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Finding common ground: Co-producing national soil policy in Wales through academic and government collaboration

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ABSTRACT

Several agricultural reforms are in progress in the UK following its withdrawal from the EU. This is an opportunity to formulate a Welsh Soils Policy Statement (SPS) that raises the status of soils and ensures that their protection and sustainable management are integrated into future policy. We share and reflect on our novel approach at co-producing a SPS for Wales involving academic researchers and policy teams and provide clear insights into soil policy development. Building consensus among the various government departments and agencies formed the basis of our approach. For pragmatic reasons, it was decided to focus on agricultural soils, which cover 85% of Wales. A rigorous evidence review and synthesis formed the foundation for the development of the SPS, which devises a vision, and primary and secondary objectives for Welsh agricultural soils. A first draft was conceived by the researchers, with further iterations developed between the researchers and the policy team. The researchers were embedded into the policy teams, and this proved to be an effective mechanism for evidence-based policy development that also enhances the science-policy relationship in the longer term. New structures and incentives that promote the engagement between researchers and policymakers should be developed to support environmental policymaking across the board.

1. Introduction

Soils sustain life and provide ecosystem services that are central to reaching many of the United Nations' Sustainable Development Goals (SDGs) (Keesstra et al., 2016; Lal et al., 2018). Almost all the food we eat relies on soil and it plays an important part in global water cycles, climate regulation, and climate change mitigation and adaptation. However, soils worldwide are at threat from poor management and climate change and their degradation is accelerating (FAO and ITPS, 2015). Soil is considered a non-renewable resource because the depletion of soil from human activities is far greater than the natural rate of soil formation.

Developing a soil policy is one key factor in achieving sustainable soil management. A policy is strategic guidance on how government objectives will be delivered. Policy making is an ongoing process for government. Developing policy is difficult, often with no simple solution that benefits everyone. Firstly, it must consider if the policy is justified, the evidence supporting it and the benefits from introducing it. It must also balance the benefits with financial costs and potential negative impacts on *any* sectors of society or business that may be affected. Policies can be subject to high level legal challenge, and any policy can be overturned if the evidence is perceived as uncertain and its potential negative impacts risky.

Regulation, voluntary based incentives, and knowledge exchange all play an important part in delivering policy. One reason for policy is to create a change, which is best adopted when the people most affected believe there is a good reason to do so, but this is not always easily achieved in practice. Knowledge exchange, societal acceptance and awareness raising are probably the most important factors in making policy effective. Voluntary incentive schemes provide support and funding to motivate the adoption of new ideas and hopefully change behaviours in the longer term. Regulation is the legal benchmark below which an activity is socially and/or environmentally unacceptable and, as such, it should stop damaging activities if other approaches fail.

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Regulation can be very effective if correctly resourced, implemented flexibly and efficiently. Robust penalties will be needed at times to provide a deterrent. It is important that people being regulated are made aware of why it is important to comply (i.e., encourage normative compliance), rather than just to be told what the penalty is (i.e., instrumental compliance). In this way, regulation can play an important role in behavioural change, but it is not the single best solution for adoption of change, it is only one part of it.

Implementing effective policy and regulation (not just for soils) can be challenging. Clear, consistent, and evidenced messaging is important as well as having skilled, committed and adequately resourced advisers and enforcers on the ground. Easy availability of guidance and data also helps success. For instance, Welsh Government has a policy to protect the Best and Most Versatile (BMV) agricultural land from loss to development (Planning Policy Wales, 2021). While the BMV policy is not a ban on soil sealing, it ensures significant consideration in the planning system. In 2017 (updated in 2019) the Welsh Government introduced a new online map of land quality in Wales, to identify the BMV land areas for planners and land developers. This used modelling of the highest resolution soil data available for Wales, combined with detailed climatic and terrain data. In this way, the resource protected in the policy can be easily identified at an early stage in a development proposal, when there is more opportunity to discuss options. This makes policy implementation much easier and more effective.

While effective soil policies are fundamental for the protection and sustainable use of the soil resource, the complexities involved in soil policy development, such as the alignment of socioeconomic, environmental, and political components, are partly responsible for the general lack of specific soil policy worldwide. In addition, the absence of an overarching soil policy framework that sets the direction of travel at a high level further complicates the development of long-term solutions (BSSS, 2022). Globally, while most countries have policies or legislation referring to soil, just under half of those have adopted some level of soil protection and only a minority (15%) have published specific soil policy (Peake and Robb, 2021).

At the national level, soil policy making becomes more intricate as the severity and extent of global soil threats are not always representative of specific national issues due to local controlling factors of soil degradation like climate, soil, and type of soil management. Even within a country, regional differences may be significant. In the context of Wales, soil erosion and formation rates are in balance in many Welsh grasslands (Tye et al., 2021), despite soil loss by erosion from agricultural land being a well-recognised global threat to the soil resource (FAO and ITPS, 2015). Other difficulties faced by countries and states (e.g., financial) might pose further challenges along the policy pathway. With no simple solution, addressing the specific context and needs of each territory while maintaining a global outlook becomes vital when developing relevant and applicable soil policies (BSSS, 2022; FAO and ITPS, 2015).

