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FORUM

Legumes in Science and Practice

Nitrogen Climate Smart: Cutting UK agricultural emissions using a farmer-focused theory of change

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Abstract

The UK is facing increasing pressure to achieve net zero emissions to limit environmental damage and climate change. The agricultural sector contributes 12% of UK anthropogenic greenhouse gas (GHG) emissions and thus has a crucial role in reducing UK total emissions. Despite knowledge and solutions being generated by agricultural research projects, many struggle to make impactful and measurable change which lasts beyond the lifetime of a short funding cycle. In this paper, we use the lack of uptake of UK-grown pulses, especially faba beans, despite their large potential for cutting carbon emissions, as an example of the gap between research and land management change. Despite their well-known environmental and nutritional benefits, pulses only comprise an estimated 5% (1 in 20) of UK arable rotations, compared to the rotational maximum of 20% (1 in 5), a switch which would reduce GHG emissions by 3.4 Mt CO_2 equivalent (*e*) per annum. This would be equivalent to 7% of UK agricultural emissions, mainly achieved through reducing mineral nitrogen fertiliser usage and replacing soybean meal in livestock rations. While it is recognised that this 3.4 Mt per year target reduction cannot be achieved in the duration of a 4-year research programme, we propose a "theory of change" for maximising lasting impact that can be followed when designing future agricultural research programmes. Using the Nitrogen Climate Smart (NCS) project as a case study, we demonstrate a pathway to impact through meaningful farmer engagement, co-designed research questions, on-farm trials and knowledge exchange, essential to delivering long-term and long-lasting shifts in land management practice and climate impact, alongside bridging the gap between research, practice and policy.

KEYWORDS

biological nitrogen fixation, cash crop pulses, faba bean, farmer engagement, greenhouse gas mitigation, on-farm trials, pulse grains, resilience, sustainable agriculture, theory of change

1 | INTRODUCTION: THE NEED FOR IMPACT IN AGRICULTURAL RESEARCH

Global net zero emissions must be reached by 2050 to avoid surpassing the 1.5°C change limit on global warming since pre-industrial levels (IPCC, 2022). As the agrifood chain contributes to around one third of global anthropogenic greenhouse gas (GHG) emissions, mostly from agriculture and land use activities, pressure is on the agrifood sector to help achieve these net zero targets (Crippa et al., 2021; Tubiello et al., 2022). This pressure should also extend to research in the agricultural sector to ensure that governmental funding with an ambition to reduce agricultural climate impact delivers real, lasting impact among these climate, environmental and economic challenges.

As of 2022, the agricultural sector contributed to 12% of total GHG emissions in the UK, dominated by emissions from methane (58%) and nitrous oxide (26%), primarily because of livestock and fertiliser usage, respectively (DESNZ, 2024). In addition to its environmental cost, the increased price and volatility of N fertiliser since 2021 have highlighted the need to reduce our reliance on these products by increasing nutrient use efficiency (NUE). These challenges lead to opportunities for agricultural research to make an impact. Although many projects produce valuable contributions to scientific knowledge, many fail to generate practice change which contributes to meaningful emission reductions, mainly because change must be sustained beyond the project lifetime, which generally only lasts a few years.

The aim of this paper is to use grain legumes, otherwise known as pulses, as an example of a well-documented and understood pathway to environmental and productivity benefits, which has struggled to be widely adopted in UK agricultural rotations. Here, we use the Nitrogen Climate Smart (NCS) project as a model for a new approach to designing future agricultural research programmes to deliver long-lasting and measurable impact.

2 | THE OPPORTUNITY FOR IMPACT WITH PULSES

Pulses, part of the legume family Fabaceae, are well known for their ability to form symbioses with the soil bacteria "rhizobia," which fix atmospheric nitrogen (N) in return for photosynthetic products in a process called biological nitrogen fixation (BNF), one of the most ecologically important biochemical reactions globally (Unkovich et al., 2008). In the field, pulses can derive up to 96% of their N from this process under favourable conditions, with faba beans being most efficient (Palmero et al., 2022). As a result, pulses require no synthetic N fertiliser during their growing season but can also leave economically valuable residual N for subsequent crops in the form of residues, contributing around 30–40 kg N/ha to the soil (Peoples et al., 2009). This offers the opportunity to further reduce fertiliser usage, and with it, the environmental footprint associated with its production and use (Jensen et al., 2012, 2020), while maintaining biomass and N output (Iannetta et al., 2016).

