Agri-environment scheme design and public goods: spatial match or mismatch

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Abstract

Designing agri-environment schemes (AESs), the European Union's main policy tool to improve the environmental performance of farms, that result in participation in the areas of most need is a challenge faced by policymakers. A number of high level options are available to policy makers including the use of voluntary and mandatory measures, top-down versus participatory approaches, collaborative versus coordinated participation, and whether to target the schemes or apply them horizontally. Using Ireland as a case study, this paper assesses the evolving structure of AES design in the context of changing environmental targets, by creating an institutional framework to analyse past and current AESs and other measures. This information is then used in a spatial analysis comparing the location of important environmental public goods to participation in agri-environment schemes. The analysis shows that although higher uptake in extensive farming areas may not result in additionality, due to their extensive nature, these areas may contain high concentrations of areas of environmental concern. However, the optimal design of an AES depends on whether the specific public good targeted is global or localised as the distribution of areas of environmental concern does not always follow strong spatial patterns.

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1. Introduction

Globally, efforts have been made to increase or at least maintain the stock of environmental public goods. The Sustainable Development Goals and the Paris Agreement on climate change are just two of the numerous international agreements aimed at encouraging environmental sustainability. Within the European Union (EU), a number of directives and regulations have been implemented to improve the environmental performance of Member States with specific emphasis on biodiversity, water quality and climate stability. Accounting for nearly half of all land within the EU, agriculture has become a sector of central importance in many of these policies. The EU Common Agricultural Policy (CAP) has moved from a focus on food production, to having numerous goals, not least the environmental sustainability of the agri-food sector. This was seen in the most recent reform of CAP in 2013 which included the sustainable management of natural resources as a priority focus. Since becoming compulsory for Member States in 1992, agri-environment schemes (AESs) have become the most important policy tool to improve the stock of environmental public goods associated with agriculture.

While the design of AESs varies across Member States, schemes commonly involve farmers voluntarily participating and being compensated for the cost of undertaking management actions. The flexible nature of AES design has resulted in a wide range of schemes with numerous objectives that are sometimes conflicting. This raises a question as to whether they are being designed in the most efficient manner to achieve their goals. Literature has focused on the environmental improvements that can be attributed to AESs (Batáry, Dicks, Kleijn, & Sutherland, 2015; Finn & Ó hUallacháin, 2012; Jones et al., 2016; Kleijn et al., 2006). Little attention however, has been paid to the spatial efficiency of design of AESs from an institutional economics perspective.

A large number of options are available to Member States such as whether schemes should be designed from the top-down or use a participatory approach involving multiple actors, or whether they payments should be based on the results achieved or the actions undertaken. While a number of these options have been looked at separately in terms of the actual impact in terms of participation and ensuing results (Lastra-Bravo et al. 2015; Wu & Babcock 1999; Gibbons et al. 2011; Newig & Koontz 2014 etc.), little work has been done to amalgamate the institutional design characteristics of AESs into one analysis and compare this to the objectives of the schemes. This paper aims to full this gap and take it further in combining the institutional analysis with a spatial analysis identifying the possible impact scheme design options have on the stock of environmental public goods.

Using Ireland as a case study, this paper outlines an institutional framework for the options available to policymakers in designing AESs and compares this to current and past schemes. Ireland presents an important opportunity to assess these options as it has experience with numerous different AES design approaches. Ireland places a strong emphasis on the environmental sustainability of agriculture as evidenced by having the highest proportion in the EU of rural development expenditure on measures aimed at improving the environment and countryside during the last programme period (European Commission, 2013). Due to the importance of spatial factors in assessing the success of schemes, emphasis is placed on identifying and comparing schemes’ characteristics with the location of important environmental public goods.

The next section outlines the institutional characteristics of environmental policy. This is followed by a description of the methodology and the spatial and survey data used to conduct the analysis. The results are broken into two sections: an institutional analysis of past and current AESs and a spatial analysis comparing scheme participation and environmental public goods. The paper ends with discussion, conclusions and policy recommendations.

2. Institutional framework

A number of policy options are available to policymakers to achieve their environmental objectives each with their own benefits and drawbacks. While not an exhaustive list, a number of these options are discussed below. These policy options represent the most significant in terms of the differences in the resulting schemes as well those that have actually been implemented within the EU and specifically within our case study country, Ireland. AESs are voluntary for farmers and the pros and cons of this are discussed first. The other sections in the framework relate to design options within the voluntary schemes. These include top-down, where one actor implements the policy, versus participatory approaches, which involve a number of actors in the design process, as well as co-ordination, which involves a higher level actor coordinating farmers to undertake actions, versus collaboration where the farmers work together to achieve goals. Policy makers must also choose between applying the schemes horizontally, where all farmers can enter a scheme and undertake the same measures, and targeted schemes aimed at a specific area or species. Finally as decision must be made about how payments levels are implemented, either action-based, if farmers are to be paid for undertaking certain management actions, results-based, if the farmers are only paid for measured improvements in the target or a mixture of the two.

2.1. Voluntary vs. mandatory

Under a mandatory policy a farmers' decision to undertake a measure is based on the cost of adoption, compared to the likelihood of receiving a penalty and the magnitude of the penalty if found to be non-compliant thus the cost of mandatory measures falls on the farmer. However, monitoring, enforcement and other transaction costs involved in the implementation of such measures may be high, especially given the non-point source nature of some agricultural pollution such as nutrient loss to waterways. This has led to the increasing popularity of voluntary measures where contributions are made to farmers towards the costs of adoption.

Under a voluntary policy farmers weigh up the cost of adopting a measure against the payments received for doing so. Wu and Babcock (1999) find that voluntary measures are more efficient than mandatory measures, if and only if the deadweight losses of government expenditures under the voluntary program are less than the difference between the private and public costs of government services, plus the additional implementation cost of the mandatory program. This is likely if the deadweight loss of raising government revenue is small, the number of farms is large, and the implementation costs of the voluntary program are much less.

Voluntary environmental policy can be implemented in two ways: through inducing participation with the threat of a harsher outcome without participation, or through incentives. The first could be considered to be not truly voluntary. Engel et al. (2008) point out three situations where inefficiencies can occur with these types of policies: payments offered are insufficient to induce a socially desirable level of adoption, the level of adoption is adequate but the cost is higher than the value of the services, or there are payments for adopting practices that would have been adopted anyway. The first two problems result in a social inefficiency, i.e. the marginal social cost is not equal to the marginal social benefit, leading to a reduction in social welfare. The third problem, known as lack of additionality, leads to a socially efficient outcome however it is not financially efficient if the socially efficient outcome could have been reached without expense. This is difficult to measure as we do not know what would have occurred without the scheme. A scheme that achieves additionality, however, has had a positive environmental impact.

2.2. Top-down vs. participatory approach

Top-down approaches to environmental policy occur where one actor, generally the government, implements advisory, regulatory or economic policies. The alternative is participatory approaches where multiple actors (including those who are impacted by the decision) are involved. Participatory approaches can differ in the level of representation of interest groups, the amount of information that flows up or down and the influence that participants can have (Newig & Koontz, 2014).