Several attempts have been made to develop soil policy over the last decades. Although the EU Soil Strategy was recently adopted by the European Commission in 2021, this was preceded by unsuccessful attempts. In 2006, the EU introduced the landmark soil protection policy, the 'European Soil Framework Directive', but it was later withdrawn in 2014 due to strong opposition from several member states, becoming the only environmental Directive to have been rejected in the EU (Chen, 2019). The `EU Soil Strategy for 2030′ was launched within the framework of the European Green Deal (European Commission, 2021). A key objective in the European Green Deal is improving the well-being and health of citizens and future generations by providing *'fresh air, clean water, healthy soil and biodiversity*' (European Commission, 2019). The suitable policy space created by the European Green Deal, coupled with the learning from the previous failure and an increased public and political awareness of the significance of soils are likely to be important elements in the successful adoption of the EU Soil Strategy (Köninger et al., 2022).

In the United Kingdom (UK), soil-related policy is devolved to each of the four nations (England, Scotland, Wales and Northern Ireland). Soil protection in Wales is considered more advanced than its neighbouring nations and has been recognised as a ``global standard bearer of soil governance'' (Peake and Robb, 2022). This recognition partly results from the protection of BMV agricultural land in Wales (determined by the grades assigned via the Agricultural Land Classification system (MAFF, 1988)) in Planning Policy. About 10–15% of Wales is graded highly enough to be classified as BMV land, representing land capable of sustaining high agricultural productivity (Welsh Government, 2019a). Development on BMV land is only considered "if there is an overriding need for development, and either previously developed land or land in lower agricultural grades is unavailable, or available lower grade land has an environmental value recognised by a landscape, wildlife, historic or archaeological designation which outweighs the agricultural considerations" (Planning Policy Wales, Edition 11, paragraph 3.59). While this policy is progressive and important, it ultimately protects a small area and is limited only to soils that deliver highly productive agriculture. Therefore, there is a lack of specific soil policy that recognises and protects a wider range of soil services.

Although, in recent decades, attempts have been made at developing soil policy in Wales, these have not succeeded. The Welsh Soil Strategy (2002) and Welsh Soil Action Plan (2008), failed to be implemented for a number of reasons, including their wide remit (Welsh Government, personal communication, 2023). Additionally, the public awareness of threats to soil was different compared to the present day. Since 2008, the withdrawal from the EU has created the opportunity to develop an overarching soil policy, stimulating dialogue between policy teams and triggering a reform of agricultural policy in Wales. This, coupled with the publication of several landmark national policies (the Well-Being of Future Generations Act 2015, the Environment (Wales) Act 2016, and the Agriculture (Wales) Bill 2022) and an increased public recognition and awareness of the importance of soils has opened a window of opportunity to develop specific soil policy in Wales (see Section 3 for more details). The intention is to start by raising awareness and building consensus between stakeholders through the development of a Soils Policy Statement (SPS) for Wales. The aim for the SPS is to bring together soil policy ambition into one place, from which different policy mechanisms can deliver on the overall aims and objectives set out in the SPS.

The purpose of this interdisciplinary article is to share and reflect on our approach to developing a SPS for Wales. This approach involved three major phases: i) a rigorous review and synthesis of the evidence base which formed the foundation for ii) the development of the SPS, and iii) a co-design with farmers, Welsh Government policy teams and other soil stakeholders. This article focuses on the first and second phases, the evidence review process and the development of a draft SPS. Science-policy interfaces are key to support the policy development process (Holmes and Clark, 2008). We used a collaborative approach between academic and independent researchers and policy teams (Soils Policy and Land Use Team, Strategic Evidence, Forestry, Biodiversity, Landscapes, Agriculture) and established approaches to identify and review the evidence base and translate this into a SPS. Evidence-based policy development is an area of increasing interest as the importance of evidence transfer into policy is now more widely acknowledged than in previous decades (Holmes and Clark, 2008; Young et al., 2014).

Although an evidence-based approach to developing policy is recognized for being effective, rigorous and transparent, integrating scientific evidence into policy remains a challenge and the approaches followed to achieve this are often unclear (Davies et al., 2000; Juntti et al., 2009). This paper adds to the growing body of literature trying to understand why evidence translation into environmental policy is not always straightforward (e.g., Holmes and Clark, 2008; Maas et al., 2022; Oliver et al., 2014; Young et al., 2014). We reflect on our experience working at the interface between science and policy and provide specific insights into the translation of evidence into a SPS. The final co-design

phase added further qualitative evidence on specific local issues and was used to revise the SPS and develop a final version (which will be covered in a separate article).

Learning from previous attempts at developing soil policy is key for maximizing the success of policy adoption and this forms the basis of our approach. This approach aimed to:

1. *Focus the policy remit* on agricultural soil;
2. *Capitalize on the right timing* from major policy changes due to the UK withdrawal from the EU and the development of Welsh agricultural policy; and
3. *Develop consensus* by conducting an independent review of the evidence base specific to Wales (i.e., locally specific to Welsh soil, climate and land use), and aimed at being rigorous, transparent, accessible and inclusive. A stakeholder co-design followed the review to inform and shape policy development.