Beyond their environmental benefits, pulses are a key source of protein for both humans and livestock. A shift to more plant-based diets in the UK, mainly for environmental or health reasons, is increasing the demand for more home-grown plant protein, which can be delivered by pulses (Alae-Carew et al., 2022). Pulses can also provide a more sustainable alternative to imported soybean meal in livestock diets (Soisontes et al., 2023), providing a more sustainable meat-derived protein source for human consumption, while providing dual benefits for soil microbiome diversity as well as human gut health (Duarte et al., 2024).

The feed and food systems of the UK are, like most European countries, pulse based. However, these are often not "home-grown," despite their obvious benefits, earning pulses their "underutilised crop" status in UK agriculture, despite the need to increase protein self-sufficiency in the UK (Hudson, 2026). Consequently, the environmental benefits offered by pulses are also not realised "at home." In 2023, only 6.3% of the UK's cropping land was used for pulse production. However, if pulse cropping is increased to its recommended rotational maximum of 20%, equivalent to 1 in 5 rotations, this could reduce GHG emissions by 3.4 Mt CO_2e (equivalent) per year (Farm Carbon Toolkit, 2025). This figure is equivalent to reducing UK agricultural emissions by 7%, and can be achieved through four key mitigation pathways: (1) direct reductions in N fertiliser usage in pulse crops; (2) indirect reductions in N fertiliser use in subsequent crops because of soil N benefits and/or increased nutrient use efficiency in the following crop because of break crop effects; (3) reduced fuel usage from reduced fertiliser applications and tillage intensity; and (4) partial substitution of imported soybean meal in livestock diets with domestically grown pulses, a low emission alternative to soybean meal (Figure 1). If using the tradeable value of carbon at approximately £40/tonne, this equates to a potential annual saving of £136 million in avoided emissions, or £820 million if using HMRC's social cost of carbon at £241/tonne (UK Government, 2021). These estimates are based on 2023 values for land use and crop areas (Defra, 2023), meaning that these calculations are based on expanding the annual area of pulses grown from 275,090 ha (6.3%) to 874,026 ha (20%).

The actual impact upon CO_2e emission reductions could be even greater than presented, because of the conservative assumptions made in the calculation. For example, if targeting the same wheat yield, the model assumes a saving of 30 kg N/ha in crops following legumes compared to cereal pre-crops, based on guidelines in the RB209 nutrient management guide. This does not account for the likelihood that compared to cereal pre-crops, break crops such as pulses increase the nitrogen use efficiency of following cereals through break crop effects (Preissel et al., 2015; Sylvester-Bradley & Cross, 1991). Evidence also suggests that direct N provision from pulses could be greater under some circumstances than others. For example, high yielding pulse pre-crops could contribute as much as 10 kg N/t of harvested seed through residues returned to the system (Maluk et al., 2022). Similarly, the model assumes a conservative faba bean yield of 4.3 t/ha, though there are currently some UK growers achieving 8 t/ha, suggesting scope to improve national yields by improving agronomy guidance. There is also an assumption that

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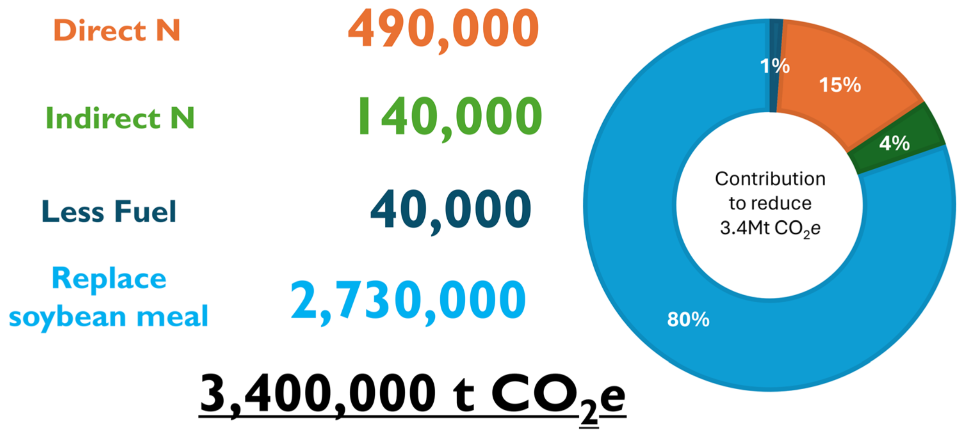

FIGURE 1 The contribution of increasing pulse cropping to 20% to the reduction of CO_2e by 3.4 million tonnes.

1 tonne of soybean meal is equivalent to 1.65 tonnes of beans. However, it could be possible to increase this feed conversion efficiency through processing techniques such as roasting and dehulling. It must also be recognised that the benefits of increasing UK legume production extend beyond domestic emission reductions. By reducing our reliance on imported soybean, we also reduce deforestation pressures, delivering knock-on social and biodiversity co-benefits in areas of soybean production, like the Amazon rainforest (Nepstad et al., 2014).