Top-down approaches are limited by the lack of information and involvement of those who live and work in the areas where the environmental policy will be implemented (Van Den Hove, 2000). Including multiple actors allows for a pooling of information as well as integration of new information, as it becomes available throughout the implementation process (Van Den Hove, 2000). Participatory approaches promote inclusivity in the planning and decision-making processes, with the objective of increasing the likelihood of acceptance (Kapoor, 2001; Newig & Kvarda, 2012). Through these methods, participatory approaches aim to improve effectiveness over top-down approaches. A key benefit of participatory approaches is that they enhance iterative programming where feedback loops result in in-situ improvements in policies, allowing for more flexibility than top-down approaches (Kapoor, 2001).

A drawback of the participatory approach is that the inclusion of multiple actors (each with their own interests), may result in conflicts over the nature of the problem and the potential solutions (Van Den Hove, 2000). This also may result in lower standards of improvement if the actors are more concerned with economic rather than environmental interests (Newig & Kvarda, 2012). The access to new information and knowledge is also not important if the issue requires more scientific and expert knowledge than that held by a layperson. The inclusion of many actors may also result in the dilution of important information pertinent to solving the issue (Rydin, 2007).

2.3. Co-ordination vs. collaboration

Agricultural environmental policy is often targeted at multiple single actors making changes co-ordinated from above but with no collaboration between the farmers themselves. The use of this type of policy in AESs has been criticised as resulting in fragmented land involved in the schemes which reduces the effectiveness and financial efficiency due to a mismatch in scale (Emery & Franks, 2012; Kleijn & Sutherland, 2003) This mismatch is due to the threshold effect where some ecosystem services operate at a larger scale than can be improved through the actions on just one farm in a local area (Cumming, Cumming, & Redman, 2006; Dupraz, Latouche, & Turpin, 2009). Only some public goods are influenced by the localised threshold effect. Global goods such as climate stability are not impacted, however, in the case of localised public goods such as water quality, a certain level of participation is necessary to make actual improvements in the good. Collaborative environmental actions involve groups of actors working together. Collaborative action between farmers is seen as generally beneficial in improving agri-environmental management, however there are limitations. Prager (2015) identify environmental benefits of collaborative action from the larger scale management of landscape which reduces the likelihood of habitat fragmentation and maintains ecological networks, improving the performance of the management actions in increasing/improving biodiversity. Other studies find that social benefits such as improved attitudes through group-working have also increased the level of conservation practices on farms (Lockie, 2006; Prager, 2015). The limitations of collaborative action largely relate to the social side as it relies on trust and social capital which may not exist amongst the farmers (Prager, 2015).

2.4. Horizontal vs. targeted

Horizontal measures are available to all farmers across the country or region in which a policy is in place with the same measures and equal payments. They generally cover a wide area and require farmers to make relatively small changes in practices (Matzdorf, Kaiser, & Rohner, 2008). Targeted measures are limited to certain zones and are usually implemented to manage specific species or ecosystems, requiring more substantial changes from farmers in practice. Theoretically, targeted measures are more cost effective as they are only implemented in areas of need, resulting in the greatest benefit. This also reduces the risk of a lack of additionality, where little or no changes are made. This type of scheme is also more likely to result in changes by reaching the threshold level above which improvements in the good will occur (Dupraz et al., 2009). However, identifying the farms to target may be difficult as this would require research, increasing the cost of implementation. Van der Horst (2007) also highlighted that public goods are not spatially compatible with each other, and thus require separate targeting for different goods may be required. Targeted measures are also less like to effective where there is uncertainty and large time and space scales associated with the environmental issue, resulting in difficulty identifying those responsible for the public goods (Van Den Hove, 2000).

2.5. Payment: Action-based vs. results-based vs. hybrid

Payments made for conducting voluntary environmental measures on farms can be mostly divided into two groups: action-based and results-based. Action-based payments are made on the basis of undertaking farm management actions that are intended to increase the supply of environmental public goods. The payments are generally in the form of prescribed amounts for each measure applied horizontally. Heterogeneity among farms means that costs of participation and compliance are lower for some which will result in some farmers being over-rewarded for participating and hence more inclined to participate. Depending on the reason for the heterogeneity in costs faced, some farmers do not need to make many changes leading to a lack of additionality. While socially efficient, this is not financially efficient as the money could have been employed to make greater changes in the stock of environmental public goods elsewhere. Derissen and Quaas (2013) find that this payment system is only optimal if there is an information asymmetry.

Alternatively, results-based payments require actual improvement in the environmental public good, according to a baseline level set prior to the implementation of the measure. They are also financially efficient as payments are not made if there is no improvement. The difficulty in implementing results-based payments is that the baseline requires on-the-ground analysis of the current state of the land, which incurs added expense. There also needs to be an evaluation system in place to determine the level of payment based on the level of improvement in the environmental public good the design of which may be complex. Results-based schemes also allow farmers to undertake management actions that fit their context, and which will achieve the best results in the most cost-efficient manner (Gibbons et al., 2011). Results-based schemes do not suffer from a lack of additionality as farmers must prove improvements to obtain payment.

However, results-based payments suffer from issues surrounding environmental uncertainty, where even if a farmer undertakes perfect measures to improve the environmental public good, uncontrolled natural events can negate the attempts, resulting in low payments or non-payment. This indicates a transfer of risk to the farmers as it is they who lose if there are negative environmental consequences from an unexpected event such as flooding or a storm (Derissen & Quaas, 2013; Schroeder, Isselstein, Chaplin, & Peel, 2013). This may result in non-participation by risk-averse farmers resulting in overall participation and lower environmental improvement. Hybrid payments, which comprise a mix of payments for action and payments for results, are suggested as a solution to this problem. These reduce the risk to farmers while still providing the incentives for direct environmental improvement as provided for by results-based payments. Derissen and Quaas (2013) find that hybrid payments are optimal for every situation other than when there is no symmetrical information.

In summary, there are numerous options available to policymakers in designing environmental policy for agriculture. Each option has its own benefits and flaws and different situations and goals require different scheme design. The next section describes the methodology and data used to analyse the schemes that have been implemented in Ireland using the institutional framework outlined in this section.

3. Data and methodology

To assess the past and current environmental policy relating to agriculture in Ireland, we use a multifaceted analysis. First, we chart the progression of voluntary environmental schemes over time and compare characteristics to the institutional framework outlined in the previous section. We then investigate the potential impact that AESs could have relative to the spatial location of environmental public good concerns in Ireland (identified at a townland level). To conduct an institutional analysis of AESs in Ireland we first identify past and current voluntary schemes and measures limited to those that have a primary goal of improving the environmental performance of farms. Table 1 lists these measures chronologically with a brief description of each.

