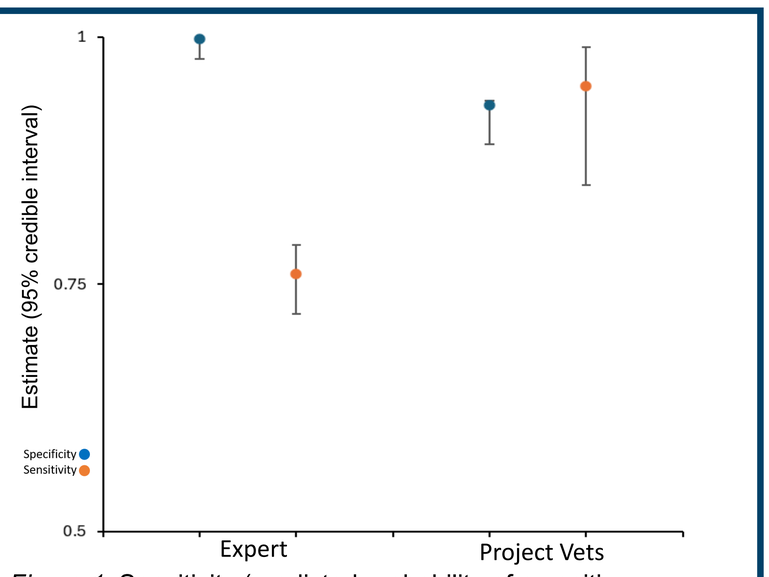


Figure 1: Sensitivity (predicted probability of a positive ultrasound result given a positive histology result) and specificity (predicted probability of a negative ultrasound result given a negative histology result) of vet practitioner's and an expert's ultrasound scanning for OPA. With 95% credible interval lines.

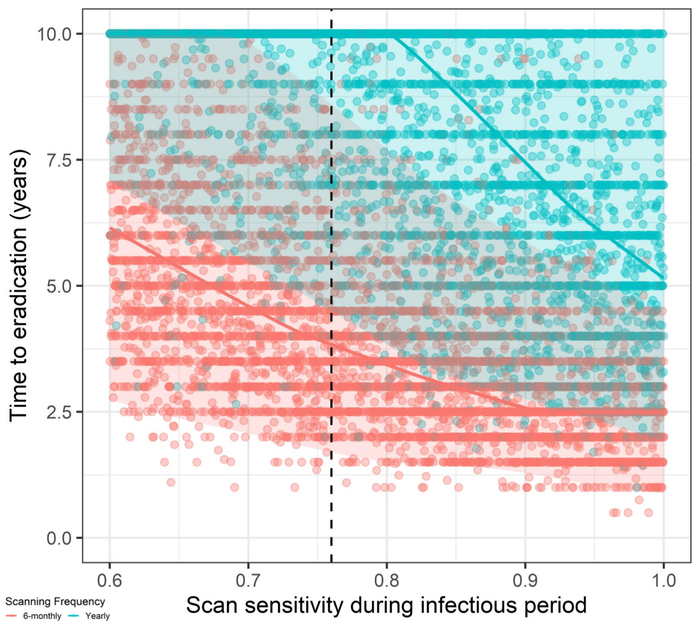


Figure 2: A scatter plot showing the time to eradication (in years) under yearly and 6-monthly scanning. The data points represent independent model runs plotted against the sensitivity of ultrasound scanning in the infectious period. The vertical dashed line represents a baseline scan sensitivity estimate of 0.76

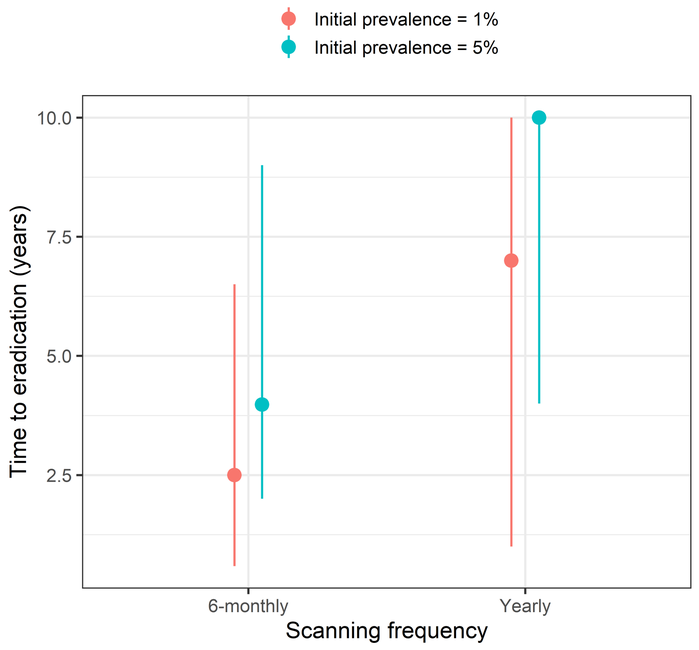


Figure 3: The predicted time to OPA eradication in years with two different scanning frequencies (6-monthly and yearly) and two different initial prevalences (1% and 5%). 95% prediction intervals.

6. Project Legacy

- **On-line training resources** & a **standardised protocol** for OPA screening.
- Register of **validated vets** across Scotland who can scan for OPA and who will play an important role in delivering an OPA control scheme.
- A **mathematical model** to underpin design of an OPA control scheme.
- Pilot version of a **decision support tool** to support vets in understanding the likely outcomes of OPA control under different conditions and to frame the conversation between vets and their clients.
- Increased **farmer awareness** of OPA through events, Press, social media (*The Sheep Game-YouTube*) and TV (*This Farming Life*).