Despite the demonstrated potential that increasing UK pulse production can contribute to GHG mitigation, the limited uptake highlights that knowledge alone does not drive change. A recent systematic review by Horril et al. (2024) explored how pulses can contribute to net zero in the UK and barriers to their implementation. Perhaps the biggest factor discouraging farmers from growing pulses is their perceived yield instability, perhaps heightened by climate variability (Marteau-Bazouni et al., 2026), although evidence shows that pulses are not more yield-variable than other arable crops in Northern Europe (Reckling et al., 2018). Moreover, Sustainable Farming Incentive (SFI) schemes (UK government agricultural subsidy schemes) that incentivise legume-based mixes and covers because of their environmental benefits may unintentionally be further reducing the use of pulses as cash crops or lead to increasing soil-borne diseases because of constraints on pulse rotation frequency (Howard, 2024).

To maximise the potential of pulses, and other promising initiatives, projects must bridge research, practice and policy and consider UK-specific climatic, economic and policy contexts to drive change, alongside establishing knowledge networks and ensuring value-chain capacity (Iannetta et al., 2021).

3 | REVIEW OF PAST UK PULSE RESEARCH PROJECTS

3.1 | UK-based projects and international projects with UK partners

The UK has been involved in several multi-collaborator projects with a focus on grain legumes over the last three decades, with projects increasing in frequency since the late 2010s (Figure 2). The overwhelming majority of projects have been funded by the European Union and have focused on a wide range of topics, including diversification, livestock nutrition and protein quality, with the main focus being the environment because of the potential to reduce nitrogen fertiliser usage (Figure 3). Other projects focused on breeding, for example identifying molecular markers for desired qualities like yield productivity and stability to feed into pulse breeding programmes, or on social constraints preventing the uptake of pulses in rotation diversification, carrying out surveys on knowledge gaps and attitudes towards growing pulses.

However, while there has been a significant investment in pulse research which has added value to our understanding of them, this has not translated into precipitating widespread change on the ground, in terms of measurable increases in pulse cropping areas, which lasts beyond the project's lifetime. In fact, field bean area in England was at its lowest level in 10 years in 2024 at 131,700 ha as farmers opted for alternative SFI options instead (Reeve, 2024). SFI options have influenced decisions on crop production and adopting a non-cash crop in some cases has often seen greater profitability. Other challenges include demonstrating the multiple benefits that pulses can bring to a farming rotation (e.g., GHG emission reduction and environmental benefits proven in previous research projects), yet pulses lack widespread adoption. Additional mechanisms therefore need to be put in place to accelerate this impact.

Additionally, there is a gap in empirical scientific studies directly comparing the full natural capital costs and benefits of pulse versus non-pulse systems in a UK systems context, though there have been funded efforts within Europe to achieve this such as projects LegumES, Valereco and Legendary. In the UK, recent empirical measurements from the James Hutton Institute show that pulses such as faba beans can fix very large amounts of nitrogen—over 400 kg N/ha in some systems—which delivers "free" nitrogen into the farming system (Maluk et al., 2022). However, there is no UK-based single study that captures all these benefits in monetary terms, including GHG emission reductions, biodiversity gains, human health benefits and more. Existing evidence strongly suggests that a pulse-based system in the UK can deliver substantial natural capital benefits, and that these benefits have the potential to be recognised through policy payments. But the gap