Table 1: Chronological list of schemes/measures implemented in Ireland

Scheme/Measure	Year implemented	Description
Western Package Scheme	1981	Grants for planting of forests on lands marginal for agriculture but suitable for forestry.
Afforestation Grant and Premium Schemes	1989	Grant for those wishing to plant forests on land that has been used for agricultural purposes in recent years.
Rural Environment Protection Scheme (REPS) I-IV	1994	Large-scale whole-farm scheme in which farmers chose specific measures to undertake.
Farm waste management scheme (TAMS)	2006	Part of the Targeted Agricultural Modernisation Scheme (TAMS) which provides capital grants. This one is aimed at improving farm assets to manage slurry and other farm waste in order to meet Nitrates Directive requirements
Organic Farming Scheme	2007	Payments to aid farmers to convert to organic production. Previously included in REPS.
Forest Environment Protection Scheme	2007	Aimed at encouraging farmers participating in the REPS to establish high nature value woodland in their farms.
EU Life+ Programme	2007	A number of small targeted schemes. Burren Life Programme was implemented with funding from the programme in the Burren in County Clare.
Agri-Environment Options Scheme (AEOS) I-III	2010	Replacement for REPS, no longer whole-farm. Reduced the input of agricultural advisors in both the design and implementation process.
Green Low-Carbon Agri-Environment Scheme (GLAS)	2015	Replacement for AEOS, targeted to specific “Priority Environmental Assets or Actions”. Farmers with these gained priority entry into the scheme.
Low Emission Slurry Spreading Equipment Scheme (TAMS)	2015	Capital grant scheme to aid farmers purchasing slurry spreading equipment.
Animal Welfare, Safety and Nutrient Storage Scheme (TAMS)	2015	Capital grant scheme to aid farmers improve animal housing, slurry storage facilities and safety upgrades.
Beef Data and Genomics Programme	2015	Rewards farmers who improve the genetics of their beef animals and therefore efficiency
Results-Based Agri-environmental Payment Scheme	2015	Pilot scheme conducted in two locations in Ireland using a scoring system to pay for results.
EIP-Agri Projects	2017	A number of projects that received funding following an open call for collaborative targeted schemes.
Tillage Capital Investment Scheme (TAMS)	2017	Capital grant scheme that includes funding for improved water storage and drainage.

These schemes are examined against the institutional framework outlined in the previous section. Further analysis of their possible impact on the stock of environmental public goods is conducted through looking at the public goods which they aim to improve as well as analysis of the scale and spatial aspects of participation. The environmental public goods used throughout our analysis are those identified by Cooper et al. (2009) as being the most important associated with agriculture within the EU. These are farmland biodiversity, water quality and availability, soil functionality, climate stability (climate storage and greenhouse gas emissions), air quality, agricultural landscapes, resilience to fire and resilience to flooding.

To analyse the types of farms involved in AESs in Ireland we utilise the Teagasc National Farm Survey (NFS) database for the years from 1996 to 2016. The NFS provides yearly information on a sample of approximately 1000 farms in Ireland which are representative by farm system and size of a large proportion of the farming population. It contains information on farm and farmer characteristics as well as their participation in past and present Irish AESs. This is combined with information from the Teagasc Agri-Environment Costs Survey conducted in 2012. This survey contains information on the level of participation in REPS and AEOS by county, allowing us to conduct a spatial analysis at county level of participants and non-participants in past schemes. For the current scheme, the Green-Low Carbon Agri-Environment Scheme (GLAS) we use a map of participation created by Gooday et al. (2017) using actual participation data.

The spatial distribution of AES participants is then compared with the location of townlands with environmental public goods of concern. The public goods analysed are those from Cooper et al. (2009) mentioned earlier that have publicly available spatial data. This information has been collated using GIS software at a townland level. Data limitations have meant that only four of the original eight goods are used in the analysis, farmland biodiversity, water quality, climate stability and resilience to flooding. Determining a spatial distribution of environmental public goods in Ireland requires combining the different public goods into one map. This requires a valuation of each of the goods in relation to the others. However, the valuation and particularly quantifying the relative value of public goods is complex and poses challenges. To simplify this complexity, we assume that each of the public goods is equivalent in terms of value. In practice, this means that combining the public goods into one map involves giving each of the public goods of concern a value of one if a particular townland has been identified as the location of a public good that should be conserved or improved. The sum of these public good concerns thus provides a relatively crude measure of the concentration of environmental public good concerns in a particular area.

The mapping resources to identify areas of importance for farmland biodiversity have been obtained largely from the National Parks and Wildlife Service (NPWS). Information on the distribution of birds, animal species and habitats that are of conservation concern within the European Union are reported as is required by the Habitats and Birds Directives. These directives also require the creation of Special Areas of Conservation (SAC), areas important for particular habitats or species protection, and Special Protection Areas (SPA), areas important for particular bird species, which together form the Natura 2000 network. Also identified are Natural Heritage Areas, which are important for the protection of certain habitats and species.

The identification of townlands important to water quality is found through using the Quality Rating System, Q-values, reported by the Environment Protection Agency (EPA). Q-values range between 1 and 5 where 1 indicates poor ecological quality, while 5 is the reference value, indicating pristine or high ecological water status. The Water Framework Directive requires Member States to protect and maintain high status water bodies. For this reason for the purposes of this study we have taken townlands with rivers with a Q-value of 5 to represent those important to water quality in Ireland. Climate stability in terms of carbon storage and resilience to flooding measures are based on the National Parks and Wildlife Service National Ecosystem and Ecosystem Services Mapping pilot which indicated where hotspots for the provision of these goods are for Ireland. These hotspots are used as the measure of importance for these public goods in this study. Table 2 presents the summary statistics for these goods in terms of the number of townlands (out of 50,109) that contain the level of public good which we have taken to indicate that it is important.

Table 2: Summary statistics for measures of environmental concern by townland

Public good	**Measure**	**Data source**	**Number of townlands**
Farmland Biodiversity	Special Area of Conservation (SAC)	NPWS	11,663
	Special Protection Areas (SPA)	NPWS	5,088
	Natural Heritage Areas (NHA)	NPWS	150
Water Quality	Q-value = 5 (high status)	EPA	2,936
Climate stability	Carbon Storage hotspots	NPWS	1,177
Resilience to flooding	Water retention hotspots	NPWS	7,842

4. Results

4.1. Institutional analysis of past and current schemes

Agri-environment schemes are voluntary economic measures aimed at improving the environmental performance of farms. EU Member States have been required to implement agri-environment schemes since 1992 following Council Regulation EEC no. 2078/92. Objectives and design differ between Member States. Ireland has implemented three large-scale schemes: Rural Environment Protection Scheme (REPS), Agri-environment Options Scheme (AEOS) and the current scheme the Green Low-Carbon Agri-Environment Scheme (GLAS). Numerous other environmental measures have also been implemented over the years. These are listed chronologically sorted by their characteristics in Table 3.

The REPS and AEOS AESs were similar in that they were both top-down, horizontal schemes that involved co-ordinated actions undertaken by farmers who volunteered to participate. Farmers signed five-year contracts agreeing to undertake certain specific environmental actions and to follow a nutrient management plan, with threat of penalty for non-compliance. REPS involved the whole farm with payments made on a per hectare basis while the consequent schemes only involved undertaking specific actions with payments per action. GLAS was the first large scale top-down scheme that attempted to target the measures towards specific farms, based on areas of environmental concern as farmers with 'Priority Environmental Assets and Actions' including Natura 2000 sites, specific bird species, commonage, high status water areas and rare breeds had priority access to the scheme. GLAS also limits the payment available to farms to €5,000. Starting in REPS 4, and continuing into AEOS and GLAS, farmers with Natura

200 designated land received a payment per hectare within the schemes for following a sustainable management plan.