2. Reducing the remit: A policy focus on agricultural soils

Soil types and their associated land uses and climate relationships are diverse and can make the development of policy relevant to all soils complicated and, in some cases, contentious. This has resulted in previous soil policy being delayed or opposed due to complications with, for example, contaminated soil. We decided to narrow the focus to 'agricultural soils' to develop the initial SPS in Wales, with potential to expand later. In this context, agricultural soils are defined as 'soils under agricultural management for crops, grasslands and seminatural habitats' (Button et al., 2022). While this narrowed the focus and excludes other areas like urban soil, agricultural soils under this definition actually cover around 85% of the total area of Wales (Wiseall, 2018). Agricultural soils are also highly relevant to the policy landscape given the contemporaneous reform of agricultural policy in Wales that involves the Agriculture (Wales) Bill, introduced in September 2022 (a Bill is a draft law in Welsh Parliament), and the development of the Sustainable Farming Scheme (July 2022) that replaces the Basic Payment Scheme (Welsh Government, 2022).

The goals for the development of the SPS (Fig. 1) are to:

1. Set out a high-level statement of ambition for the sustainable use of soil in Wales. The starting point is agricultural soil, given this constitutes the largest area of soil in Wales under management. However, policy should be seen as a holistic, joined-up aspiration and work in progress, and as the policy develops, other areas of soil could be considered for inclusion.
2. Place soil-focused policy ambition in one statement rather than spread across a number of bills or acts. This is a first for the Welsh Government and with a dedicated SPS any other soil-related policies would need to consider and address the sustainability of soils.
3. The SPS will set a direction of travel. The intention is to start simply by keeping it short and to the point, and build on the SPS, with opportunity to revise in the future.

3. Right timing: The opportunity space for developing new soil policy in Wales

There has been a significant policy spotlight on soils over the last few years, resulting in the development and adoption of soil policy or strategies in a number of nations and regions (Peake and Robb, 2022). In 2021, the European Commission adopted the EU Soil Strategy for 2030. The strategy is a framework for sustainable use of soil, setting out concrete measures to protect and restore soils to achieve healthy soils by 2050. A proposed EU Soil Health Law in 2023 would provide a legal basis for the strategy, giving soil the same status as air and water. National policies include the Swiss National Soil Strategy adopted in 2020 by the Federal Council to ensure that soils can continue to perform their services for society and the economy (Swiss Federal Council, 2020). It has six key objectives covering land take, reducing degradation, restoration, awareness raising and international collaboration. Australia's first national policy on soil, the National Soil Strategy, was published in 2021 (DAWE, 2021). The 20-year strategy aims to protect and restore soils via co-ordinated research, education and on-ground action, supported by soil monitoring and governance.

These recently developed national soil policies have focused on issues relevant to national soil threats or pressures. For example, a key objective in the Swiss Soil Strategy is no net land-take due to significant land use pressures exacerbated by the unique topography. Thus, development of soil policy should reflect the national context so that effective policies can be designed and implemented. The soils and agricultural landscapes in Wales are distinctive and understanding this is important to ensure policy is aligned to a Welsh specific context and does not include irrelevant objectives. Wales is relatively unusual when compared with most of the UK and other European countries in several ways. It is characterised by very high rainfall (1000–3000 mm y^{-1}); a large area of uplands (28% of Wales lies >300 m.a.s.l) and a high proportion of land in agricultural use (>80% of Wales) (Cranfield University, 2016). For most of Wales, the climate and landscape limit land working opportunities, which reflects the small extent of highly productive horticultural and arable land (4%) and the large extent of improved (44%) and semi-natural grasslands (23%) (Morton et al., 2020). The limiting climate and landscape have enabled the formation of organic soils (i.e., peat and organo-mineral soil), which despite only covering 20% of Wales contain 48% of the soil carbon stock (ECOSSE, 2007).

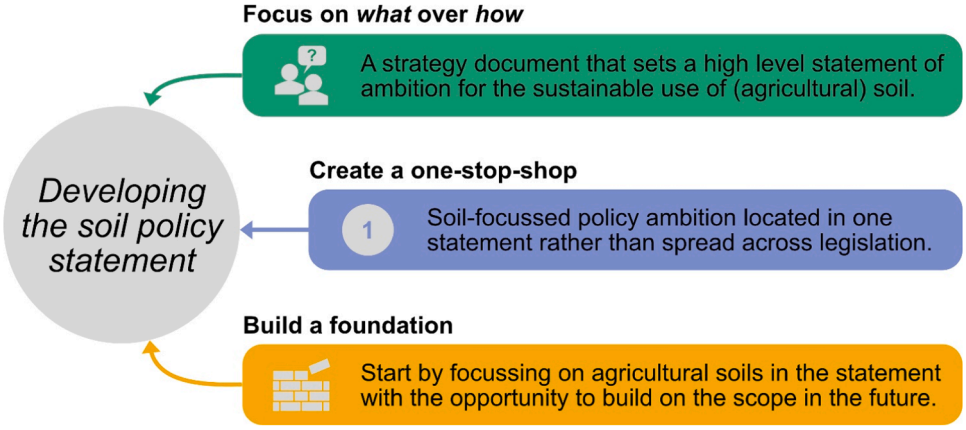

Fig. 1. Goals for the development of the Soils Policy Statement.