Try the tool!

Moredun
E-mail: Jennifer.savage@moredun.ac.uk

BioSS

RESAS
Scottish Government
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Many thanks to the veterinary practitioners, the farmers, Moredun pathology team and Moredun bioservices.

Funded by

- Scottish Government: *Improving the efficiency of Scotland's sheep farms by supporting control of Ovine Pulmonary Adenocarcinoma*
- RESAS: Project MRI-A2-2 Obj 4: *Control of Ovine Pulmonary Adenocarcinoma (OPA)*

References

Cousens, C., Ewing, D.A., McKendrick, I.J., Todd, H., Dagleish, M.P. and Scott, P.R., 2022. Efficacy of high-throughput transthoracic ultrasonographic screening for on-farm detection of ovine pulmonary adenocarcinoma. *Veterinary Record*, *191*(3), pp.no-no.

From LIVING LAB to Farm:

De-risking **SUSTAINABLE** Pasture Management

Moredun
www.moredun.org.uk



Jade M. Duncan[1], Adam D. Hayward[1], Philip J. Skuce[1], Robin J. Pakeman[2], Stuart Smith[2], Alison Hester[2], Fiona Kenyon[1]

[1] Moredun Research Institute; [2] James Hutton Institute

SRP Project MRI-B2-1:
Improving livestock productivity & sustainability through management and genetics

Scottish Government
Riaghaltas na h-Alba
gov.scot

The Question

Regenerative agriculture:

- suggested as a **pathway** to meet food demand whilst protecting the **environment**
- has varied **definitions** and interpretations
- **scientific evidence** on its practicalities, impacts and benefits remains **limited**

- We assessed the **practicalities** of establishing a diverse species grass mix into established rye-grass pasture across two field studies at the Moredun Research Institute (MRI) & The James Hutton Institute (JHI)

The Study

- Up to **10 plant species** (Fig.1) were introduced into established pasture to deliver a range of benefits e.g., carbon capture, soil nitrogen, anthelmintic properties etc.
- **Direct drilling** was used as recommended by **The Code of Practice on Sustainable and Regenerative Agriculture**(1)
- This was to **minimise** carbon emissions and soil disturbance
- **MRI** had 2 plot treatments (Fig. 2) (2023-2024):
  1. No sward enrichment
  2. Spring direct drilling across two seasons
- **JHI** had 3 plot treatments (2022-2024):
  1. No sward enrichment
  2. 2022 Autumn direct drilling (sward steaming)
  3. 2023 Spring direct drilling (sward steaming)

Plant name	Species	Type
Cocksfoot	*Dactylis glomerata*	Grass
Meadow fescue	*Festuca pratensis*	Grass
Tall fescue	*Schedonorus arundinaceus*	Grass
White clover	*Trifolium repens*	Legume
Red clover	*Trifolium pratense*	Legume
Birds-foot trefoil	*Lotus corniculatus*	Legume
Ribwort plantain	*Plantago lanceolata*	Herb
Chicory	*Cichorium intybus*	Herb
Yarrow	*Achillea millefolium*	Herb
Salad burnet	*Sanguisorba minor*	Herb

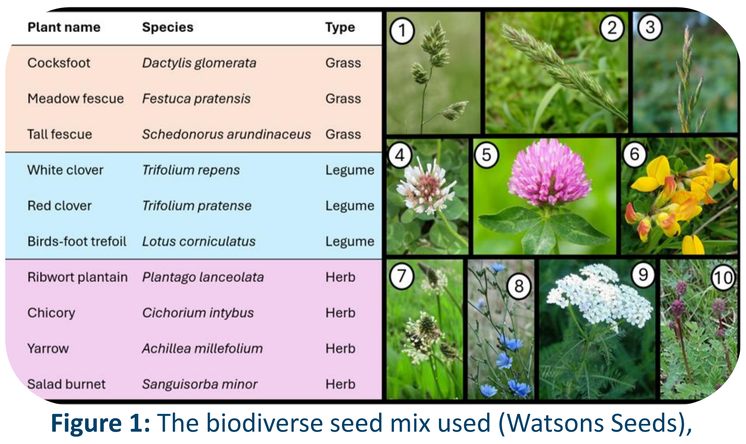
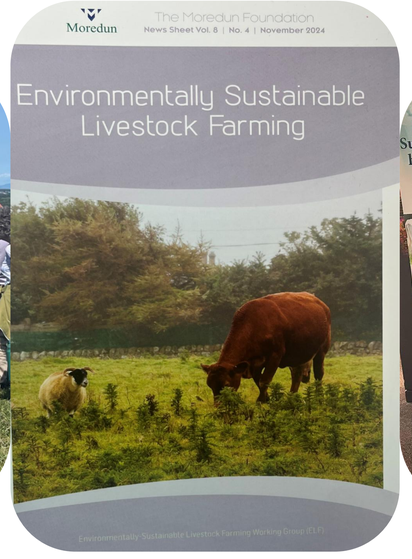


Figure 1: The biodiverse seed mix used (Watsons Seeds), JHI did not include Cocksfoot in their seed mix











The Outcomes

- **Sward composition** was measured in August 2023 and 2024 by the JHI for both sites
- MRI- **Three** of the species sown had established; *L. corniculatus* (Birds' foot trefoil), *T. repens* (white clover) and *T. pratense* (red clover)
- JHI- **Four** of the species sown had established; *Achillea millefolium* (Yarrow), *Plantago lanceolata* (Ribwort plantain), *Trifolium repens* (white clover), *Trifolium pratense* (Red clover)
- JHI: reported **no obvious impact** of steam treatment on establishment and no differences in sward productivity (2024)
- MRI: Spring 2023 there was a **drought** which lasted 6 weeks that may have affected establishment, in 2024 conditions were more favorable