The most recent progression in the design of agri-environment schemes is the European Innovation Partnership (EIP-Agri), where open calls for farmer-led, participatory project applications were sought in thematic areas including the preservation of agricultural landscapes, water quality, biodiversity and climate mitigation. Two of the projects implemented under this programme are the Hen Harrier and Freshwater Pearl Mussel scheme which are targeted at specific species with core target areas identified as important habitats where participants would be sourced from. The aim of the projects is to develop locally tailored solutions to problems with strong collaboration between a wide range of stakeholders.

There are a number of results-based or hybrid agricultural projects under The EU Life+ Programme, which began in 2007. The most significant and well-known is the Burren Life Programme which commenced in 2010. It aims to increase the supply of a multitude of public goods including farmland biodiversity, water quality and agricultural landscape. Payments for the scheme are hybrid in nature, with some payments based on actions undertaken, while others are based on improvements in the quality of habitats and water. A key component of the programme is that it is 'locally-led', employing a collaborative approach between farmers and other stakeholders. The programme has been very successful and has paved the way for more collaborative schemes that base payments on results. While there are concerns from policy makers and others about high transaction costs in these types of schemes the Burren Life Programme had proportionately similar implementation and administrative costs in comparison to the large-scale AESs which showed that targeted results-based schemes could be implemented without the costs outweighing the benefits (Cullen et al., forthcoming).

A number of other measures have been introduced with specific priorities. The Beef Data and Genomics Programme that was implemented in 2015 rewards farmers for improving the genetic merit and consequent efficiency of their animals to generate less greenhouse gas emissions per kilo of beef produced. This scheme includes a requirement for applicants to complete a Carbon Navigator[1] with the aim of promoting the environmental and economics 'win-win' of improving efficiency of production and reducing greenhouse gas emissions on participating farms. Payments to aid farmers to convert to organic production have been available in Ireland since 1994. Between 1994 and 2006 these were made within the REPS scheme and in 2007 a separate Organic Farming Scheme was introduced. Over the period, the area under organic farming in Ireland has doubled.

The Targeted Agricultural Modernisation Scheme (TAMS) is a grouping of capital grant schemes designed to incentivise private investment in physical farming assets in order to improve the economic and environmental performance of farms. In an early iteration of TAMS, the Farm Waste Management Scheme allowed farmers to improve their ability to meet the requirements of the Nitrates Directive by investing in assets to manage slurry and other farm waste. The current TAMS which was implemented in 2015 includes the Animal Welfare and

[1] The Carbon Navigator is an online farm management package that quantifies the environmental gains that can be made on individual farms by setting targets in key areas such as grassland management. It allows farmers to see the reduction in GHG emissions from making changes such as lengthening the grazing season or improving animal genetics.

Nutrient Storage Scheme and the Tillage Capital Investment Scheme which have primary goals of reducing nutrient loss to waterways while the Low Emissions Slurry Spreading Scheme aims to reduce greenhouse gas emissions from agriculture. Another TAMS scheme is the Organic Capital Investment Scheme which has a primary objective of reducing risk to converting or registered organic farmers, however secondary objectives also include reducing nutrient loss and emissions.

The earliest schemes identified in Table 3 are all aimed at increasing forest cover on private agricultural land in Ireland. The Western Package Scheme, was the first EU funded afforestation scheme and was available only in western counties, had a slow uptake. This was replaced in 1989 with the Forest Premium Scheme, and various iterations of the current Afforestation Grant & Premium Scheme which was opened in 1992. This provided grants to plant land and maintain it in the first few years as well as payments to compensate for the agricultural opportunity cost of planting. Over time these schemes have been added to and now include the Forest Roads Scheme, aiming to improve access to the forests, the Woodland Improvement Scheme and the Native Woodland Scheme among others. These schemes are all top-down co-ordinated schemes that are applied horizontally.

The scheme characteristics found in Table 3 indicate that the dominant form of AES implemented in Ireland to date, is top-down, co-ordinated, horizontal, action-based schemes. While these are still currently in place, largely in the form of schemes aimed at providing capital to improve the environmental performance of farms, there is also an increased use of targeted schemes aimed at specific areas, species or habitat types. There is also an increase in the use of collaborative approaches, funded under the Life+ Programme and EIP-Agri, indicating the evolving nature of AES scheme design in Ireland.

Table 3: Characteristics of voluntary schemes/measures in Ireland

Characteristics	Horizontal	Targeted
Top-down Co-ordinated Action-based Payments	Western Package Scheme (1981) Afforestation Grant and Premium Scheme (1989) REPS I-IV (1994) TAMS – capital grants (2006) Organic Farming Scheme (2007) Forest Environment Protection Scheme (2007) AEOS (2010) Beef Data & Genomics (2015)	GLAS (2015)
Participatory Collaborative Results/hybrid payments		EU Life Programme (2007) RBAPS (2015) EIP-Agri Locally Led projects (2017)

While the policies mentioned differ in their institutional characteristics, they all are aimed at improving the stock of environmental public goods on agricultural land. Table 4 indicates the public goods targeted for improvement by the different environmental policies. The majority of policies are targeted at the improvement or maintenance of public goods such as farmland biodiversity, water quality and availability, soil functionality and agricultural landscapes. The horizontal schemes all target numerous public goods, which provides evidence of their multiple objectives.

While climate stability was a primary goal of AEOS and the current large-scale scheme GLAS, the only optional measure available for farmers is the introduction of improved slurry spreading methods. Largely the capital grants under TAMS have concentrated on maintaining or increasing the stock of one specific public good. These schemes generally provide the capital to either help farms achieve cross compliance standards in order to receive subsidies (or not incur penalties) or assist farmers to meet the infrastructural criteria to enter horizontal schemes such as GLAS or the Organic Farming Scheme.

In relation to targeted schemes, the EIP-agri programme is comprised of a number of localised targeted schemes. These individual schemes are aimed at improving only one public good by providing more appropriate habitats for specific endangered species such as the Hen Harrier or Pearl Mussel. In contrast, schemes under the Life+ programme such as the Burren Life Programme target multiple public goods in a holistic way as they are aimed at general improvement of the environmental performance of farms and increasing the amenity value of a specific area.

