Title: How can academic research on UK agri-environment schemes pivot to meet the addition of climate mitigation aims?

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Highlights

- Agri-environment schemes have begun to include climate mitigation aims, in addition to their continuing predominate focus on biodiversity loss. This shift presents an opportunity for academic research.
- Academic research in relation to agricultural policy has the opportunity to influence the re-designing of schemes to contribute to new targets for achieving negative emissions.
- Additionally, research is needed into where agri-environment schemes might combine removing carbon with other environmental aims, and where trade-offs and conflicts with other values might arise.

Abstract

Agri-environment schemes were introduced in the UK in the 1980s as a response to the widespread environmental damage caused by post-war farming practices. Given such schemes are approaching forty years old, the academic literature is prolific and spans numerous fields including ecology, geography, economics and sociology. This paper reviews the existing literature on such schemes and discusses how it can contribute to benefit the explicit climate mitigation aims of more recent schemes. The focus is upon two key areas: the evaluation of environmental and social outcomes and recurring suggestions for innovation in these schemes. As schemes have been retrofitted to meet new climate aims over the years, moving on from a predominate focus on biodiversity loss, it is argued that academic research has an opportunity to contribute towards the co-design of schemes, with regards to mitigating climate change, especially in light of the key role land use will play in attaining negative emissions. Academic research can inform the development of a new generation of

schemes that prioritise carbon sequestration and emission reduction, alongside more traditional biodiversity aims.

Keywords:

Agri-environment schemes, climate change mitigation, carbon removal, agricultural policy

1.0 Introduction

Post-war agricultural policy and funding was dominated by a drive towards increased production (Grant, 1995). Criticism of the effects of this process went hand in hand with the wider burgeoning environmental movement, catalysed by the publication of Rachel Carson's *Silent Spring* in 1962, which was an early and arresting account of damage to wildlife caused by excessive use of pesticides, such as DDT. With increasing public pressure to reduce and reverse the environmental damage caused by industrial farming, the UK government and later, the devolved administrations, began introducing agri-environment schemes (AES) from the mid-1980s (see Figure 1), funded by the 'second pillar' (rural development) of the European Union's Common Agricultural Policy, in order to mitigate the decline of biodiversity. In later years, beginning with the Environmental Stewardship scheme, these schemes have begun to explicitly acknowledge their role in climate change mitigation, and so are sometimes termed agri-environment-climate schemes, especially in Scotland.

The Department for the Environment, Farming and Rural Affairs (DEFRA) intends to release a new iteration of schemes for England, termed Environmental Land Management Schemes, around 2024, although the National Audit Office has raised doubts about the likelihood of timely completion (National Audit Office, 2019), not least because of the continuing uncertainty around post-Brexit policy and trade. Agri-environment schemes in the devolved nations are also likely to change in coming years – a Sustainable Farming Scheme for Wales is currently under consultation, while Scotland's agri-environment-climate schemes are only open for extensions in 2020 rather than a normal application round[1], although Northern Ireland's schemes have effectively been in stasis until very recently, given the years without an assembly.

As such this is a fruitful time for a review of the prolific academic literature on agri-environment schemes in the UK, in light of shifting scheme aims and recent high profile support from academics for the post-2020 Common Agricultural Policy to better prioritise sustainable agriculture (Pe'er *et al.*, 2019). This paper addresses whether the literature on agri-environment schemes has reflected the recent ad hoc adaption of schemes to climate mitigation aims, and how research can contribute in this area. In the interest of concision, the discussion will focus on two key areas that are particularly relevant for future schemes: the evaluation of the environmental and social outcomes of schemes, and discussions around scheme innovations. The contribution of agri-environment schemes to climate mitigation is critical, in light of the urgent necessity of attaining negative emissions to safeguard the wellbeing of current and future generations as current global temperatures are already over +1.0 ◦C above the 1880-1920 mean (Hansen *et al.*, 2017). Land use is at the centre of most methodologies for capturing carbon and the UK must contribute significantly in light of its current and historical emissions, as acknowledged by the Committee on Climate Change's 2019 white paper on Net Zero (Stark *et al.*, 2019).

UK Agri-Environment Schemes
1985 - Broads Grazing Marsh Conservation Scheme and local schemes within National Parks
1987-1994 - Environmentally Sensitive Areas, 4 stages
1988 - Farm Woodland Scheme
1989 - Countryside Premium Scheme

[1] https://www.parliament.scot/parliamentarybusiness/110693.aspx

1991 - Countryside Stewardship Scheme

1992 - Farm Woodland Premium Scheme

1994/1995 - Habitat Scheme, Countryside Access Scheme, Moorland Scheme and other small schemes

1998 - Arable Stewardship

1999 - Tir Gorfal

2001 - Tir Mynydd

2005 - Environmental Stewardship (Entry level and higher level), English Woodland Grant Scheme, Tir Cynnal

2006 - Better Woodlands for Wales

2007 - Northern Ireland Countryside Management Scheme

2010 - Uplands Entry Level Stewardship

2012 - Glastir

2014 - Forestry Grant Scheme (Scotland), Agri-Environment Climate Scheme (Scotland)

2015 - new Countryside Stewardship Scheme

2017 - Environmental Farming Scheme (NI)

Figure 1: Timeline of agri-environment schemes in the UK

This paper reviews the contribution of existing literature on schemes, in light of the shift to including climate mitigation aims, before moving onto discussion of scheme innovations and opportunities for future research.