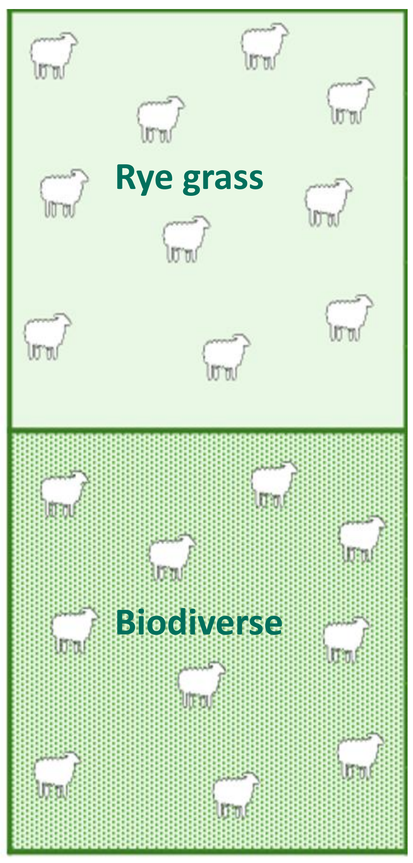


Figure 2: MRI experimental design

The Impact

- Living labs help **de-risk** regenerative farming practices before **implementation** on commercial farms
- Findings highlighted **trade-offs** between minimising soil disturbance and carbon emissions and successfully **establishing** a diverse species grass mix
- Evidence supports:
  - **Scottish Government policy teams** in developing policies on climate change, biodiversity and animal health
  - **Land managers and farmers** implementing regenerative practices to improve environmental outcomes, animal health and long-term farm sustainability
- Results were shared using the **Environmentally-Sustainable Livestock Farming** (ELF) working group, **RESAS** visits and **farmer** events to support improvements in animal welfare and environmental sustainability

1. Sustainable and regenerative agriculture: code of practice [Internet]. [cited 2026 Oct 20]. Available from: https://www.gov.scot/publications/code-practice-sustainable-regenerative-agriculture/

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Fostering connections to maximise impact for Living Labs

The Living Lab Link Up as an instrument for change

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The James Hutton Institute, Craigiebuckler
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The James Hutton Institute

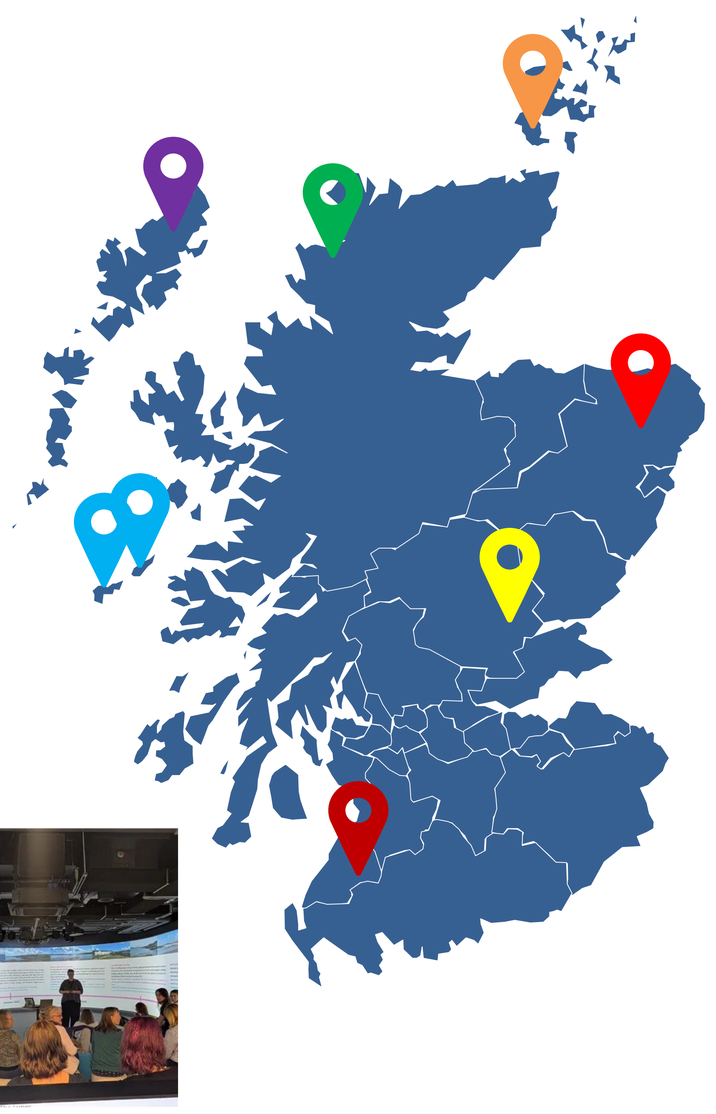
Living Labs as a tool to explore rural communities and research

We are working with nine communities across rural and island Scotland during the project (2022-2027). Each living lab explores a different topic, ranging from young people to community-owned renewable energy. Across each community we aim to understand:

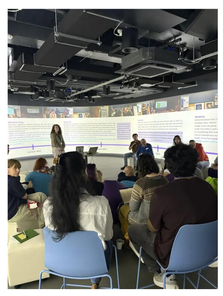
- The challenges they face in their everyday lives
- How things in their communities are changing
- What they would like to see happen in the future

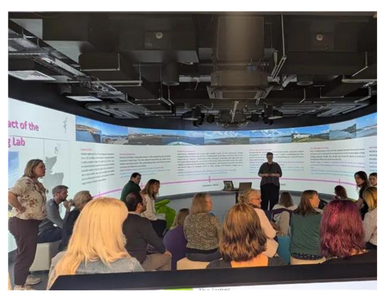
As well as listening to the experiences of residents and businesses, we are activating our role as researchers – where there is a call to do so – by putting our skills to use for the benefit of the communities such as helping with the development of two Local Place Plans.