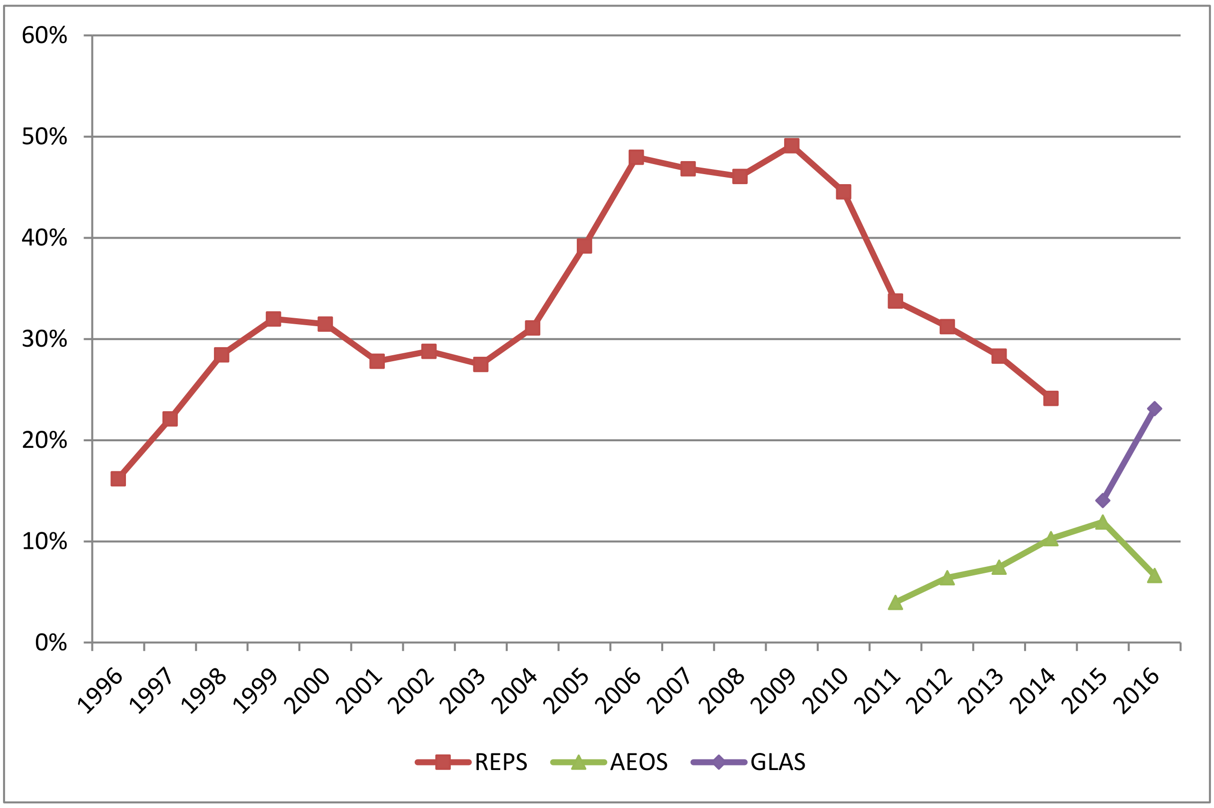
Table 4: Public goods and agri-environment scheme primary goals

Type	Scheme	Farmland biodiversity	Water quality and availability	Soil functionality	Climate stability	Air quality	Agricultural landscapes	Resilience to fire	Resilience to flooding
Horizontal AES	REPS I-IV	✔	✔	✔			✔		
	AEOS I-III	✔	✔	✔	✔		✔		
	GLAS	✔	✔	✔	✔		✔		
	Organic Farming Scheme	✔	✔	✔			✔		
	Afforestation grant and premium scheme	✔	✔		✔	✔			
Targeted AES	Life+ Programme	✔	✔	✔			✔		
	RBAPS	✔	✔	✔			✔		
	EIP-Agri	✔	✔	✔			✔		
Capital scheme	Farm waste management scheme		✔						
	Low Emission Slurry Spreading Equipment Scheme				✔				
	Animal Welfare, Safety and Nutrient Storage Scheme		✔						
	Tillage Capital Investment Scheme		✔						
Other	Beef Data and Genomics Programme				✔				

4.2. Agri-environment scheme participant analysis

The three large scale action-based AESs in Ireland, REPS, AEOS and GLAS, share a number of characteristics as identified in the previous section. Participation in these schemes differed significantly as illustrated in Figure 1 which charts scheme participation from 1996 to 2016 based on the Teagasc National Farm Survey. REPS had by far the highest participation rate, reaching almost 50% in 2009, following which no new contracts were issued. This scheme was a whole farm scheme and the payments available to each farm were higher than the schemes that followed. AEOS had relatively low participation levels, however, there was significant overlap between the two schemes with the more lucrative REPS contracts on-going for most of the AEOS period. GLAS began in 2015, and in 2016 over 20% of the NFS farms were involved, still well below the REPS level. GLAS is split into three tranches with new entrants yearly. With only two data points available little can be said on the participation trend.

Figure 1: Percentage of farms in the National Farm Survey involved in an agri-environment scheme (1996-2016)

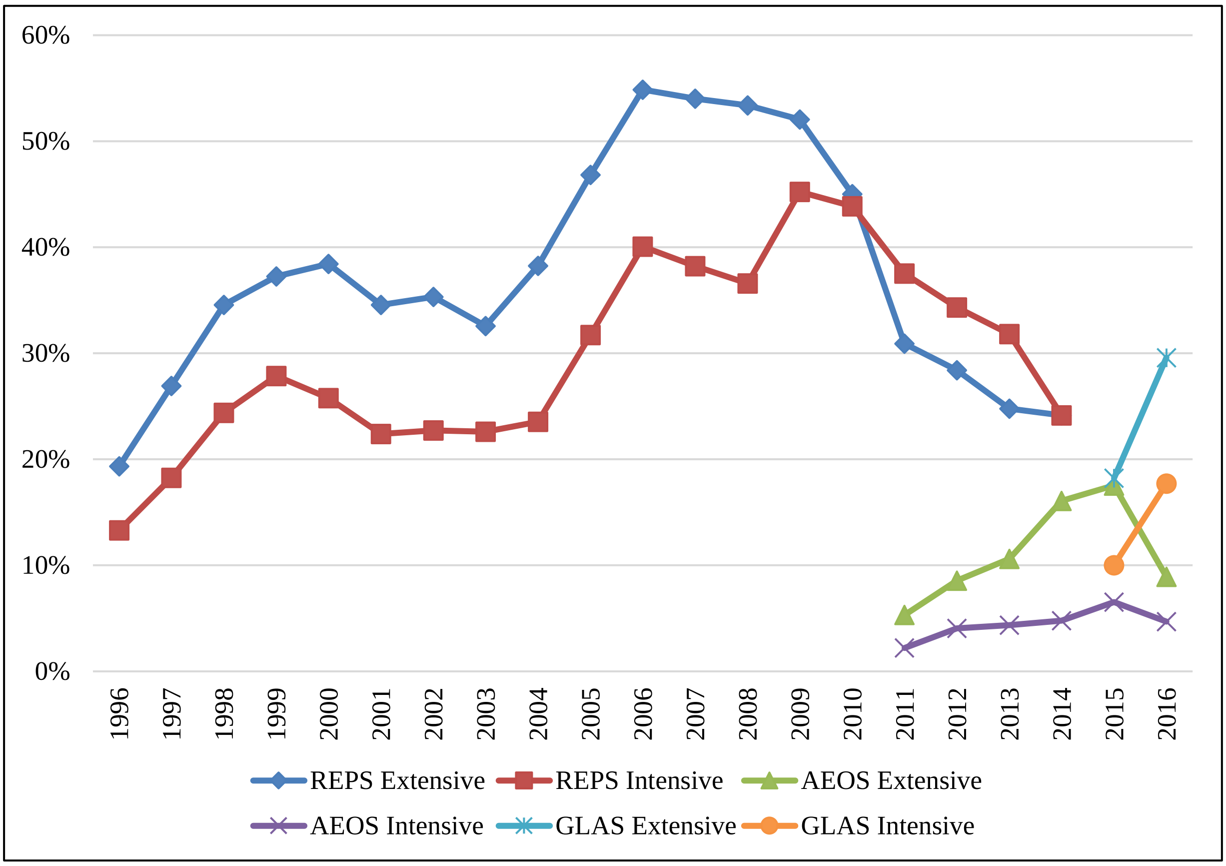


Extensive farms are likely to require fewer practice changes to participate in an agri-environment scheme in Ireland. This lower level of change is also generally associated with a lower opportunity cost of participation for extensive than for intensive farms. As horizontal schemes pay the same amount to all farms for specific measures, theoretically this will result in higher participation of extensive farms in schemes as they will likely be overpaid relative to intensive farms. This has been shown in past research (Hynes & Garvey, 2009; Murphy, Hynes, Murphy, & O'Donoghue, 2014). This indicates a possible financial inefficiency in the schemes as the costs to the public result in fewer changes than if intensive farms joined.