2.0. Agri-environment schemes, land use and climate mitigation: a review

Agriculture contributes around 10% of the UK's greenhouse gas emissions[2] and land use is critical to most models of climate change mitigation. For example, the Net Zero by 2050 report encourages mitigating livestock emissions through breeding and diet as well as reduced consumption, alongside afforestation, peatland restoration and the growth of energy crops (Stark *et al.*, 2019). Many climate change activists and organisations have decried even this report as not ambitious enough, and, as one example, Extinction Rebellion demands the government 'halt biodiversity loss and reduce greenhouse gas emissions to net zero by 2025'[3]. There is also the fact that existing commitments are not being upheld; the Committee on Climate Change has highlighted that afforestation targets are not being met and that 'the voluntary approach that has been pursued so far for agriculture is not delivering reductions in emissions' (Stark *et al.*, 2019, p. 12). This is despite a DEFRA survey reporting that 61% of farmers studied stated they were taking action to reduce emissions[4].

Current agri-environment schemes and wider agricultural policy and regulation are not enough to secure even net zero by 2050, let alone the negative emissions that are required, not least because of obligations due to historical equity and environmental justice. This is despite 70% of farmland being enrolled in AES[5] (about 3.2 million hectares[6]) at a cost of around £400 million a year[7].

DEFRA's Environmental Land Management Schemes policy discussion document[8], part of the February 2020 consultation, only makes indirect reference to carbon removal: "These examples of land use change projects would make a substantial contribution towards our net zero target by creating and restoring carbon rich habitat". In this vein, while actions suggested for the three tiers,

[2] https://www.parliament.uk/business/committees/committees-a-z/commons-select/environment-food-and-rural-affairs-committee/news-parliament-2017/agriculture-achieving-net-zero-emissions-inquiry-launch-17-19/
[3] https://rebellion.earth/the-truth/demands/
[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831267/Agriclimate-summary-12sep19a.pdf
[5] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183824/defra-stats-foodfarm-environ-obs-research-setaside-farmenviroment-cfeevidencesummfeb2013-130214.pdf
[6] https://jncc.gov.uk/our-work/ukbi-b1a-agri-environment-schemes/
[7] https://publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/599/59907.htm
[8] https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf

such as soil management, woodland creation and peatland restoration, will be beneficial in this regard, carbon removal is not explicitly mentioned as a public good. Without carbon removal as a direct and explicit goal, it seems unlikely that agri-environment schemes will be well targeted towards achieving negative emissions.

It is DEFRA's intention to increase enrolment to 88,000 farmers (from 29,600) through their new Environmental Land Management Schemes (DEFRA, 2019), but beyond a possible focus on public goods, it is not yet clear how or if these new schemes will be able to address the changes to land use required by continuing anthropogenic climate change. As these schemes are being retrofitted towards meeting climate mitigation aims, it is essential that a body of research is produced that can underpin these critical land use decisions, and so inform the understanding and practices of key stakeholders.

Furthermore, the new schemes may face substantial delays. The National Audit Office has already published its doubts about DEFRA's current timeline (National Audit Office, 2019), and there is still substantial political uncertainty, both in terms of domestic governance and the effects of exiting the EU. As well as the negative impact of delay on farmer engagement, climate change demands urgency. With this in mind, there is a need for more academic research that informs the design of schemes that explicitly seek to mitigate climate change. A review of existing publications on agri-environment schemes in the UK establishes the existing evidence base.

A Web of Science Topic search (14/09/20) for 'agri-environment AND climate AND UK' returned thirteen articles (see Figure 2), compared with the roughly two hundred returned for the same search terms without including climate. Of these, three papers discussed the role agri-environment schemes can play in combatting climate change (Stoate *et al.*, 2009; Warner *et al.*, 2017, 2020; Haddaway *et al.*, 2018).