We are also providing opportunities for linking them to policy-makers and other stakeholders to help address challenges.









The story so far

In 2023 we interviewed around 100 people across 7 of our living labs and in the last year, we returned to conduct follow-up interviews, exploring continuity and change. Initial findings indicate:

- Ferries are still a huge issue, prompting people to consider leaving and negatively affecting local businesses.
- Sense of community is diluted in some places due to an influx of incomers not participating.
- People do not wish to leave but ongoing challenges like cost-of-living are reaching critical points.
- Housing remains an issue, preventing young people from being able to settle in these places.
- Lack of representation/interest from local and national authorities. Challenges contacting key people/services and perceived reluctance from authorities to visit the areas.
- Communities want to learn from each other, share success stories and replicate such successes in a local-to-them, place-based way.

Example of our work in Tiree

In addition to longitudinal interviews, researchers have been involved in creating an agent-based model with representatives from Urras Thiriodh. Across three workshops, representatives explored the importance of roles and services and how roles are currently combined in individuals and households. The model will map these interdependencies, simulating potential possible disruptions to the island to help the Development Trust plan effective interventions.

The Living Lab Link Up as a tool for co-creation

❖ As part of this RESAS programme, we adopted a living labs approach because we aimed to not only observe but facilitate change at different levels, including at community and policy levels.

❖ As the project was coming to an end, we were keen to use our knowledge and local and national contacts to explore how to achieve further impact – through co-creation – this means moving from being *understood/consulted* to *learning* and *transforming together* (i.e. multi-level governance in Fig1).

❖ For this, we wanted to (1) explore the experiences and examples of existing impacts across our living labs, and (2) provide a space for discussions between policy and communities on what project outputs and outcomes they would find most beneficial, and (3) gain insights into shaping future living lab engagements in the next SRP

❖ Organising for key actors across governance levels to discuss frankly how to govern collectively provides the opportunity for facilitating change.

Figure 1 - Living Lab Maturity: Typology of Community Involvement in Living Labs

Non-researched communities	Lack of understanding of needs, low visibility in policy and research, Opportunities for initial engagement and trust-building, potential for significant new learning.
Case study communities	Community voices are documented on the terms of researchers, local experiences inform understanding, research agendas may be externally-led and opportunities exist to deepen participation
Standard Living Labs	Strong bottom-up engagement, co-design and local ownership of solutions. Opportunities exist to strengthen cross-sector collaboration and influence broader systems change
Multi-level governance approach	Community and policy engagement, co-design and local ownership pf solutions. Opportunities exist to embed change more deeply across institutions and governance levels
Transformative Living Lab	Shared leadership, mutual learning, distributed ownership supporting systemic change. Opportunities focus on sustaining impact, spreading learning and adapting to emerging challenges

Evaluation of the Link Up

The Living Lab Link Up in Aberdeen, June 2026 involved over 40 participants from across the communities, local authorities, relevant charities and government linked to the project. The event included use of the state-of-the-art immersive suite to explore the story and impact in each Living Lab, providing an opportunity for both the research team and communities to share experiences. We also discussed continuity and change arising from the interviews, as well as having discussions about ways the project can facilitate change *with* and *for* communities and policymakers.

The Living Lab Link Up provided opportunities for:

❖Communities to hear the experiences from other communities and feel 'less alone' hearing about similar challenges.

❖Government and communities to hear from each other.

❖New connections and new knowledge sharing from across rural Scotland, for both current and future planning and development.

❖Discussions around ways to implement change at multiple levels which in turn helped with understandings of how a more transformative living lab approach might be developed.

Alongside the existing programme, participants made plans for the future. Potential future engagements included:

❖Communities being willing to feed evidence into policy decisions using Hutton as an intermediary.

❖Communities and policymakers appreciated the space to share experiences and learnings. These learnings have and will be used within the next SRP programme which will develop of Living Labs further.

Acknowledgements

We are grateful for the support of our research participants, the Scottish Government-funded SEFARI Responsive Opportunity Initiative, and the Scottish Government's RESAS Strategic Research Programme 2022-2027 [JHI-E1-1, JHI-E2-2]. With thanks to Hebe Nicholson, Mairi Laidlaw, Tami Wooldridge and Acacia Marshall for their contributions to this project.