Figure 2 shows the percentage of extensive and intensive farms that participated in REPS, AEOS and GLAS between 1996 and 2016. Extensive farms are those with stocking rates below 1.4 livestock units per hectare as this was the level below which farmers could obtain an 'extensification' payment. In order to reduce the mapping complexity in this analysis, stocking rates above 1.4 livestock units per hectare are designated as intensive. Prior to 2010 a higher percentage of extensive farms participated in REPS than intensive, however post 2010 this relationship changed. This is likely due to the wind-down of REPS indicating that contracts were ending for the extensive farmers who had joined the scheme earlier.

Figure 2 also shows higher extensive farm participation rates for those involved in AEOS. In this case the participation rate for extensive farms was at least twice as high as intensive farms for all years of the scheme. A similar result is seen for GLAS farms.

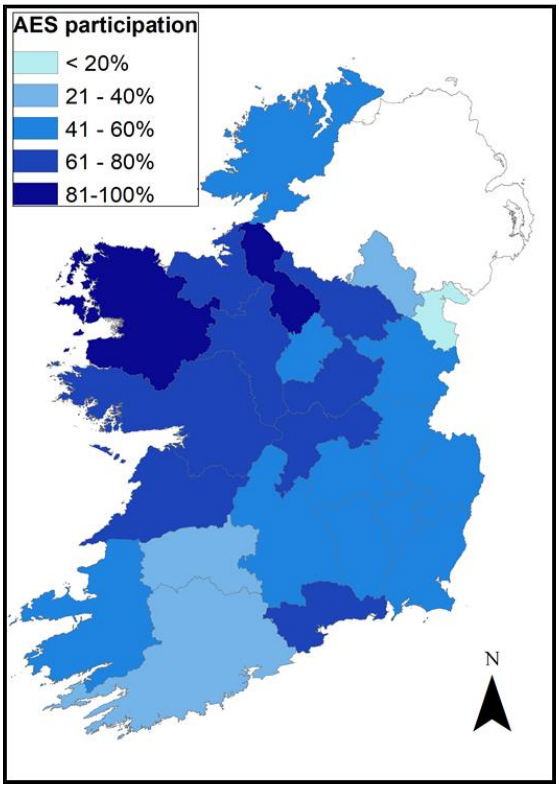
Figure 2: Scheme participation of extensive and intensive farms in Ireland



The participation rates across the country for the previous wide scale schemes REPS and AEOS as well as the current scheme GLAS which provides priority access to farms with a Priority Environmental Asset or Action are displayed in Figure 3. Figure 3.1 shows the percentage of farms in each county that are current or past participants in AESs as of 2011 using data from the Teagasc Agri-Environment Cost Survey. A pattern is evident with lower participation rates in the south-west. Higher participation rates are found in the north-west of the country with Leitrim and Mayo having the highest level of participation at 86% and 84% respectively within the sample. Figure 3.2, created by Gooday et al. (2017), gives an accurate view the amount of land involved in GLAS. The west of the country continues to have higher participation rates similar to REPS and AEOS which indicates that a number of participants continue to be involved in schemes. In the next section we will compare these participation patterns with that of the location of environmental public goods.

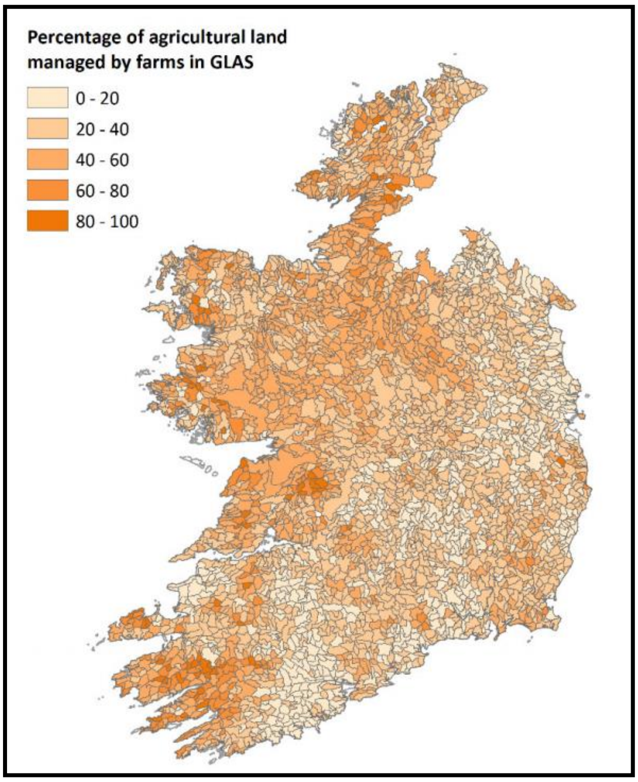
Figure 3: Agri-environment scheme participation rate in Ireland

Figure 3.1: REPS and AEOS participation by county (%)



Source: Authors'

Figure 3.2: GLAS participation rate (%)