Paper	Topic	Role of land use and AES in mitigating climate change?
Botham *et al.*, 2015	Moth and butterfly habitats	No mention of climate change.
Bradbury, Stoate and Tallowin, 2010	Farmland bird conservation	Brief mention of mitigating climate change as an ecosystem service.
Brereton *et al.*, 2011	Butterfly indicators and assessment	Some discussion of climate change. No mention of the role of AES as a climate action.
Froidevaux *et al.*, 2017	Recovery of greater horseshoe bat	Discussion of climate change but no mention of the role of AES as a climate mitigating action.
Haddaway *et al.*, 2018	Vegetated strips around fields	Mention of verges (from AES options) and climate regulation, as well as climate-related knowledge gaps across EU.
Hodge, 2019	Rural policy, Brexit, ecosystem services	Mention of climate change and rural policy's role in climate change mitigation, nothing on AES specifically.
Lamb *et al.*, 2019	Land sparing and birds	Some mention of how land use might affect climate change.
Ormerod *et al.*, 2003	Agricultural change	Focus on agricultural productivity, with a few comments on the impact of climate on this.
Stoate *et al.*, 2009	Agricultural change in Europe	Extensive discussion of climate.
Walker *et al.*, 2007	Arable field margins	No mention of climate change.
Warner *et al.*, 2017	AES for greenhouse gas mitigation	Direct relevance - AES options and GHG mitigation. Also published a 2020 report for Natural England.
Watts *et al.*, 2008	Forest biodiversity	Some mention of climate but more about impact of climate than the impact of land use on climate.

Wood *et al.*, 2018	Land cover and habitats	Some mention of climate but more about impact of climate than impact of land use on climate.

Figure 2: Table summarising articles from a 29/11/19 Web of Science Topic search on 'agri-environment AND climate AND UK'. Highlighted articles discuss the role of AES in climate change mitigation.

Stoate *et al* (2009) present a review of the ecological impacts of 21st century agricultural change in Europe and specifically consider both emissions and climate change. Their overall recommendation is for better information exchange 'between science disciplines, practitioners and policy makers' and a focus on relating agriculture to the ecosystem services it interacts with (Stoate *et al.*, 2009, p. 40). Haddaway *et al* (2018) builds upon these recommendations in their review of the literature on field buffer strips, featured in most UK agri-environment schemes, specifically looking at the various outcomes of these initiatives, including biodiversity, water or soil loss and greenhouse gases (Haddaway *et al.*, 2018, p. 24). Finally, Warner *et al* (2017) was the only paper found that considered UK agri-environment options for arable agriculture in terms of their potential for greenhouse gas mitigation and carbon sequestration, including whether there is a risk of production displacement as a result of removing land from production and where there are trade-offs with other environmental objectives, such as through leaving land fallow for biodiversity (Warner *et al.*, 2017, p. 118). They emphasise options that protect soil and water, as well as under-sowing spring cereals, which can mitigate greenhouse gas emissions without reducing yields (Warner *et al.*, 2017, p. 117).

Additionally, there is also literature on the interrelation between agri-environment schemes and climate both outside of the UK (e.g. Galler, von Haaren and Albert, 2015) and outside of academia, for example, a recent report from Natural England has focused on the contribution of AES to climate change adaptation, for example, in the case of tree planting, by reducing flood risk and storing carbon (Natural England, 2018, p. 10).

As such, while some papers on UK agri-environment schemes have begun to address climate change mitigation and carbon removal and storage, the bulk of the literature has largely focused on other environmental outcomes such as benefits for individual species and biodiversity more generally. This in itself is not surprising given the continuing focus of schemes on biodiversity, and so the following review will outline existing literature, with a focus on how research can pivot to contribute to the growing inclusion of explicit climate aims in agri-environment schemes.

2.1 Review: environmental outcomes

Literature on the environmental outcomes of AES varies tremendously, which is only to be expected given the complexity of the schemes themselves and their intended impact. As well as academic literature, it is important to consider the perspective of government policy on schemes as well.

The 25 Year Environment Plan (Her Majesty's Government, 2019) sets out environmental goals and a wide range of mechanisms for achieving these goals such as the principle of 'net environmental gain', plans for forest creation and peatland restoration, and reducing agricultural inputs and emissions. However, agri-environment schemes receive only a single mention in the 150 page long document, in the form of a positively framed case study that makes no mention of the challenges schemes have faced or the limits to their environmental impact. Indeed, many of the mechanisms proposed feature research that is not directly linked to policy implementation or alternative schemes focused outside of agriculture. For a document that espouses a natural capital approach, there is little material on how farming subsidies might better pay for ecosystem services and natural assets.

A more recent indication of the potential policy approach to biodiversity can be seen in the Dasgupta Review on the Economics of Biodiversity (HM Treasury - UK Goverment, 2020), which features a similar ethos of 'market failure' to conserve natural assets, and as such, agri-environment schemes are framed as a form of Payment for Ecosystem Services (PES). In this vein, the new schemes – ELMS – are framed as a national form of PES in line with the government's commitment to the 25 Year Environment Plan and the net zero emissions by 2050 (Stark *et al.*, 2019), that aim to focus on payment for public goods rather than income foregone or land area managed. Essentially, it is argued that agriculture has engendered environmental degradation because it has failed to consider non-market values, and that efficient agricultural production can be combined with environmental gain while remaining economically viable.