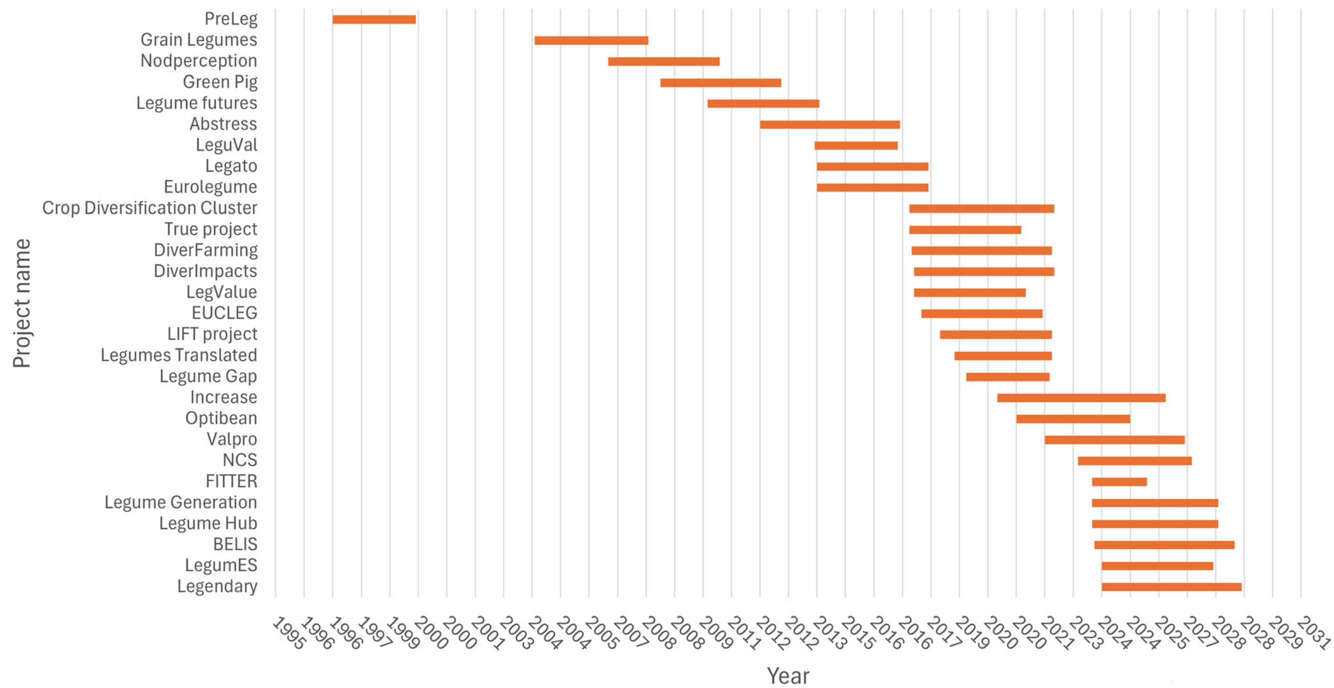

FIGURE 2 Timeline of pulse-based research projects involving the UK.

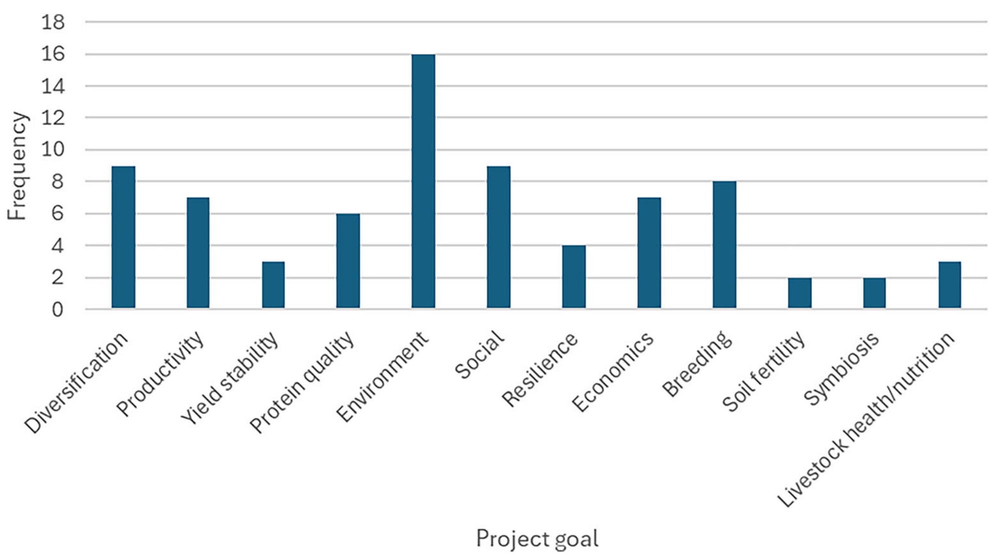

FIGURE 3 Project goals for grain crop pulse projects involving the UK.

that remains is full rigorous accounting over time, comparing pulse versus non-pulse systems with all externalities valued, although it is a challenge to disentangle the change in pulse cropping alone from other system changes (The Protein Project, 2026).

To be able to make an impact from agricultural projects which involve a change in land management to create this impact, increasing the uptake of farmers making these changes on their farm is key, with the backbone of ensuring that it makes financial sense by strengthening the value chain. Here we propose that The NCS project, which began with considering a "Theory of Change" at project conception, could be used as a template for future agricultural research projects where change in land management is a key outcome.