The Welsh agricultural and environmental policy landscape is under significant flux, and new agricultural policy reform is currently under development. In recent years, the Welsh policy landscape related to soil has been driven by three landmark policies which represent the structure within which all policies should be framed. First, the Well-Being of Future Generations Act 2015 (WBFG Act 2015), which places a duty on the Welsh Ministers, as a public body, to work to improve the ``social, economic and environmental and cultural well-being of Wales by taking action in accordance with the principle of sustainable development, aimed at achieving the seven well-being goals.'' Maintaining and enhancing soils supports a globally responsible and resilient Wales. Second, the Environment (Wales) Act 2016, which set the regulations and future direction for sustainable land management and beyond, including ``better managing soil and safeguard our best and most versatile agricultural land to improve soil quality, productive capacity and its resilience to degradation'' and ``better soil management for carbon storage and sequestration''. By law, numerous actions must be taken by public bodies, including the Sustainable Management of Natural Resources (SMNR), creation of greenhouse gas emission reduction targets, implementing The Biodiversity and Resilience of Ecosystems Duty for public authorities and compiling a State of Natural Resources Report (SoNaRR) every 5 years. In addition, there is a requirement to produce a Natural Resources Policy (NRP) which sets priorities to deliver nature-based solutions and increase renewable energy and resource efficiency. The NRP also enables delivery of priorities at a local level, through the creation of Area Statements. The third landmark policy is the Agriculture (Wales) Bill 2022, which is underpinned by the principles of Sustainable Land Management and outlines the framework to provide agricultural support to Welsh farmers (Fig. 2).

All policy areas in Welsh Government need to address how they meet the aims of the first and second landmark policies, especially in the context of climate and biodiversity crises. In addition, three major recent events have further driven the policy direction. These are: the UK's withdrawal from the EU, which triggered the biggest reform in agriculture policy for decades; and the declarations of climate and nature emergencies in Wales in 2019 and 2022 that acknowledge these challenges and set important context and targets for future legislation (Fig. 2). Altogether, these have directly or indirectly resulted in soil-relevant legislation aimed at driving action on the climate and nature emergencies and achieving the sustainable management of natural resources – the target principle of land management in Wales.

Fig. 2. The recent soil policy drivers in Wales highlighting the relevance of soil to different agricultural, environmental, and developmental legislation and how the Soils Policy Statement could overarch these to better achieve the goals of climate and nature action and sustainable management of natural resources.

Although soil is directly referred to in legislation like the Environmental Impact Assessment Directive and in UK components related to forestry and agriculture, it is not explicitly protected by any Welsh policy. A dedicated SPS would ensure consistency across the Welsh Government and provide protection from adverse impacts and legitimacy in challenging conflicts with other policies (Fig. 2).

4. Building consensus towards a draft policy statement

4.1. Evidence review process

For policy development to be well-informed, effective and transparent it is essential for it to be based on appropriate evidence that includes a variety of sources (Parkhurst, 2017). This also facilitates understanding in the target audience regarding the problem and the need for a policy. To achieve this, the first step was to conduct an independent review of best available evidence to identify the status of Welsh soils and their future threats. For the SPS to be objective and representative of the best available evidence, a collaboration between the Welsh Government Soil, Peatland & Agricultural Land Use Planning Unit and academic researchers was sought to synthesise extensive evidence specific to Welsh soils. Rather than commissioning the work externally, three researchers were seconded into the policy team through a research fellowship and two PhD student placements as part of the Welsh Government's Doctoral Training Policy and Evidence Programme, which provides a framework for researchers to work directly with policy teams. The duration of these secondments differed, lasting from three to six months for the PhD placements, and 18 months for the research fellowship.

The collaboration played to the strengths of the policymakers and the academic researchers. While the soil policy team has domain knowledge and expertise on soils, agriculture and ecology, the team lacked the capacity and resources to carry out a job of that scale in-house. Embedding researchers into the policy team also provided Welsh Government with the opportunity to try an innovative approach to policy making, engagement and evidence communication, and to improve the links between academia and government in the long term. The researchers provided an independent perspective and interpretation of the evidence and put the research into context according to current thinking in soil science research. The researchers were also able to challenge and evaluate evidence that the Welsh Government would not have expertise or capacity to do. This independence and robustness of the review process helped to overcome previous challenges to the evidence base on which policy was being developed.