In terms of academic literature, there has been much published on the impact of management options that are intended to benefit specific fauna. For example, one paper considered fallow plots for stone curlews (a wading bird that breeds in some parts of the UK) and found that this management also benefitted other species including four red-listed farmland birds as well as butterflies, bumblebees and hares (MacDonald *et al.*, 2012).
To contrast, a recent paper suggested that while UK agri-environment wildflower seed mixes might be attractive for some bumblebee species, they were not optimal for most solitary bee species (Nichols, Goulson and Holland, 2019). Figure 2 summarises a selection of recent studies conducted in the UK that focus on the impact of AES upon individual species, and shows that on the whole, schemes have been found to have a positive impact on desired species despite caveats, debates over sampling methodology and advice on how to further increase gains from schemes.

Class	**Study**	**Location**	**Animals**	**Effect**
Mammals	Reid, Mcdonald and Montgomery, 2007	NI	Irish hares	0
	Moro and Gadal, 2007	Wales	Voles, Shrews, Mice	+
	Broughton *et al.*, 2014	England	Voles, Shrews, Mice	+

	Hof and Bright, 2010	England	Hedgehogs	+
	Petrovan, Ward and Wheeler, 2013	England	Brown hares	+
	Fuentes-Montemayor, Goulson and Park, 2011a	Scotland	Pipistrelle bats	-
	Fuentes-Montemayor *et al.*, 2013	Scotland	Bats	+
	Moorhouse *et al.*, 2014	England	Hedgehogs	+
Birds	Burgess *et al.*, 2015	England	Yellowhammer, Corn bunting	+
	Baker *et al.*, 2012	England	Farmland birds	+/-
	Colhoun *et al.*, 2017	NI	House & Tree sparrows, Yellowhammer	+
	Walker *et al.*, 2018	England	Farmland birds	+
	Bright *et al.*, 2015	England	Farmland birds	+
	Perkins *et al.*, 2013	Scotland	Corn bunting	+
	Askew, Searle and Moore, 2007	England	Barn owls	+
Insects	Carvell *et al.*, 2015	England	Bumblebees	+
	Fuentes-Montemayor, Goulson and Park, 2011b	Scotland	Moths	+
	Merckx *et al.*, 2010	England	Moths	+
	Wood, Holland and Goulson, 2017	England	Solitary bees	0
	Cole *et al.*, 2017	Scotland	Pollinators	+/-
	Cole *et al.*, 2015	Scotland	Pollinators	+
	Holland *et al.*, 2014	England	Beneficial invertebrates	+
	Alison *et al.*, 2017	England	Moths	+

Figure 3: Table summarising a selection of recent UK studies on the effect of agri-environment schemes on species populations

Evaluation of the impact of schemes on biodiversity more widely is much more contested, despite early research highlighting the promise of agri-environment schemes in this regard (Ovenden, Swash and Smallshire, 1998). However, several reviews since have argued that AES have failed to conserve – let alone enhance – biodiversity (Kleijn *et al.*, 2001, 2006, 2011; Berendse *et al.*, 2004; Pe'er *et al.*, 2014). In addition, it has been argued that as conservation targets are not linked to national and supra-national biodiversity goals, evaluation itself is untenable (Kleijn *et al.*, 2011, p. 480), and as such, future agri-environment schemes need to be better targeted (Batáry *et al.*, 2015). Others have also highlighted the impact of additional factors, including, for example, farmer experience and confidence (Mccracken *et al.*, 2015). This suggests that the schemes have failed to live up to the expectations of wider policy such as the 25 Year Environment Plan.

Researchers have also raised concerns about studies of effectiveness (Hodge and McNally, 1998). Kleijn and Sutherland (2003) found that studies of effectiveness disproportionately represented the UK and the Netherlands, despite them only receiving around 6% of EU agri-environment funding, and that the experimental design most often employed was at high risk of bias. They call for 'the collection of baseline data, the random placement of scheme and control sites in areas with similar initial conditions, and sufficient replication', as well as for such research to better feed into policymaking (Kleijn and Sutherland, 2003, pp. 948–966). The lack of baseline data, in the context of the UK, has begun to be addressed by recent collaborations between government and academia (Smart *et al.*, 2018; Her Majesty's Government, 2019). However, the setting of a baseline for conservation is also controversial, as can be seen in debates over 'shifting baseline' syndrome and rewilding (HM Treasury - UK Goverment, 2020).

Suggestions to target schemes on enhancing biodiversity have also varied widely in spatial scale (Oatway, 2018). At a local scale, it has been suggested that financial rewards for retaining and planting hedgerow trees would benefit moth species, and that such a measure would have more impact than grass margins (Merckx *et al.*, 2009). To contrast, Merckx and Pereira (2015) have suggested two tiers of schemes depending on land fertility and spatial scale – as such, fertile lands would be targeted by schemes promoting biodiversity alongside agricultural yields, whereas marginal land and protected areas should be the focus of rewilding and natural succession.