4 | THE NITROGEN CLIMATE SMART PROJECT AS A CASE STUDY

4.1 | Overview and aims

The Nitrogen Climate Smart (NCS) project began in 2023 with a clearly defined "Theory of Change" at project inception, an approach used in academic research projects to plan and track the impact of their research (Wolfe, 2016). Theory of Change approaches are also regularly used in government, where a new policy, programme, or process is being implemented, to ensure that planned activities will lead to the desired short, medium and long-term outputs by considering

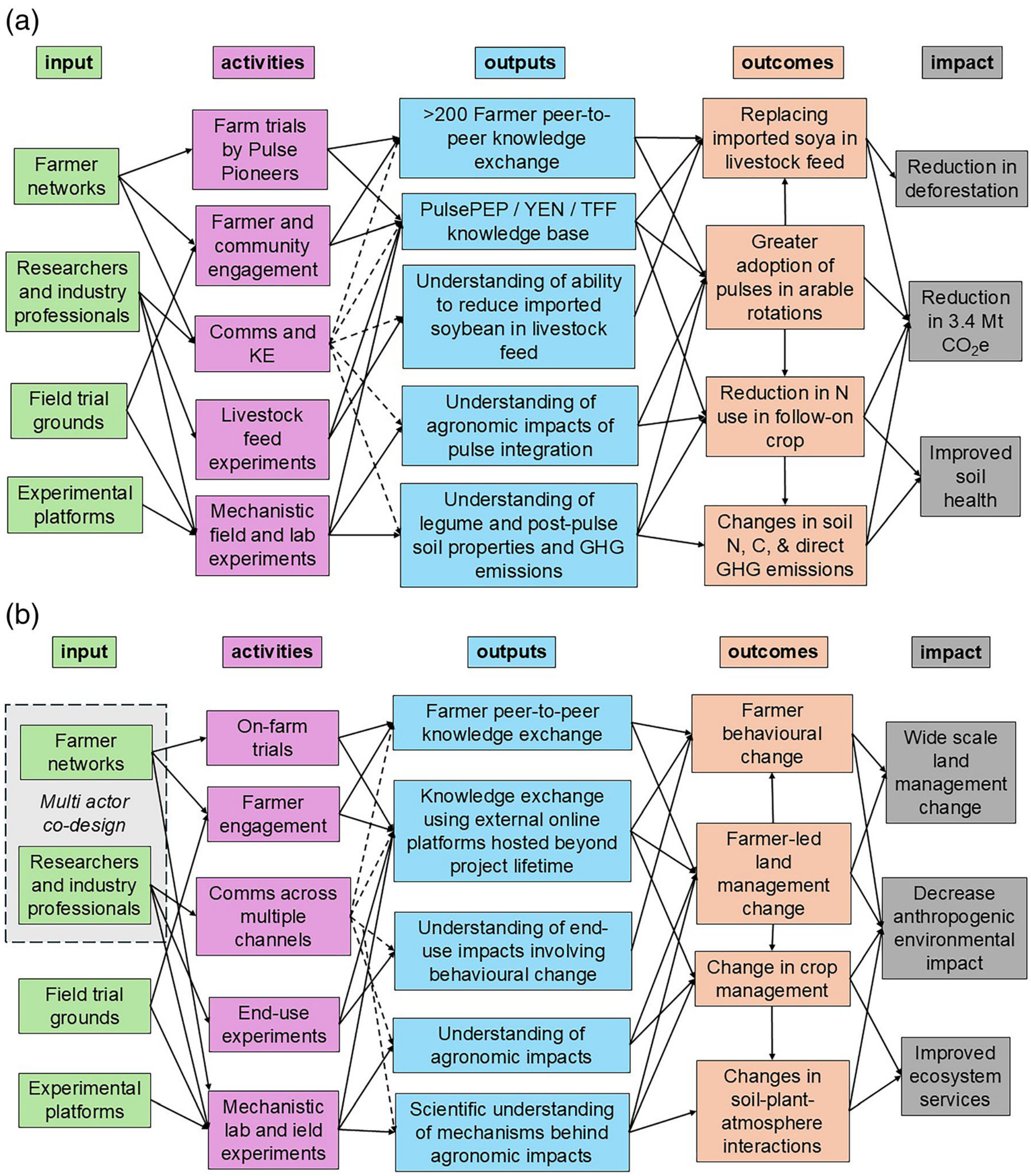

FIGURE 4 Pathways to impact, based on a theory of change for the (a) Nitrogen Climate Smart project and (b) general future agricultural research projects in the form of a transferable framework, aimed at maximising engagement, outputs and impact beyond a project's lifetime. C, carbon; Comms, communications; GHG, greenhouse gas; KE, knowledge exchange; N, nitrogen; TFF, The Farming Forum; YEN, Yield Enhancement Network.

process complexities, key stakeholders and assumptions (Government Analysis Function, 2026). Crucially, a theory of change identifies the causal links between inputs, outputs, outcomes and impact, thus demonstrating how impact can be tracked and achieved through a project or policy lifecycle.