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RESAS
Rural & Environmental Science and Analytical Services

SEFARI
LEADING IDEAS FOR BETTER LIVES

ENRA Research, Evidence and Policy Conference, 29 October 2026
ENRA Research Portfolio Delivering for Scotland:
Our Environment, Rural and Island Communities and Industry

Theory of change scenarios of agricultural innovation in rural Scotland

Controlled Environment Agriculture in the Orkney Islands

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RESAS Rural & Environmental Science and Analytical Services
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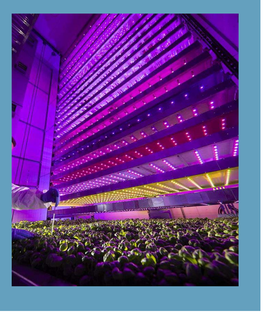
Introduction

- In **Scotland's remote regions**, the availability and accessibility of fresh, nutritious, and affordable food, primarily **vegetables**, remain a challenge.
- This is particularly the case for **islands** due to unsuitable growing conditions – climate and soil – and lengthy transport networks, causing products to reach consumers close to the end of shelf life.
- **Indoor or hybrid growing** can be a viable solution to these challenges.
- The introduction of advanced technology in small communities requires sound **ex-ante assessment**.
- We focus on the **Orkney Islands**, characterised by stronger farming tradition compared to other island groups, and on **vertical farming** (**VF**) technology, proposed under the Island Growth Deal in 2022, but with limited progress to date.
- We compare it to less sophisticated, lower-cost hydroponic **Tower Farms** (**TF**) to be installed in **Polycrubs®**.



Our methodological approach

- We apply a protocol developed to **assess place-based interventions** in Europe (Piras *et al.*, 2022).
- We build on research on the acceptability of VF products (Mzek *et al.*, 2025), and perception of controlled environment agriculture in Orkney (Dinnie *et al.*, 2025).
- We conduct **interviews** with policy and industry stakeholders and separate **workshops** with residents and food stakeholders in Orkney Mainland and Westray.

A. We develop a **Theory of Change** (**ToC**) of the VF technology under current conditions.
   1. Developing the VF, conceptualised as an **intervention**, is decomposed into **actions**
   2. These actions trigger causal pathways of **outcomes**
   3. Each outcome is conditional on **assumptions**, which in turn depend on **contextual conditions**
   4. If the assumptions hold, the **final goal** is achieved

B. We develop **place-based scenarios** for Orkney.
   1. A scenario consists of a combination of eight **rural drivers of change** (Piras *et al.*, 2026).
   2. We assess the drivers' **relevance** for Orkney, and the **likelihood** and **desirability** of future states.

B. We reflect on how the intervention may perform under future place-based scenarios, and whether it could impact future conditions in turn.

Acknowledgements

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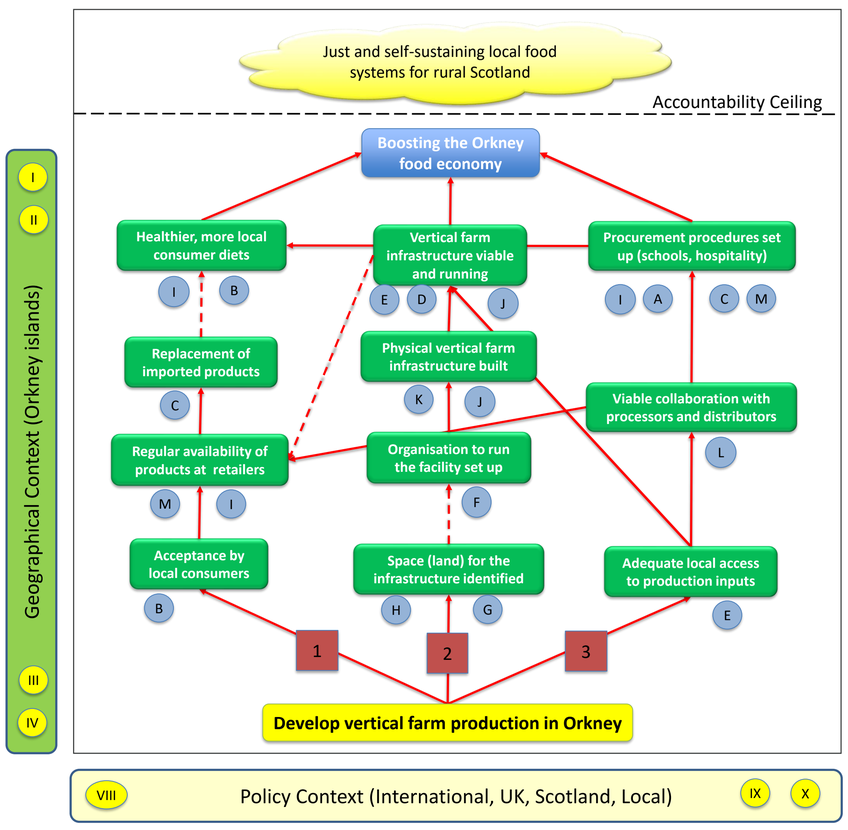
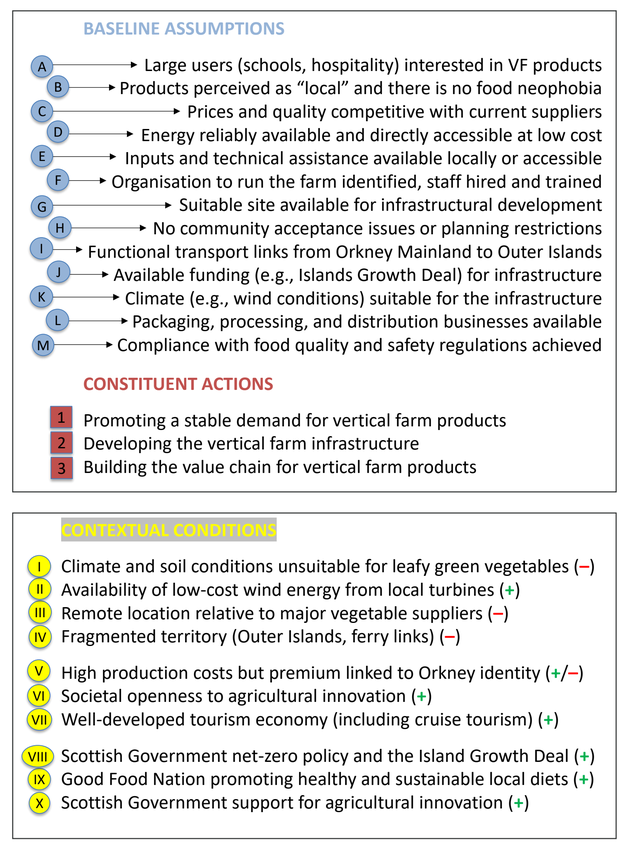
Mzek, T., *et al.* (2025). Understanding Consumer Preferences for Vertical Farming Produce and the Impact of Information: Insights from a Scottish Case Study.
Piras, S., *et al.* (2022). Spatial justice on the horizon? A combined Theory of Change scenario tool to assess place-based interventions. *European Planning Studies*, *30*(5): 952-973.
Piras, S., *et al.* (2026). Guidelines and resources for developing likely and aspirational scenarios of rural and island places in a workshop. Zenodo.