There have been repeated calls for schemes to avoid focusing on small, unconnected parcels of land, as this limits biodiversity gains (Whittingham, 2007; Toderi *et al.*, 2017). This relates to the concept of 'wildlife corridors', such as hedges; which serve to connect high biodiversity areas and can be vital for the persistence of species (e.g. Dinerstein *et al.*, 2017, pp. 339–341). As such, there are many proponents for greater collaboration from environmental land mangers (Prager, 2015b; Leventon *et al.*, 2017; Franks, 2019), which will be discussed later in more detail.

Another issue linked to the interconnectedness of landscape relates to farming beyond agri-environment schemes. Geiger *et al* (2010) have found that pesticide use outside of agri-environment parcels has limited the positive impacts of scheme enrolment. As this pesticide use has the effect of decreasing bird numbers, it thus also limits biological pest control through a feedback cycle (Geiger *et al.*, 2010, p. 104). Additionally, Ekroos *et al* (2014) have argued that measures for biodiversity should be twinned with targeting ecosystem services that benefit agricultural production, which is in line with the recent Dasgupta Review.

Clearly the ecological and environmental literature has not neglected to contextualise research with regards to mass biodiversity loss and species extinction, although explicit connections between scheme managements and climate change remain rare. This is likely due to biodiversity decline continuing to be the main driver behind scheme design and delivery. Climate change mitigation has been included in some scheme options in recent years, but schemes tailor made for carbon sequestration and emissions reduction are required urgently, presenting a substantial opportunity for research to provide an evidence base to inform these decisions.

Agricultural policy needs to be innovative if it is to deliver much needed climate change mitigation and emissions reduction. Agri-environment schemes should focus on carbon removal that also benefits biodiversity, supported by a wider agricultural policy aimed at reducing the emissions of the sector and trade that does not offshore our emissions (related to the idea of policy coherence[9]). Agri-environment schemes could increase carbon removal by supporting afforestation, regenerative agriculture, peatland or wetland restoration or Bio-Energy Carbon Capture and Storage (BECCS) such as through mixed woodland short rotation coppice and waste biochar (Buck, 2019). However, carbon that is removed also needs to be stored semi-permanently, and so agri-environment schemes need to offer long-lasting benefits and encourage change in the attitudes and norms of the agricultural sector. Additional research is also needed to inform where schemes might successfully co-produce positive outcomes, such as removing carbon whilst also creating habitats that benefit biodiversity, and where trade-offs and conflicts between competing aims might arise. Priority areas for research are addressed in a later section, following the review of the social literature on schemes below.

Social and behavioural factors clearly have a large impact on the environmental outcomes of schemes. This can take the form of diverse farming styles (Schmitzberger *et al.*, 2005) as well as previous experience of environmental management and supportive implementation (Mccracken *et al.*, 2015). As such, designing schemes to achieve climate and biodiversity benefits requires taking account of a wealth of social, cultural, spatial and biophysical factors, which may go some way towards explaining the widespread academic dissatisfaction with the attainment of existing schemes (de Snoo *et al.*, 2013).

2.2. Review: social outcomes

[9] https://researchcentres.city.ac.uk/__data/assets/pdf_file/0018/504621/7643_Brief-5_Policy_coherence_in_food_systems_WEB_SP.pdf

With all of this in mind, it is critical to also consider the socio-economic dimensions of schemes, beginning with scheme design. The literature has suggested that the factors that determine an agri-environment scheme's impact are poorly understood, and social factors such as farmers' experience can play a key role in determining environmental outcomes (Mccracken *et al.*, 2015).

It has also been argued that schemes with numerous options, such as Entry Level Stewardship, run the risk of farmers choosing those that involve little change or cost and that may not match the priority environmental needs of the area (Hodge and Reader, 2010). Furthermore, such schemes may also prove a 'challenge to the idea of stewardship in terms of a duty on landowners to forgo maximum financial return in order to protect the environment' (Hodge and Reader, 2010, p. 280). It is on these grounds that agri-environment schemes as they are currently designed have been called culturally unsustainable, as payments may need to continue in perpetuity if participation does not also foster engagement and shifts in the intrinsic values of farmers (Burton and Paragahawewa, 2011). This point is key if schemes are to succeed in capturing and storing carbon.

Additionally, it is important to take account of how the implementation of schemes is affected at an institutional level. Vesterager *et al* (2016) have analysed how five EU countries have responded to changes in agri-environment policies at the level of the EU; they suggest three main, and sometimes overlapping, implementation strategies: inertia (maintaining the status quo but reducing capacity to adapt), absorption (minor changes in order to comply at little or no cost) and transformation (change of policy to meet the new context). These strategies are shaped by factors such as political will, policy legacy, press response, the state of the agricultural sector and institutional capacity (Vesterager *et al.*, 2016). These factors are likely to come into play in a UK context during EU Exit and the implementation of the Agriculture Bill.