With this approach, the overarching NCS aim of achieving a reduction of UK agricultural emissions by 3.4 Mt CO_2e by encouraging greater incorporation of pulses cash crops in UK crop rotations is broken down to describe a clear, and the most efficient, pathway to the end long-term goal. The Theory of Change for the NCS project structure clearly identifies the causal links between *input-outputs-outcomes-impact* (Figure 4a), and key aspects are explained in more detail throughout sections 4.2–4.6.

4.2 | Levers to impact

Why UK legume production remains low is complex and because of a series of "lock-ins" which are compounded by existing crops and their linked commercial dominance, which in the UK, for example, are cereals such as wheat and barley. Additionally, the true costs of crop production are not accounted for in the current marketplace, highlighting a major project keystone of making pulses become an attractive, profitable alternative to locked-in crops.

The NCS project offers a specific GHG-based approach, with one of the main outputs feeding into policy being whether the potential fertiliser savings and improved feed conversion potentials stack up financially without subsidy. And if not, whether the value of other natural capital and public benefits, such as reduced GHG emissions, improved soil function or water quality, will also need to be evaluated to provide reasoning for financial incentives. Valuing the emissions that are commonly externalised is critical to driving change in practice, as while the emission reductions and other ecosystem services provided by pulse production and soybean meal substitution with pulses continue to be externalised the soybean meal lock-in will remain. Stakeholder engagement is important but if we cannot demonstrate value and commercial demand for pulses, substitution of soybean meal will not materialise.

The NCS project is unique in how it has identified and tries to address the "push-pull" of using pulses in the UK in order to break the "lock-ins" described. For example, the project is designed to address the need for the UK to produce more pulses to fill the demand of soya, but farmers must choose to use soya as a feed to create this demand. However, it is acknowledged that these choices may be beyond control when choices need to be made based on financial margins, and these margins are determined by policies that actively or inadvertently promote the use of internationally traded commodities over locally produced alternatives. Therefore, both production and end use must be addressed within the same project to facilitate these levers.

To achieve this, the Theory of Change stems from the key *input* of a large consortium of industrial and academic partners and farmer networks (Figure 4a) that work collaboratively to promote legume-based systems and their use as livestock feed to reduce nitrogen fertiliser usage and emissions through a flow of causal links. The consortium generates various *activities* and *outputs*, including collation and analysis of existing datasets and legacy trial data, generation of new experimental evidence from field and glasshouse trials, and the creation of a new digital pulse knowledge exchange community, known as the "PulsePEP," to support ongoing dissemination of information and promote peer-to-peer learning (Figure 4a).

4.3 | Farmer engagement as the backbone of impact

It is appreciated that to be able to facilitate any change at all, we are reliant on farmers changing their cropping sequences. The NCS project emphasises meaningful farmer engagement as a cornerstone activity (Figure 4a). Farmers are engaged in all phases of the project, from hypothesis generation to in-field validation, a key step in providing commercially realistic data on risks, costs and benefits for growers wishing to change cropping practices (Hawes et al., 2025). This engagement uses existing *inputs* from long-term farmer networks across partner organisations. Farmer-led field trial *activities* balance both scientific rigour and practical feasibility of pulse integration and enable effective communication channels to support widespread dissemination of research findings.

Since the NCS project's launch, and as of April 2026, a community of 633 members, 347 of whom are farmers and advisors, have joined the "PulsePEP" digital network. This *output* fosters a collaborative environment for knowledge exchange among farmers, scientists and agri-industry professionals with a specialist interest in pulses—a "safe space" within which to share knowledge and experience and for this to be valued. Thought-leading farmers are intimately engaged as project ambassadors and providers of agricultural insights and data, termed "Pulse Pioneers." Building on the concept of Participatory Farmer calls often found in multi-actor projects [see examples within projects such as the "Yield Enhancement Network|YEN" (YEN, 2024) and "DIVERSify" (DIVERSify, 2026)], these farmers are also provided with clear incentives for supporting peer to peer learning through the digital space. The approach of the NCS project represents a modern evolution of existing participatory research models (e.g., Van De Fliert & Braun, 2002), adapting them to a more digitally connected and market-aware context, opening up opportunities to reach a far broader platform for data collection and farmer engagement (van de Gevel et al., 2020). To date, in April 2026, 58 "Pulse Pioneers" have engaged with on-farm trials, with plans to take 18 of these Pulse Pioneers forward for final project trials in spring 2027. These farmers are provided with tailored resources, scientific guidance and financial incentives to ensure active and sustained participation and motivation.