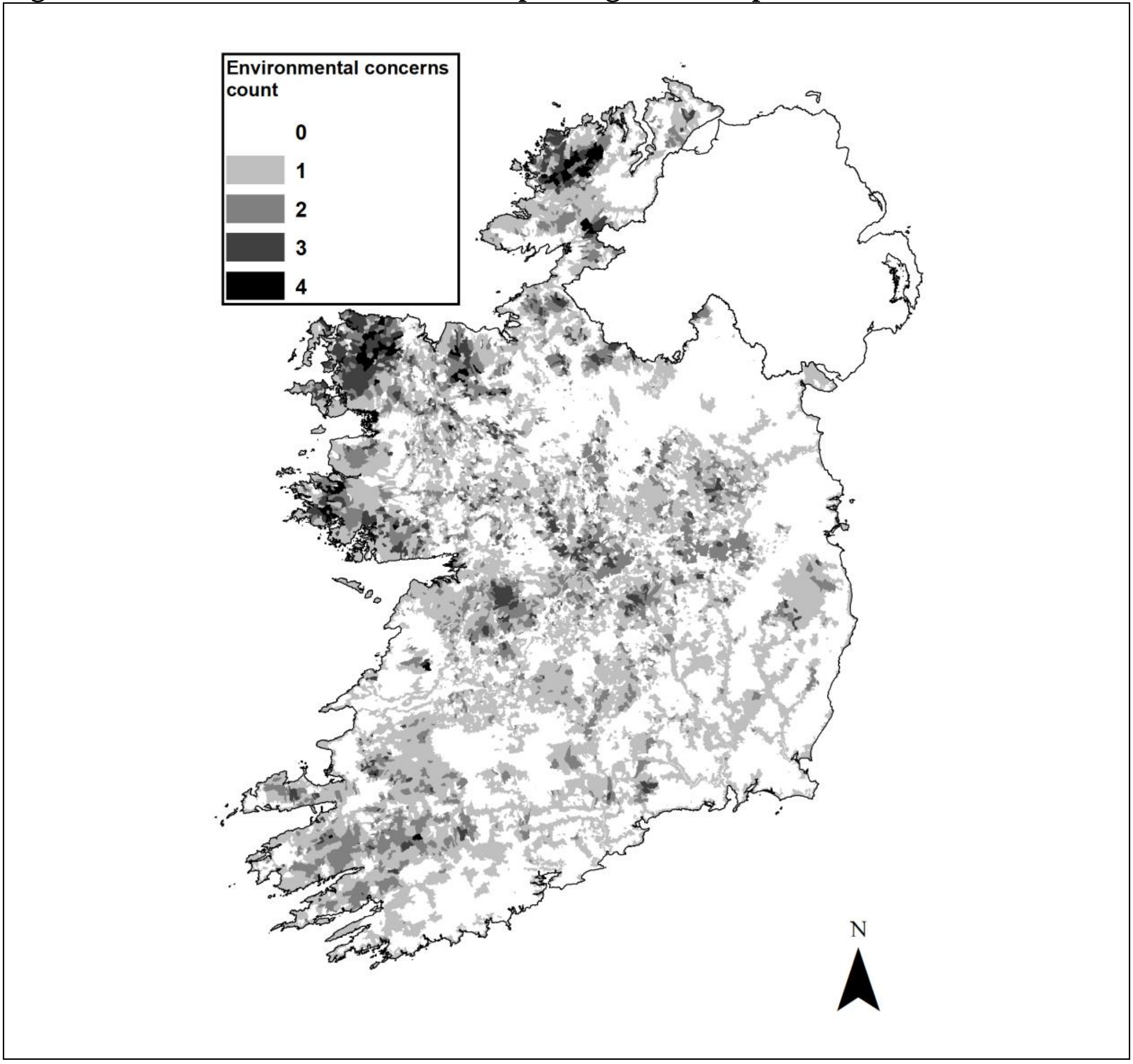
Source: Gooday et al. (2017)

4.3. Spatial analysis of environmental public goods

The locations of concentrations of environmental public goods of importance to the sustainability of agriculture in Ireland are identified in Figure 4. Specifically, we have identified areas of importance associated with farmland biodiversity, water quality, climate stability (carbon storage) and resilience to flooding. These are combined through a count of the number of different goods each townland contains based on the signifier of importance discussed previously. For example, if a townland contains special protection area, then it receives a value of one for farmland biodiversity, leading to a range of zero to four for the four different types of public goods.

Figure 4 shows us that largely these concerns are spatially discrete. While there are certain areas that have a high concentration of locations of environmental concern, such as the west of the country, there are also multiple townlands with a high concentration of different environmental public goods of importance adjacent to townlands with none. Groupings of townlands with high concentrations of concerns can be seen in the north-west of the country as well as in the south-west.

Figure 4: Coincidence of environmental public goods of importance at townland level



These concerns are broken down into their separate categories in Figure 5. Each townland is categorised based on the concentration of different environmental public goods of importance as identified by each of the different measures in Table 2. Figure 5.1 shows the concentration of farmland biodiversity concerns at townland level. There is a large concentration of townlands of importance for farmland biodiversity in coastal areas, specifically in the north-west, and south-west. Water quality concerns show a similar pattern (Figure 5.2). The townlands with carbon storage hotspots (Figure 5.3) are largely in the top half of the country. This is largely driven by physiological factors such as soil type. Resilience to flooding (Figure 5.4) indicates the most random spatial pattern, with discrete townlands across the country containing water retention hotspots. Together these images show that the different types of environmental concerns in Ireland are not spatially consistent and have diverse patterns.