Results

Theory of Change: An intervention logic conditional on many assumptions

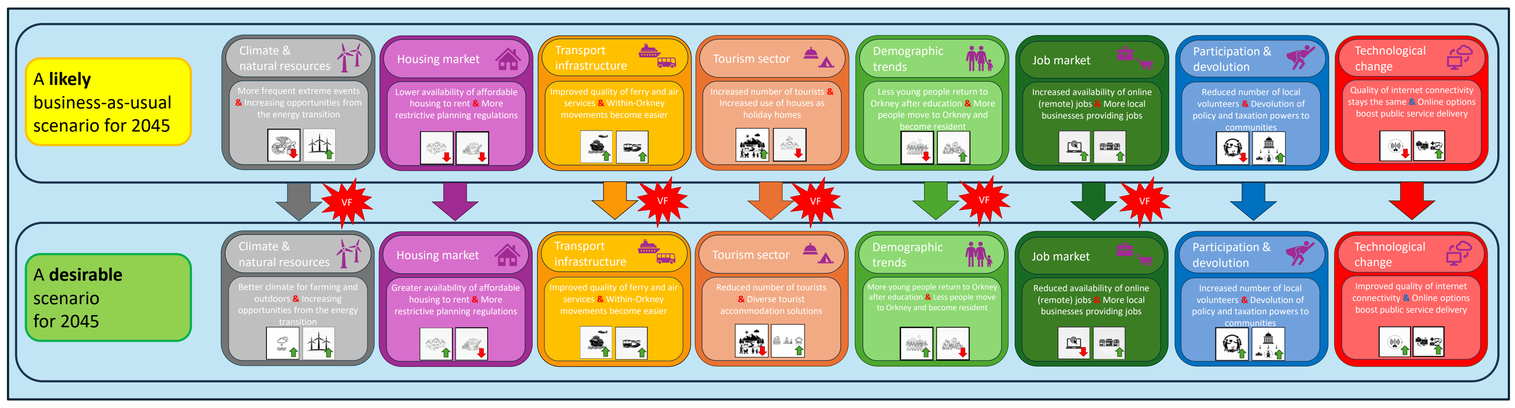
- The VF was understood as a **centralised** structure where high technology is applied for growing vegetables (mostly leafy greens) for the Orkney market.
- If developed in the Orkney Islands, a VF would have the **objective** of **boosting the overall food economy**.
- However, most stakeholders expressed **reservations** about the advantages of introducing this technology and whether it would be viable – this is reflected in the **many ToC assumptions**, not always verified.
  - The infrastructure would need to be based in **Orkney Mainland**, close to where **energy** is produced.
    - This would shorten supply chains for Outer Islands but not fully solve accessibility issues there.
  - **Collaborations upstream and downstream** must be established and a managing organisation identified.
    - Large **supermarkets** have established suppliers; collaboration requires competitive production costs.
    - Short-term **cruise tourism** generates limited opportunities for local produce beyond restaurants in Kirkwall.
  - **Acceptability** of VF produce is not an issue, especially if sold under the local **"Orkney" brand**.
  - **Dependence** on external technology and input providers is the main risk to be avoided.
- *By comparison, wide uptake of **TFs in Polycrubs®** would improve self-sufficiency in fruits and vegetables across islands, and generate broader social benefits, but would barely make a profitable business.*





Business-as-usual and aspirational scenarios: How would they interact with the technology?

- **"Climate and natural resources"** will be the most relevant driver of future change – more frequent extreme events, increased opportunities from the energy transition – followed by the **housing market**, **transport infrastructure**, and the **tourism sector**.
- The VF and its ability to benefit the local economy will be **affected by the drivers of change**, but they will make a limited difference for their future direction in turn.
  - The VF will help address future **challenges** related to transport and climatic events and may benefit the job market.
  - It will leverage **opportunities** related to natural resources (windfarm developments), tourism (if longer-term), and change in the population distribution between Orkney Mainland and Outer Islands.



Outcomes: Conclusions and Policy Recommendations

- ✓ Limited progress in developing the VF proposed under the Island Growth Deal points to **uncertain demand** and **financial risk**.
- ✓ The need to **consult stakeholders** and the wider **Orkney population** emerged strongly.
- ✓ We engaged with Orkney Council, HIE, and UHI Orkney – who were demonstrating the TF in the Polycrubs® in their premises – and discussed with the general population both in Kirkwall and Westray, to have a full picture.
- ✓ Our results suggested that covering **capital costs** alone is not enough to trigger innovation, and support towards **variable costs** (inputs, labour, etc.) should be provided, at least in the initial period.
- ✓ Better **preliminary understanding** of local society and market conditions is also required through consultations.
- ✓ Low-cost, widespread innovations like the TFs emerged as an alternative, but are not a silver bullet either.