Crucially, the multi-actor approach of stakeholder prioritisation of the field trial *inputs* is balanced with collecting standardised data for cross-site analysis to address research questions important to the project. This is integrated with the *outcomes* from experimental platforms in the scientific-led work packages. Farmers can test their own pulse productivity treatments of interest within a larger cross-site analysis framework. This builds on the concept of the "living lab" approach to ensure that both stakeholder-prioritised research and wider project research questions are addressed. In short, Pulse Pioneers are encouraged to set up comparative field areas of pulse or non-pulse pre-crops and monitor these over several years. Monitoring methods are standardised and the *outputs* recorded through established data collection platforms (YEN and Farm Carbon Toolkit) to enable cross-site analysis (see section 4.5). Farmers can then choose their own sub-trial treatments within the pulse cropping areas following co-design sessions within ideas labs.

Pulse Pioneers therefore contribute to the success of the project, not only through their own on-farm trials but also by playing a vital role in extending its legacy. By promoting pulse production within their own communities and networks, they serve as credible examples for their peers, helping to demonstrate the practical benefits of pulses to other farmers. This peer-led approach encourages trust, a wider uptake of pulses, and enables continued delivery of the project *impacts* beyond the formal funded lifetime of the project.

4.4 | Communication and knowledge exchange

A significant *activity* is dedicated to community engagement (Figure 4a) and features a multi-channel proactive communication strategy, designed to reach and engage diverse audiences across agriculture and beyond. This has been successful, evidenced through monitored engagement metrics, which are at 362,837 impressions across all social media platforms as of April 2026. Key elements include engaging agricultural media, attendance at industry events, podcasts and webinars. Peer-to-peer learning is also encouraged by Pulse Pioneers featuring in content through a range of online communities. Practical resources, such as feeding guides, also translate project data generated by scientists into easily and quickly digestible information and actionable advice for farmers. Communications are targeted towards addressing levers or causal links between the different elements of the Theory of Change (Figure 4a), such as building trust with farmers through co-creation of field trials and incorporating real-world practicality through end-use examples.

The "PulsePEP" digital platform, alongside The Farming Forum and WhatsApp networks, facilitates a central hub for regular updates and discussions among participants, ensuring that knowledge generated through project research is rapidly disseminated and openly shared among farmers, advisors, external researchers and the public.

Additionally, an annual conference named "From Soya to Sustainability," alongside on-farm "Inspiration Days" following the example of LEAF (Linking Environment And Farming), brings together farmers, researchers, processors and retailers. These conferences aim to reinforce the importance of the projects' aims, share findings and strengthen relationships throughout the supply chain—a crucial step towards creating viable end markets for UK-grown pulses. Here, the project demonstrates the value of homegrown pulses to the supply chain; that essentially, once the costs that are currently externalised by the commodity price, climate change, food security, broader rotational and ecosystem services, homegrown protein can feature much more prominently in least cost formulation of livestock rations because of the more favourable comparison with imported proteins such as soya bean meal. This promotes the value for retailer and food service businesses, which the project has sought to engage with to support their recognition of this value and alignment with commitments. Quite often the scale of the opportunity is not understood, but addressing this supports demand generation.

Involving farmers in research is a critically important part of the project model to generate and disseminate knowledge, especially among farmers, who are shown to trust other farmers more than agricultural researchers from academic backgrounds (Rust et al., 2022). Figure 4a illustrates the idea behind the Pulse Pioneers directly involved in the project who share knowledge via the PulsePEP digital platform and community, which can then reach the "Innovation Community," consisting of farmers and advisors who are interested in research outputs and implementing these on their own farm, but are not directly in the research—the early adopters.

4.5 | Integrating multi-scale data and evidence

To maximise the project's research value and impact, data is integrated across multiple scales. Data outputs from farm trial *activity* (Figure 4a) feed into the Pulse Yield Enhancement Network (YEN) database, which collects and benchmarks field-scale data from farmers about their performance, agronomy, soil and weather to aid farmer decision making through annual reports and conferences (White et al., 2022). This extensive database enables aggregated, multi-site analysis of agronomic performance and land management strategies, from which drivers for key system performance indicators (such as: crop yield; yield stability; soil surface N balance, etc.) can be unpicked and presented back to the industry as on-farm guidance, crop system ideotypes and further hypotheses to test within the project. Farm-scale trials are complemented by small-plot and glasshouse experiments, gathering additional data and providing *outputs* on nitrogen dynamics, fertiliser reduction potential and yield performance under more controlled and replicated conditions than are possible at whole-field scale. Together, these datasets create a large, multi-scale evidence base for statistical analysis to provide *outcomes* that improve best growing practice guidance and support the expansion of pulse cropping, particularly among non-pulse growers, which offers the greatest potential to expand pulse cropping across the UK (ADAS, unpublished).