Compared with the approach where evidence reports are commissioned externally, the embedded nature of the researchers in the policy team facilitated fluid communication and exchange of expertise by allowing time and space for discourse. For example, scheduling regular weekly meetings to discuss the project and progress on the evidence review allowed for greater understanding, while also helping to refine and adapt the researchers' communication and presentation skills. Although most interactions were online, as remote working was in place due to COVID-19 restrictions, maintaining regular communication and developing a shared language throughout the duration of the secondments was key for quickly building a trusted relationship. The policy team were available to the researchers to consult with throughout the project development. They supported the embedded researchers with policy context and resources by inviting them to participate in regular business meetings with senior policymakers and committees, and provided links with other policy teams, agencies, and research expertise. This exposure boosted the researchers' understanding of the wider policy context and policy development within Welsh Government, and of the motivation behind the evidence synthesis and the SPS. It also

helped to set the tone and language in the evidence review, ensuring that it was appropriate for Welsh Government policy teams, informed readers, and wider audiences. Overall, the researchers had a much better overview and understanding of the policy drivers and needs, and the independent review could effectively address these, being better placed in the current policy context.

In the absence of time and available evidence for a systematic approach (i.e., meta-analysis) to the evidence review, we followed the four governing principles of evidence synthesis to ensure the review was robust and fair (Fig. 3; Donnelly et al., 2018). The principles are:

1. **Rigour:** we used the most comprehensive and feasible body of evidence available within the timeframe (6 months). This timeframe was designed so that policy decisions could be made within a short window of opportunity aligning with the development of the post-Brexit Agricultural Policy in Wales, maximising its success. The evidence synthesis started with a review of the Welsh Government Soil Policy Evidence Programme (SPEP) and the associated Capability, Suitability and Climate Programme (CSCP). These contain detailed reports and topical syntheses of multiple documents (e.g., Cranfield University, 2016; Rollett and Williams, 2019), that were commissioned by the Welsh Government's soil policy team from independent specialists and experts in response to policy needs. The policy team provided information on the motivation behind the commissioning of each of those reports. This evidence was augmented by key sources, such as the State of Natural Resources Report (SoNaRR; NRW, 2020) and additional evidence from published scientific literature. The focus was to target evidence relevant to Welsh soils and agriculture (e.g., extent of soil erosion in Wales), but where this was lacking, evidence from parallel or similar contexts were used (e.g., soil erosion in England) and explicitly stated (see point 2 below). The policy team provided the reasoning and policy needs behind the commissioned reports as part of their evidence programmes and where further information or clarification was needed, they facilitated communication with the original authors. However, the researchers decided what evidence was ultimately considered in the synthesis. Having the researchers embedded in the policy team also facilitated rigorous challenges and open discussions between researchers and policy makers, which helped to contest beliefs or unconscious bias based on inherent familiarity of information, emotions and background.
2. **Transparency:** policy decisions occur in brief windows of opportunity which often involve developing recommendations under uncertainty (or incomplete evidence) as there is limited time to gather more evidence (Juntti et al., 2009). Such evidence-gathering often requires long-term research, although it is worth noting that policy evidence-gathering should be an ongoing process so that relevant evidence is available when needed. To make the synthesis more transparent to policy and to a wide range of stakeholders, uncertainties and complexities associated with specific evidence were highlighted, and where evidence was insufficient, gaps were identified. These included, for example, the lack of field data on soil erosion rates to validate models (Tye et al., 2021), the lack of evidence on soil organic matter content in Welsh arable soils, or the limited evidence on soil compaction across agricultural soils in Wales (Button et al., 2022; Rollet and Williams, 2019). The wider Welsh policy context was also summarised to evaluate how the development of a SPS would be informed by and inform wider policy objectives.
3. **Accessibility:** academic work is often perceived as inaccessible because of the frequent use of acronyms, jargon or technical information that is a major barrier to policy translation. In addition, different language is also used between the stakeholders involved in the policy development process, whether a researcher, policymaker, farmer, politician or non-governmental organisation (Glied, 2018). To overcome this, the evidence synthesis was aimed at a 'public' audience (i.e., a range of stakeholders) from the start. Accessible and plain language was a priority design criterion that arose from the frequent and fluid communication with the policy team facilitated by the embedded nature of the collaboration. For this, the evidence synthesis was written in plain language with the use of infographics facilitating the communication of key messages with multiple stakeholders. The synthesis was proofread by non-technical personnel and made available online. An executive summary that concisely highlighted key evidence was published alongside the reference document. The evidence review was translated into the Welsh language, a legal requirement of the Welsh Language Act 1993. The Welsh language is also an important part of the identity of