Cost-effectiveness is another key part of evaluating scheme implementation. However, a recent review found that most papers that evaluate agri-environment schemes fail to consider cost-effectiveness, despite the fact that toolkits now exist for this purpose (Pacini *et al.*, 2015; Ansell *et al.*, 2016). Furthermore, survey research on the perceptions of stakeholders with regards to improving provision for pollinators has found that low-cost – and thus efficient - options were often seen as ineffective, while the opposite held true for high cost options (Austin *et al.*, 2015). This suggests that 'economies of scale', with regards to farm and parcel size, need to be taken into account when implementing and evaluating scheme options (Austin *et al.*, 2015, p. 161).

It is also worth considering the unintended impacts of agri-environment schemes. Some have suggested that this can include the 'provision of jobs, contributions to the local economy and opportunities for businesses, and contributions to the social fabric of rural communities' (Dobbs and Pretty, 2001, p. 2). Banks and Marsden (2000) have shown how the *Tir Cymen* ('Tidy Land') scheme in Wales benefitted rural development, for example, by providing work constructing and maintaining hedges and dry stone walls, which in turn preserves the features valued by residents and tourists alike.

Courtney *et al* (2013) take a systematic approach to the incidental benefits of schemes using a framework informed by economic base and net income theory, and an economic approach intended to consider the effects of schemes at a sub-regional level, which they applied to a stratified sample (based on landscape character types) of telephone and face-to-face interviews. They ultimately found that while Entry Level Schemes (ELS) resulted in £1.29 entering the local economy for every pound spent, this rose to £2.23 for Higher Level Schemes (HLS), with HLS also generating the highest amount of employment (Courtney *et al.*, 2013, p. 34). ELS and HLS options involving infrastructure generated the greatest benefits as they required high demands for materials and labour (ibid). While this approach provides only a 'snapshot', it does indicate that policy evaluations should take account of this important dimension of scheme outcomes (Courtney *et al.*, 2013, p. 36), especially as, ultimately, the funding for AES comes under the guise of rural development and political support is important for ongoing legitimacy.

If agri-environment schemes are to enact landscape scale environmental improvement and make a significant dent in reducing emissions and storing carbon, they must be designed to both increase enrolment and engagement, as the latter is key for fostering a lasting change in farming culture and practice. Ongoing research into attitudes towards carbon dioxide removal will be key (Cox, Spence and Pidgeon, 2020). To some extent, the change in land use required by urgent climate mitigation is so vast that some of the choices must be made voluntarily, albeit with government advice and support. It remains to be seen how or if agri-environment schemes, in concert with regulation and social movements, can enact such a radical shift in attitudes.

Having discussed the evaluation of the environmental and social outcomes of AES, there are two modifications to schemes that emerge again and again: payment by results and co-operative agreements.

2.3. Review: developing schemes through payment by results

Burton and Schwarz (2013) have suggested that payment by results could be better suited than prescribed management options in generating the cultural and social capital necessary for farmer engagement (de Snoo *et al.*, 2013). It has also been argued that such an approach could improve the 'ecological and economic efficiency' of agri-environment schemes (Hasund, 2013; Schroeder *et al.*, 2013, p. 135; Reed *et al.*, 2014).

Schroeder *et al* (2013) interviewed and surveyed farmers around Yorkshire and the Humber river, and found that the majority thought favourably of an example payment by results based option, a finding which has been supported by other case studies (Fleury *et al.*, 2015). In fact, the Yorkshire Dales were recently the home of a successful DEFRA pilot scheme that aimed to test the feasibility of payment by results (Natural England and Yorkshire Dales National Park Authority, 2019). Schemes designed around payment by results are also likely to require significant advisory support, which has been a criticism of past schemes (Moxey and White, 2014). This is true of the Yorkshire pilot, where it is not clear to what extent the results are the result of payment by results or the greater advisory attention received by participants. Furthermore, there are extensive knowledge gaps around such an approach, particularly with regards to the long term conservation impacts and potential additionality (Herzon *et al.*, 2018).

Despite the potential benefits of payments by results approach, it would be bounded by WTO Green Box requirements which stipulate that payments must be limited to additional costs and income foregone (Hasund, 2013, p. 231; Reed *et al.*, 2014). Nevertheless, there are payment by results based schemes currently active in the EU, which necessarily also meet WTO requirements (e.g. Franks and McGloin, 2007). An evaluation of such a scheme in Baden-Wurttemberg concluded that the scheme benefited innovation, adaptability and intrinsic motivation, while increasing the risk for farmers and transaction costs (Matzdorf and Lorenz, 2010). Another study of the same scheme found that the payments only covered the opportunity costs of some types of farmers and that enrolment was threatened by other environmental policies such as biogas subsidies (Russi *et al.*, 2016). Clearly this approach shares some of the limitations of more prescriptive agri-environment schemes.

Using a case study of participation in the Welsh Glastir scheme, Arnott *et al* (2019) argue that current schemes are better suited to supporting rural cohesion and farming lifestyles than delivering ecosystems services. They argue that enacting management on a landscape scale, including through collaboration, can reduce the occurrence of misplaced options or duplicated funding and payments that don't require any changes, and better target schemes at generating public goods (Arnott *et al.*, 2019). Additionally, it is worth highlighting the some public goods are likely better suited to a payment by results approach than others.