4.6 | From farm to policy impact

The NCS project's scale and structure is designed to generate evidence with both scientific credibility and policy relevance (Figure 4a), such as through publishing in peer-reviewed journals and producing research that aligns with government policy goals of reducing GHGs in agriculture. This impact could inform policy changes, for example, by strengthening the evidence base for integrating cash crop pulses into Sustainable Farming Incentive (SFI) schemes, rewarding farmers for environmental benefits, or informing future updates to nutrient management guides. While UK government incentive schemes such as the Sustainable Farming Incentive (SFI) pay farmers ~£102/ha/year for establishing legumes in grassland, implicitly valuing benefits such as improved nutrient efficiency, reduced nitrogen leaching, enhanced soil structure and reduced runoff—there is no equivalent for UK grown pulse cash crops.

5 | PROPOSING A THEORY OF CHANGE FRAMEWORK FOR FUTURE RESEARCH

The NCS project provides a compelling example of how a well-structured, collaborative project spanning research, practice and policy domains can be used to inform the design of future agricultural initiatives which have a greater influence on creating more sustainable agroecosystems.

We propose this can be achieved by applying a generalised "Theory of Change" framework as outlined in Figure 4b to maximise the impact of future agricultural research projects that lasts beyond their funded duration. The Theory of Change concept is a recognised methodology for planning, monitoring and evaluating an initiative that identifies causal pathways that link actions to outcomes (Weiss, 1995). Using the Theory of Change framework of the NCS project as a case study example, we have demonstrated how this approach can help ensure that project outcomes influence practice, policy and behaviour change across the agricultural sector. This framework highlights the importance of early stakeholder engagement, multi-actor participatory co-design and effective multi-channel communication and knowledge exchange mechanisms. This generates outputs for farmer and wider audience knowledge exchange and better understanding of end use, behaviour agronomy and fundamental mechanisms. These in turn generate outcomes of behavioural, land and crop management change. Co-developing activities and outputs from project inception can increase the likelihood that project outputs lead to impactful and measurable transformation of the agrifood supply chain.

Research on farmer-participatory approaches consistently finds that, compared with traditional top-down research, projects that engage farmers as co-designers achieve stronger participation and produce innovations more relevant and representative of real farming systems (Van De Fliert & Braun, 2002). However, many of these initiatives remain small in scale and lack links to market or value chains (Pagliarino et al., 2020). Rather than relying on more traditional local "field school" models for farmer-to-farmer dissemination, linking farmers through national and online communities, supported by a variety of digital communication and data platforms that aid cooperation and trust in agricultural innovations, is a more modern approach (Bekee et al., 2024). By integrating a national farmer network with on-farm trials, supply-chain collaboration and embedded climate and production targets, this approach transitions participatory research from simply localised experimentation towards system-level implementation enabled by farmer behavioural change and ultimately changes in land and crop management.

Renewed interest in pulse-based research reflected by an upturn in funding reflects the recognition of their potential to reduce UK agricultural emissions that contribute a significant share to the UK's overall climate impact. To ensure future initiatives deliver long-lasting benefits, project design must integrate a collaborative input approach across the agrifood chain, from farmers and advisors to industry, retailers, researchers and policymakers. This approach promotes the co-development of practical and scalable solutions to maximise adoption and momentum beyond the project lifetime by ensuring a viable end market for economic sustainability. The proposed, more widely applicable, Theory of Change (Figure 4b) provides a transferable framework to guide future research programmes towards impact to unlock their climate mitigation potential and contribute to more resilient, biodiverse and nutritionally robust food systems. This in turn can lead to impacts which are beyond a project's initial scope such as implementing wide-scale land management change, leading to a notable decrease in anthropogenic environmental impact and improved provision of ecosystem services.

6 | CONCLUSIONS AND OUTLOOK

The NCS project demonstrates how agricultural research projects, if designed with a Theory of Change model from project conceptualisation, involving clear farmer and supply chain participation, can deliver widespread land management change, enabling measurable and long-lasting environmental impact. Using pulses as an example, we have illustrated that well-established scientific knowledge alone does not drive change without mechanisms to bridge the gaps between research, practice and policy. By embedding farmers as co-designers, supporting on-farm trials and sustaining dialogue between farmers, supply chain partners and academic research through digital platforms, the NCS project structure broadens participatory research to achieve system-level implementation rather than isolated local innovation alone. Integration of collected farm-representative evidence, peer-to-peer learning and supply-chain collaboration can extend impact translating into land management change beyond the project's lifetime, while strengthening the evidence base for policy incentives that support climate-smart farming. We therefore propose that in the initial design phase of future agricultural research projects, cross-sector and digitally connected frameworks should be adopted which connect scientific, economic and social objectives, to accelerate the transition towards more sustainable agroecosystems which are measurably closer to national net zero targets.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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