Access the full report here:

ClimaScope

Mapping climate risk across Scotland

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The James Hutton Institute

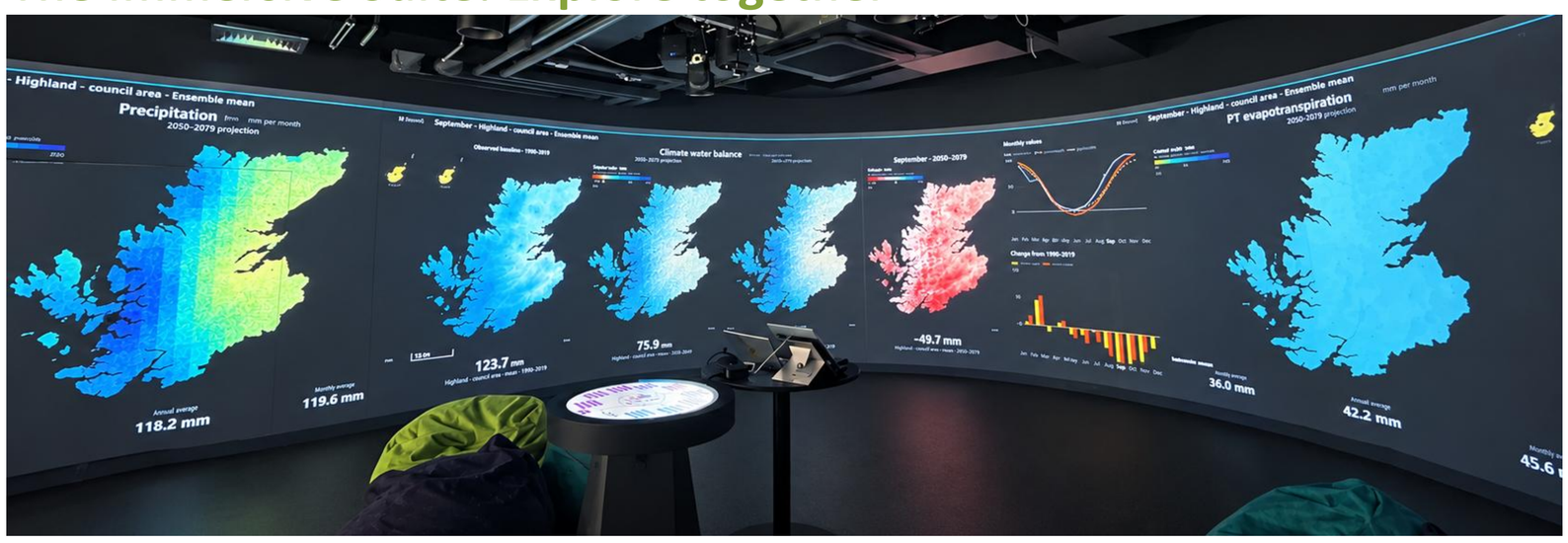
Introduction

Climate change is expected to affect Scotland's natural capital in different ways across the landscape. Understanding these impacts requires climate projections to be considered alongside information about land cover, habitats and physical terrain.

ClimaScope is a data visualisation and analytical platform developed through the Climate Change Impacts on Natural Capital project. It brings these datasets together, enabling users to explore how climate conditions may change over time, investigate differences between locations, and identify areas that may warrant further attention.

Through an interactive web application and an immersive visualisation environment, ClimaScope supports the exploration of complex environmental information by researchers, policymakers, land managers and other stakeholders.