While payment by results is a feature of ongoing agri-environment scheme tests and trials in the UK, there remain several aspects of its potential implementation that remain unclear. A key aspect of this is how any baseline and results might be measured, and how the effect of factors outside of the land manager's control will be accounted for. In this vein, payment by results appears more appropriate for public goods such as soil, water and air quality, as well as carbon sequestration, rather than for biodiversity. As such, it is likely that the longstanding model of payment for outcome will persist in some form, especially with regards to managements focused on habitat creation, while many questions remain about the potential implementation of payment by results, offering an important area for future research.

2.4. Review: developing schemes through co-operative agreements

Collaboration between farmers is often suggested as a means of improving the environmental and social outcomes of schemes (Macfarlane, 1998; Whittingham, 2007; Prager, Reed and Scott, 2012; de Snoo *et al.*, 2013; Reed *et al.*, 2014; Leventon *et al.*, 2017), not least by attempting to attain landscape scale improvements (Franks, 2019). It has also been promoted as beneficial more generally, for example, the recent Our Future in the Land report suggested that peer mentors, farmer support networks and producer organisations would contribute to a 'fourth agricultural revolution driven by public values' (Food Farming and Countryside Commission, 2019). Co-operation could be one way of making schemes more culturally sustainable (Burton and Paragahawewa, 2011), thus creating longer term benefits and increasing cost effectiveness.

Several papers have argued that co-operative agri-environment schemes would be welcomed by UK farmers (Franks and McGloin, 2007; Prager, Reed and Scott, 2012; Franks, Whittingham and Mckenzie, 2016). However, Riley *et al* (2018) argue that co-operative environmental management is hampered by the fact that 'good conservation farming' is not obvious to the naked eye and is also not yet substantially tied to social capital, and as such, this stymies the build-up of trust that is necessary for farmers to enter into a contract together (Riley *et al.*, 2018, p. 644). As such, most of those interviewed in the study were unwilling to enter into collective contracts despite being on positive terms with their neighbours, as 'land management has become a predominately independent activity' (Riley *et al.*, 2018, p. 645).

This ties into Emery's (2015) argument that while independence can be used to justify co-operation, this is not the case when independence is mistakenly conflated with individualism, thus hiding very real structural dependencies and enhancing isolation via competitiveness (Emery, 2015, p. 3)[10]. As such, it is beneficial to take a more relational view of co-operation as an 'emergent process which can move the individuals involved beyond their preformed judgements and measures of social positioning' (Wynne-Jones, 2017, p. 267).

Furthermore, there is a distinction between co-ordination and collaboration (Prager, 2015b). While co-ordination is more easily attained, collaboration has greater environmental, economic and social benefits but faces challenges such as 'the dilemma between individual and collective benefits', 'trade-offs between different objectives', 'the choice of appropriate organisational structures', and 'the prerequisite of building trust and social capital' (Prager, 2015b, p. 62).
However the practicalities of co-operation remain a stumbling block. One way of supporting a cultural shift towards co-operation would be through a bridging organisation, as is the case with Dutch Environmental Co-operatives (Franks and McGloin, 2007; Franks, 2011; Terwan *et al.*, 2016).

[10] See Stock *et al* (2014) for a discussion of how this ties into neoliberalism.

Such organisations enable: ‘accessing resources’, ‘bringing together different actors’, ‘building trust’, ‘resolving conflict’, ‘networking’ and ‘social learning’ (Berkes, 2009). Bridging organisations have also been found to contribute to implementing policy and services, mediation, raising awareness and changing behaviours, as well as positive environmental and economic impacts (Dedeurwaerdere, Polard and Melindi-Ghidi, 2015; Prager, 2015a).

The Higher Level Scheme option HR8 – “Supplement for Group Action” – in England is a concrete example of an agri-environment option attempting to encourage co-operation in the absence of such an organisation. Franks and Emery (2013) highlight that there are significant barriers to participating in HR8, including: ‘the need for assistance from an external agency’, the ‘size and timing’ of the payment, the lack of flexibility in applying the options and in changing the agreement based on new environmental evidence, ‘the competitive basis of HLS’ and potential contractual issues (Franks, 2011; Franks and Emery, 2013, pp. 854–9). Other research has highlighted the need for ‘demonstrable benefits’, i.e. to a specific species or habitat, and greater ‘farmer involvement in scheme design’ (Emery and Franks, 2012, pp. 226–227; Franks, Whittingham and Mckenzie, 2016). A bridging organisation would go some way towards overcoming these barriers and a recent review has suggested specific revisions that could be made to improve Countryside Stewardship’s Mid Tier farmer groups (Franks, 2019, p. 156).