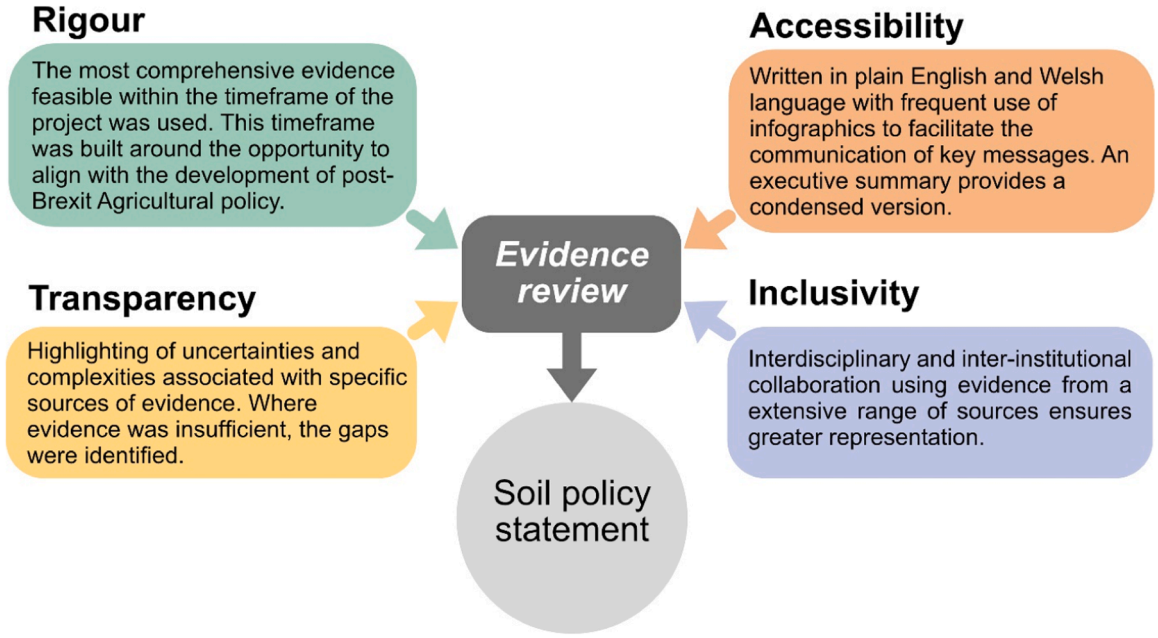

Fig. 3. The four governing principles of evidence synthesis that were followed during the development of the evidence review which formed the basis of the Soils Policy Statement.

the farming stakeholders; 43% of agricultural workers speak Welsh, compared to 17.8% of the general population (Welsh Government, 2019b; 2021).

4. **Inclusivity:** the evidence synthesis was co-developed with the Welsh Government soil policy team and reviewed by a wider policy steering group. The embedded nature of the researchers also facilitated collaboration with researchers from different disciplines, such as social sciences, providing a broader perspective and insight into relevant methods. For example, the farming and cultural context in Wales used to frame the evidence review was informed by discussions and work conducted by the Strategic Evidence Unit in Welsh Government, which has a cross-portfolio understanding of the current evidence base to tackle the climate and biodiversity agendas, with particular emphasis on interdependencies.

4.2. Main outcomes of the evidence review

The evidence review identified the current status, future threats, and opportunities of Welsh agricultural soils, and clearly highlighted the uncertainty and evidence gaps associated with these (Button et al., 2022). What follows is a short description of the key messages from the evidence review.

Welsh agricultural soils deliver key ecosystem services such as the supply of food and timber, water regulation and filtering, and play a key role in regulating climate. In Wales, the large proportion of agricultural land under permanent grassland alongside the wet climatic conditions and the characteristic geology result in an overall low risk of soil degradation and a relatively high carbon content when compared with most soils in England or Europe. However, the sustainable use of Welsh soils is threatened by inappropriate management. The agriculture sector in Wales is strongly centred around livestock grazing, sheep in particular (Wiseall, 2018), so even if grasslands are associated with low degradation risk, this is highly dependant on the intensity of their management for grazing (i.e., the type of grassland, type of grazing activity or stocking density). At the same time, some of the risks associated with soil degradation, such as the risk of soil erosion, can be high in specific areas of Wales such as bare land, light-textured soils and/or steep slopes.

Welsh soils are also threatened by future changes in land use in response to climatic, socio-economic, and political factors. Among these are irreversible building development on agricultural soils. However, Welsh agricultural soils face the opportunity to adopt land use changes that will maintain and enhance the soil carbon stock and help achieve Net Zero by, for example, restoring degraded peatlands or increasing tree planting in the right locations.

Climate change represents another major threat to soils. In Wales, climate change is causing wetter winters, drier summers, and more frequent and intense extreme weather events, like flooding and droughts (IPCC, 2022). This has negative consequences on soil functions and ecosystems services. For most of Wales, longer and warmer growing seasons mean an improvement in the agricultural potential of the land until 2050, after which land quality is expected to decline in response to limitations from drought. In addition, these changes may exacerbate current threats, such as soil compaction and erosion, due to longer grazing and land working seasons.

4.3. From the evidence review to a draft soils policy statement

A draft SPS, informed by a theory of change, was developed with the soil policy team drawing on the evidence review. We used the following definition of a theory of change ``a method that explains how a given intervention, or set of interventions, are expected to lead to a specific development change, drawing on causal analysis based on available evidence'' (UNDG, 2017). In this context, the development change is the vision for the SPS that represents the intended policy outcome ``resilient agricultural soils that provide services for current and future generations through sustainable soil management''. The causal analysis represents the pathways or interventions needed to achieve the vision (primary and secondary objectives), where the selected objectives were principally informed by the evidence review (Fig. 4).