The Immersive Suite: Explore together



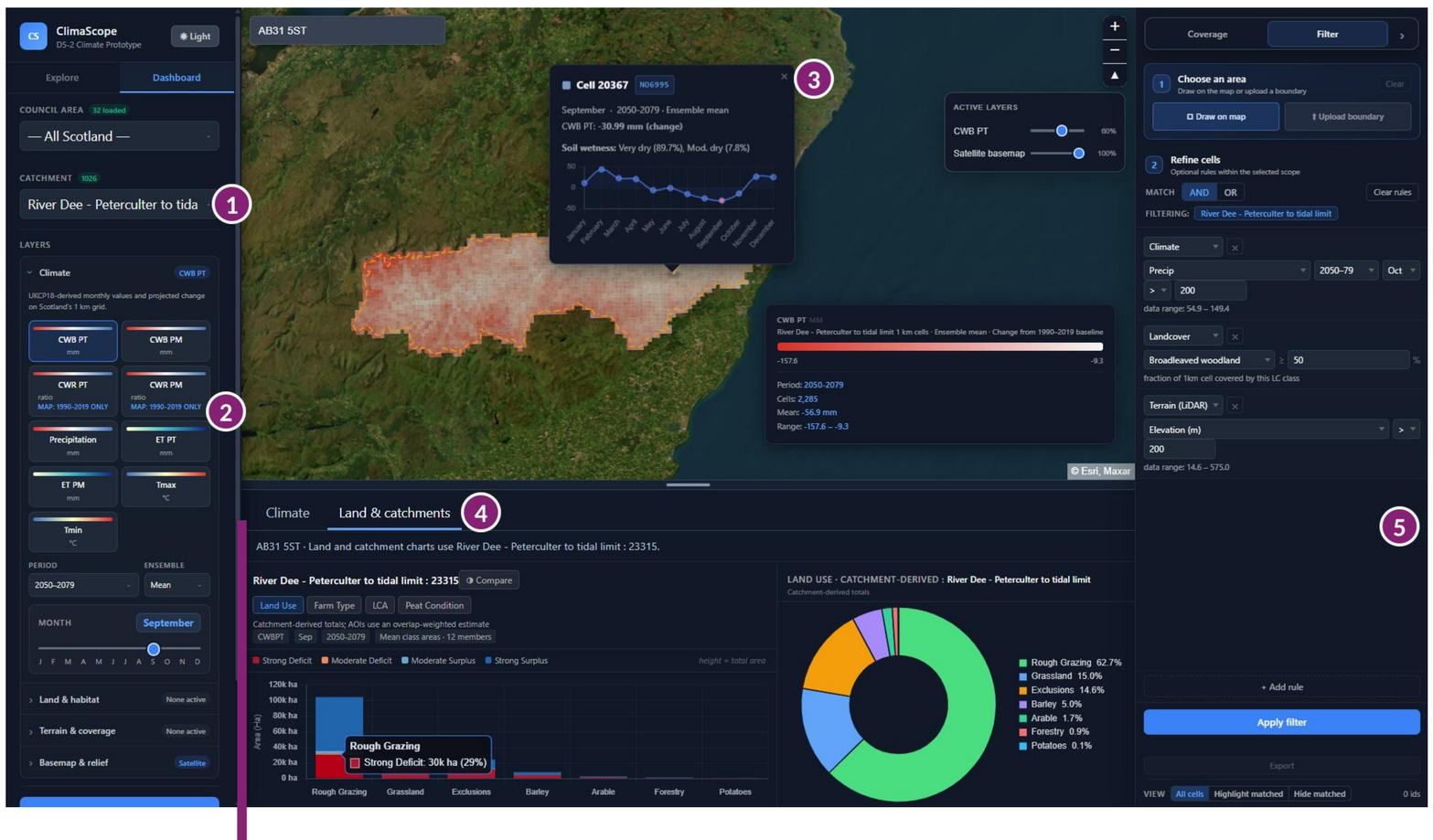
Located at the James Hutton Institute in Aberdeen, the Immersive Suite is a 360-degree visualisation environment that extends ClimaScope beyond the web app. Its large, immersive display presents multiple maps, charts and climate variables simultaneously, enabling users to explore spatial patterns and compare observed and projected climate conditions across different locations and time periods.



By bringing climate projections and landscape information together in an immersive, shared environment, the suite helps communicate potential climate change impacts on Scotland's natural capital. It encourages users to explore data interactively, identify patterns and relationships, and discuss their implications collaboratively, supporting knowledge exchange between researchers, policymakers and other stakeholders.

Web App: Explore climate impacts

The ClimaScope web app allows users to explore climate variables, compare baseline and projected conditions, and investigate how climate change relates to landscape characteristics. Users can move from a national overview to a council area or catchment, or search by postcode to explore climate conditions for a location of interest. Custom spatial queries allow users to identify and compare areas with specific combinations of climate and landscape characteristics.



1 Choose an area to inspect

Explore Scotland at a national scale, select a council area or catchment, search by postcode, or draw or upload a custom boundary.

2 Select climate data

Choose a climate variable, time period, month and ensemble member, or view the mean across all 12 ensemble members.

3 Inspect a 1 km grid cell

View the selected climate metric for each month of the year at the chosen location.

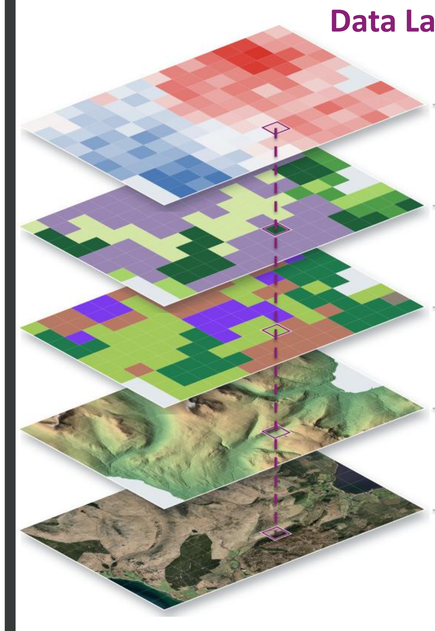
4 View the climate and land summary dashboard

Compare climate conditions across the three time periods and explore the breakdown of land cover types for the selected area.

5 Filter and download

Query climate, land cover and terrain layers to filter data. Save matching features and export results as CSV or GeoJSON for further analysis.

Data Layers



Climate

UKCP18 projections: temperature, rainfall, evapotranspiration and water balance. Monthly, three 30-year periods (a baseline and two projected), 12 ensemble members.

Drier · Little change · Wetter

Land cover

UKCEH Land Cover Map

Heath & bog · Rough grass · Conifer · Broadleaf · Improved grass

Habitats

NatureScot habitat map

Scrub · Grassland · Woodland · Wetlands · Rock & s :r :e

Terrain

National LiDAR Programme 2025: 50 cm terrain model

Satellite

Esri World Imagery basemap · © Esri, Maxar

Consistent 1 km grid cell across all layers

North Arran, 15 × 10 km; grey is sea. Climate shown: water balance change, December 2050–2079. Land use, farm types, land capability and peat are also available by catchment.



RESAS
Rural & Environment Science and Analytical Services

Scottish Government
Riaghaltas na h-Alba

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