Moreover, there is a debate to be had about the extent to which agri-environmental contracts are the best means of encouraging co-operation. Additional methods that could be harnessed include farm clusters and support for peer learning and advice services. What should be apparent from this overview is that the UK must make significant headway if it is to come close to realising landscape-scale agri-environment options, which could greatly benefit climate change mitigation. The scale effects of such an approach could be significant, as one example, the carbon sequestration and cobenefits achieved by collecting waste, including slurry, from multiple farms in an area for processing through pyrolysis into biochar for application to fields or as an addition to animal feed or bedding could be extensive (Bates and Draper, 2018).

In short, Co-operation may be one way of improving the effectiveness of agri-environment schemes, by combining scale effects with the benefits to land manager engagement that may result from group membership and skill sharing, however, significant uncertainty remains with regards to implementing this through UK agri-environment schemes.

3.0 Priority areas for research

This review has evaluated existing literature on UK agri-environment schemes in relation to environmental and emissions related impacts, and the ongoing development of the new Environmental Land Management (ELM) scheme. This section builds on the above discussion in order to identify three key areas for future research. One area of critical importance concerns the impact of agri-environment options and schemes more broadly on greenhouse gas emissions, which has only really begun to be researched (Warner *et al.*, 2017, 2020). For example, an area of key concern involves land use trade-offs, such as the risk of production displacement; for this reason Warner et al. emphasise options that combine agricultural production with soil protection and input reduction (Warner *et al.*, 2020). However, there is still a requirement for further research that considers the emissions impact of agri-environment options holistically and as part of the wider sector.

Additionally, as payment by results is beginning to be included in the design of new schemes, it is critical that this is done on the basis of robust empirical evidence, particularly with regards to the measurement of both a baseline, the continuing impact of scheme management and the payment mechanism. There is also a need for empirical studies that assess how farmers can be engaged in this process, whether through taking the measurements themselves, and how they might be trained for this, or through co-operation with trusted partners or formal inspectors.

Regarding co-operation, while the literature on this is extensive regarding the benefits and barriers to co-operative agreements, it is not clear how these might be implemented in practice, such as what governance structures might be needed or what legal standing agreements between partnering farms would have. This is necessary groundwork if farmers are to be convinced that co-operation is both beneficial and low risk, and that they will be suitably supported throughout.

The ongoing re-development of agri-environment schemes, along with the increasing emphasis of their role in climate mitigation, presents a series of opportunities for scholars from a wide range of disciplines, from the natural to the social sciences. The potential future directions offer a great scope for research with a significant positive impact, both environmentally but also for farmers' livelihood, wellbeing and agency.

4.0 Conclusions

Current schemes do make some contribution to climate change mitigation, for example through their support for reducing inputs and creating or restoring habitats. However, the overall emissions of the agricultural sector have not decreased (Stark *et al.*, 2019), despite the fact that a majority of farmers say they have taken action to reduce emissions[11] and that in 2018, 3.2 million hectares of land was in agri-environment schemes across the UK[12] (out of a Utilised Agricultural Area of around 17.2 million hectares[13]). The re-design of schemes across the UK provides an opportunity to address these failings by targeting schemes explicitly at carbon sequestration, for example, through greater

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831267/Agriclimate-summary-12sep19a.pdf
[12] https://jncc.gov.uk/our-work/ukbi-b1a-agri-environment-schemes/
[13] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/208436/auk-2012-25jun13.pdf

inclusion of woodland creation and management, peatland and wetland restoration, and technologies such as biochar production, where appropriate.

This presents an area of opportunity for the academic literature on agri-environment schemes in the UK. A key theme to emerge from this discussion of the academic literature on the development, implementation and impacts of agri-environment schemes is the importance of a landscape-scale approach, for the purposes of biodiversity and cultural sustainability (Macfarlane, 1998; Merckx *et al.*, 2009; Emery and Franks, 2012). This same innovation could be harnessed towards the aim of climate change mitigation, if carbon removal was explicitly recognised as a driving motivation. A landscape-scale approach to carbon removal could incentivise land managers to motivate and share expertise with others in the local area, thereby increasing engagement by reducing barriers to participation and potentially leveraging social capital.

Furthermore, there are unanswered questions about the extent to which management practices designed to reduce greenhouse gas emissions and capture carbon dioxide might also co-produce other benefits, such as for biodiversity. In planning future policy that has the support of land managers and the public alike, it will be critical to identify such mutually beneficial scenarios, while navigating potential trade-offs or even conflicts, such as with amenity values. Some of this work has already been undertaken, such as in framing carbon dioxide removal in terms of ethics through concepts such as 'democracy, justice and acceptability' (Cox *et al.*, 2018). However, such a perspective has yet to be applied to agri-environment schemes specifically.

Schemes as they are currently imagined in the UK must undergo a system level change if they are to fulfil land use's potential contribution to achieving negative emissions, which is built into the UK's current targets and models. The retrofitting of agri-environment schemes to include some climate mitigation options is not sufficient; such schemes need to be designed with carbon sequestration and emissions reduction as priorities. Academic research has the opportunity to provide the evidence base that will be critical to informing such design decisions.

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