A draft SPS was initially conceived by the researchers drawing on our previous learnings from the process of the evidence review, distilling complex information into core statements and using accessible language for rapid assessment by policy teams and wider stakeholders. The researchers developed the initial draft because they had written the evidence review, were familiar with the key messages and, in the view of the policy teams, had the impartiality necessary to shape the main objectives for the SPS. The initial draft was further developed in an iterative process between the researchers and soil policy team, which involved discussions and challenging of key points. For example, the soil policy team has responsibility for advising on the application of planning policy in respect to the development of agricultural land. Much of the commissioned evidence review and expertise in the team was related to this topic, yet this had little relevance to the SPS, which dealt with agricultural land in the broadest sense. We were able to draw on the breadth of knowledge from the wider evidence review to effectively articulate this 'omission' from the SPS with the policy team. We also considered the language in the SPS to avoid using negative messaging or instructive language for example using `how' or `demonstrate' to be more neutral, rather than `achieve' which implies setting targets. The draft SPS produced was succinct (< 4 pages) to maximise its impact and provide a readily digestible overview of the ambition for sustainable management of soil in Wales.

With the policy team, we developed three overarching objectives for the draft SPS (Fig. 4): 1) reduce soil degradation, 2) maintain and develop soil monitoring, and 3) exchange knowledge. The first two were informed from the evidence review that identified current status and future threats to soil in Wales. While the evidence review indicated these threats were generally low on a national level, there were hotspots of high risk, and/or risk could increase in the future due to changing land management or land use, or in response to climate change.

To select the secondary objectives that focus on specific aspects of soil degradation we first considered a 'soil-centred' policy approach based on key components in the evidence review that impacted directly on the soil resource and the resulting provision of services and functions (Fig. 4). For example, soil carbon, an essential component of soil and active in multiple functions (e.g., carbon storage, soil structure, soil resilience) was included. Soil nutrients were not included at this stage as the primary impact of excess nutrients in soil was on the wider environment (reduced water quality), rather than directly affecting the soil. In addition, nutrient application to land is regulated by other policy instruments such as The Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021. The secondary objectives selected using this logic were: maintaining and enhancing soil organic matter, reducing soil erosion, reducing soil compaction and fostering soil biodiversity (Fig. 4).

Maintaining and developing soil monitoring and modelling was included as an objective as there were many evidence gaps highlighted in the review which necessitated further data or modelling. In addition, much of the Welsh-focused evidence on soil condition was based on existing national monitoring schemes (Glastir Monitoring and Evaluation Programme), providing an important source in the evidence synthesis. This objective has multiple benefits for achieving the SPS vision by: 1) providing additional evidence at different scales (national and local) so that policy can be adjusted accordingly in the future; 2) being able to evaluate policy outcomes (i.e., are we achieving resilient agricultural soils?); and 3) feedback data to land managers who are responsible for implementing actions (e.g. soil management requirements for payments under the emerging Sustainable Farming Scheme) that can be linked to the policy.

The inclusion of knowledge exchange did not stem directly from the evidence review as the focus of the review was to identify the status and threats to Welsh soils, rather than how or why they are managed.

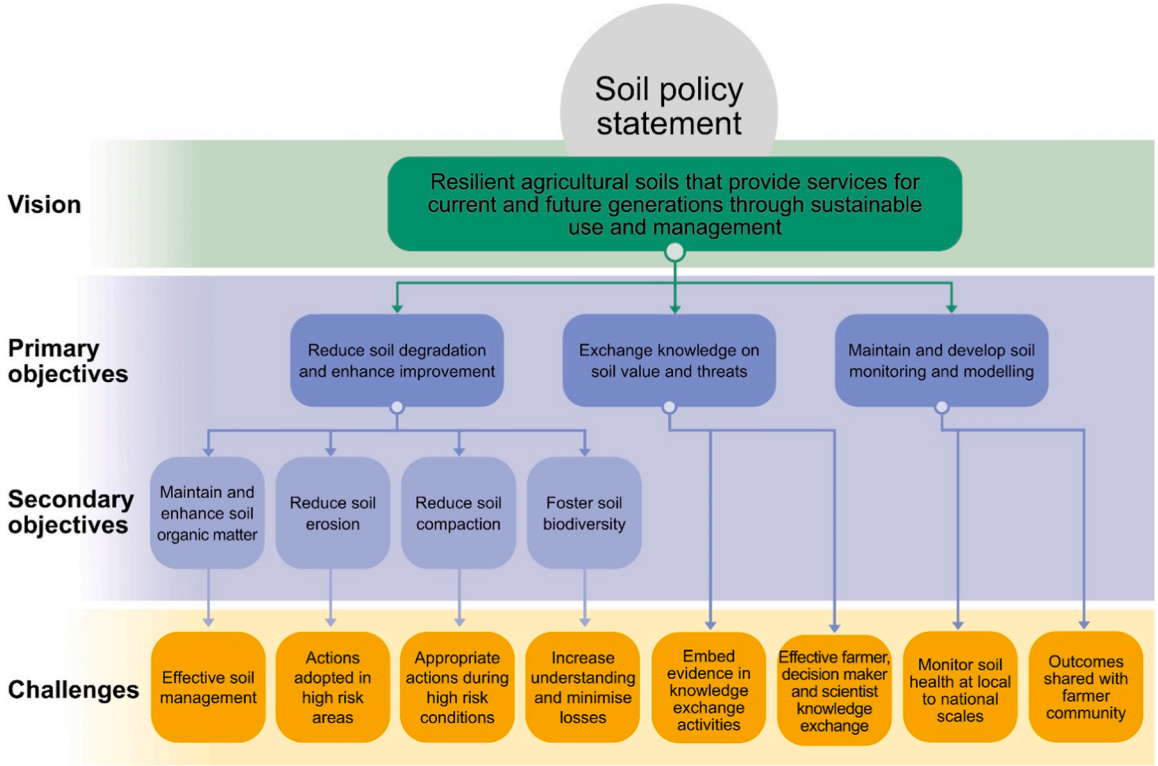

Fig. 4. Development of the framework for the draft Soils Policy Statement using the concepts of theory of change.

Knowledge exchange was an ongoing topic of discussion during the review of evidence and development of the draft SPS and was highlighted by the soil policy team as an important component of policy development and implementation. Knowledge exchange within the science-policy-farmer interface is crucial to the uptake of sustainable soil management actions necessary to meet the objectives of reducing soil degradation identified in the SPS. Support, knowledge and advice has been recognised at international and national levels as key to assisting farmers to transition to practices that can achieve sustainable soil management (de Bruyn and Ingram, 2019; FAO, 2017; Ingram et al., 2022). There are numerous complex and interacting socio-economic factors (e.g., market forces, education, knowledge, psychology, agronomy, environmental context) that can explain the adoption of sustainable soil management actions by farmers, and underpinning these factors is knowledge exchange; i.e., the means by which a farmer learns about a practice and tries it (Ingram and Mills, 2019; Rust et al., 2020; Šūmane et al., 2018). As these socio-economic and socio-cultural aspects are important drivers for the objective of reducing soil degradation, the overarching context of knowledge exchange was identified as the third primary objective in the SPS (Fig. 4).

The embedded nature of the researchers within the policy team fostered collaborative development and learning to evaluate the evidence synthesis and co-create the draft SPS. This was a new way of working for everyone, giving opportunity for innovation, challenge and discussion drawing on a diverse mix of expertise from team members and touching on wider engagement with other policy teams and researchers. This new way of working has been enhanced through innovations in behavioural change in the Welsh Government, which are linked to the delivery of the Well-being of Future Generations Act. The structure of the theory of change provided a guiding framework to help the team distil the evidence and identify the priorities for the draft SPS. The PhD policy and fellowship placements developed longer term relationships with policy makers that built trust and were mutually beneficial, creating a shared vison for the draft SPS.

4.4. Next steps

In this article we have described the approach that we followed to develop a draft SPS in close collaboration between academic researchers and government policy teams. The next phase involved co-production with other stakeholders, where additional evidence and knowledge from these relevant actors was required to augment the evidence base and inform the development of the SPS. This ensured that locally relevant knowledge for decision-making across Wales was included as well as identifying additional challenges and solutions through sharing experience and knowledge. A revision of the SPS addressed additional sources of information gained through engagement with farmers, NGOs, farming unions, other Welsh Government policy teams and government-sponsored bodies with environmental advisory and regulatory responsibility (Natural Resources Wales). The revision of the SPS also involved other embedded researchers in the soil policy team. The outcomes of the stakeholder engagement and incorporation into a final SPS will be covered in a separate article.

5. Final reflections

A key barrier to policy adoption, known from previous experience, was building consensus between different government policy teams and government agencies and this was an important basis for our novel approach involving academic researchers and government policy teams. Working closely as a policy-researcher team enabled a collective challenge of views and evidence together. The evidence was often revisited and discussed, which helped to distil the key messages to inform the draft SPS. Working in this way built an effective rapport and developed trusted relationships between the researchers and policy team.

It was important to overcome previous challenges, and by working within the policy team the researchers had insight of these. For example, previous evidence has been challenged when used to inform policy, and it was therefore important to conduct the evidence review independently with researchers that could objectively synthesise a large body of

evidence from multiple sources. Presenting the outcomes of the evidence synthesis clearly and concisely and outlining evidence gaps and uncertainties was fundamental to ensure accessibility by government teams and other stakeholders. This was also a key factor in the effective translation of the evidence into specific objectives for the draft SPS.

Articulating experiences and reflecting on policy processes is important to promote best practice in environmental policy development across the board, with an increasing body of literature engaging with this challenge. We demonstrate that the collaboration between researchers and policymakers, though potentially challenging because of differences in cultures, perspectives, and language, can be an effective instrument for developing evidence-based policy and is an opportunity to enhance the science-policy relationship in the broader context. Encouragement of a closer relationship between researchers and policymakers is very important. We recommend embedded placements as one approach for effective policy co-design, not only in soil policy but also for other environmental policy arenas. New structures and incentives should be developed to facilitate this, for more effective delivery of science, development of policy and general knowledge exchange across multiple sectors.

CRediT authorship contribution statement

Carmen Sánchez-García: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Erik S. Button:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Sophie Wynne-Jones:** Formal analysis, Writing – review & editing. **Helen Porter:** Writing – review & editing. **Ian Rugg:** Writing – review & editing. **Jacqueline A. Hannam:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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