Figure 5: Spatial distribution of specific environmental public goods of concern

Figure 5.1: Farmland biodiversity

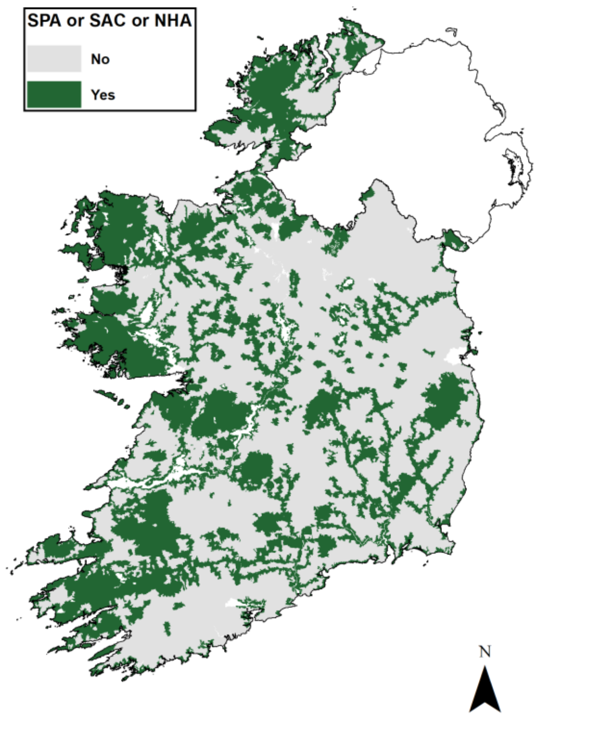


Figure 5.2: Water quality

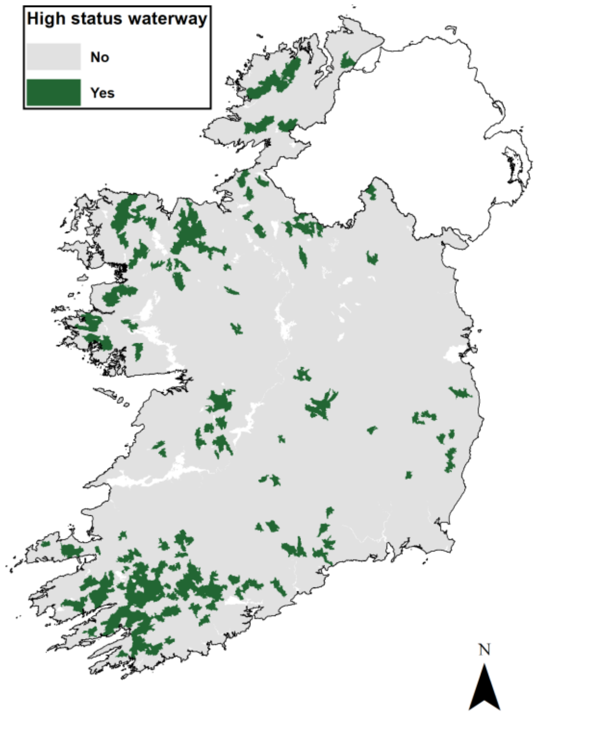


Figure 5.3: Climate stability

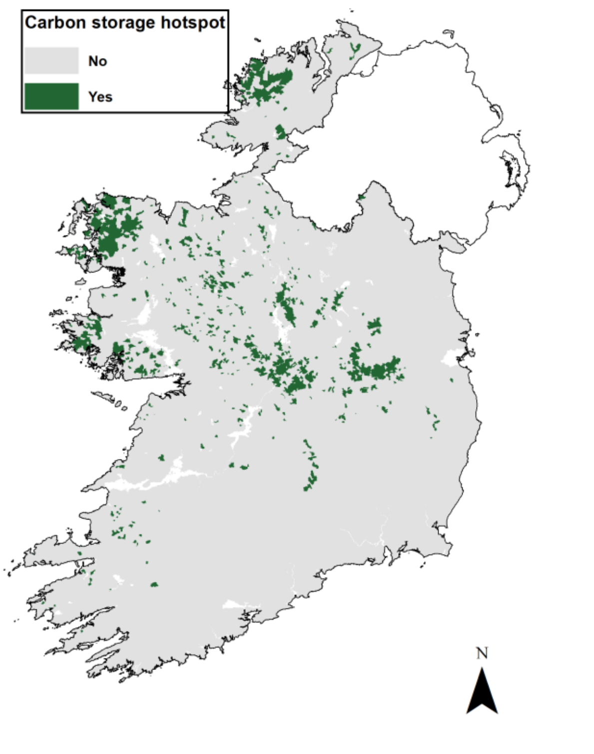
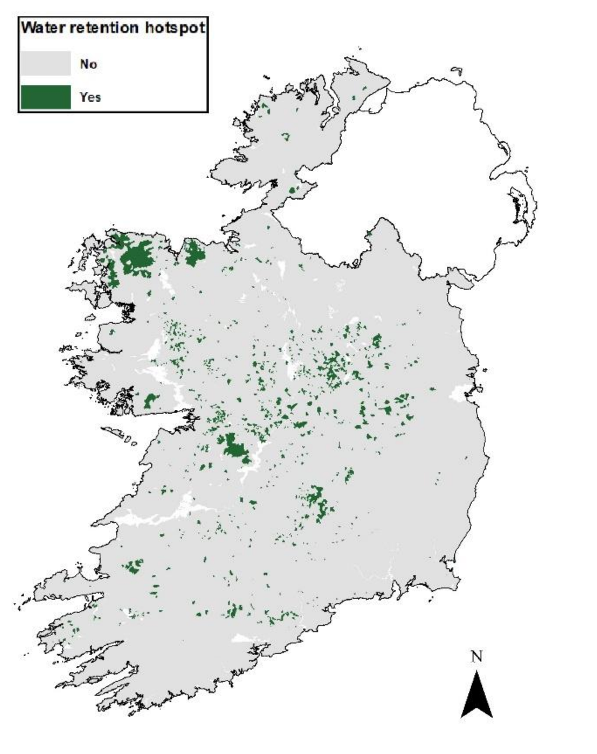


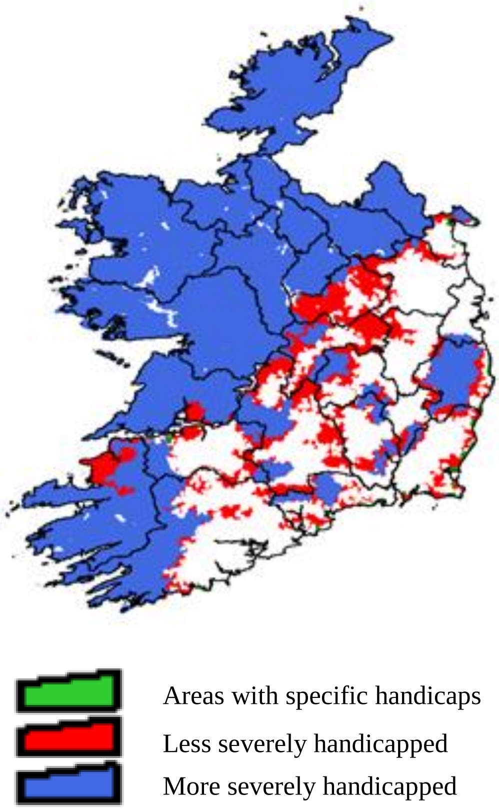
Figure 5.4: Resilience to flooding



5. Discussion

The location of the high coincidence of environmental public goods is in areas that suffer from natural handicaps to agricultural production. Figure 6 shows the classification of disadvantaged areas into those with less and more severe natural handicaps as required under the Less Favoured Areas scheme which aimed to bolster farmers' incomes in areas of socio-economic and natural handicaps to halt land abandonment. This suggests that although more extensive farms are more likely to participate in AESs they may also be the farms that have more to protect or improve in terms of public goods.

Figure 6: Disadvantaged area classification



Source: DAFM (2014)

Comparing the concentrations of environmental public goods of importance (Figure 4) to participation rates of different counties in REPS and AEOS (Figure 3.1) we can see that high participation rates are not always in locations with a large number of important environmental features requiring protection and/or conservation. While the highest participation rates in the north-west correspond to high concentrations of environmental concerns, this trend does not hold for all areas. Similarly, in the south of the country, where AES participation is low, there is a mixture of high and low concentrations of environmental public goods of importance. By comparison GLAS, which was targeted at Priority Environmental Assets, including SPAs, SACs and high-status waterways, the spatial relationship between the participation and the location of environmental public goods, is much clearer with a similar pattern emerging in Figure 3.2 and Figure 4. This suggests that the targeting of schemes did result in participation in these areas suggesting a high chance of additionality. The threshold level at which actual improvements in the targeted goods are realised is also more likely to be reached. If this is the case, then a targeted scheme such as GLAS would be more financially efficient than a horizontal scheme.

Not included in our spatial analysis are the small-scale, results/hybrid-based payment schemes, EU Life Programme and EIP-Agri Locally Led Projects. These schemes were spatially targeted, hence are located in the areas where there is a perceived need for them based on their objectives. As a certain level of payments in these schemes is based on actual improvements in public goods, there is clear evidence that they achieve their objectives.

6. Conclusions

This paper set out to combine an institutional analysis of AESs with a spatial analysis in order to learn lessons from past AESs and provide information on design options that may be useful to policymakers. While in the past the literature has focused examining each design option separately and evaluating the environmental improvements that can be attributed to AESs, we explore all the scheme options available as well as the likely impact these have at a spatial level by identifying the location of environmental public goods of importance.

AESs have been evolving over time from top-down, horizontal, co-ordinated, actions-based schemes to more targeted approaches (with increasing use of a participatory model) to scheme design and collaborative implementation. Both our study and the literature show that AESs have tended to be taken up by extensive farmers relative to non-extensive farmers (Hynes & Garvey, 2009; David Kleijn & Sutherland, 2003; Murphy et al., 2014). This is likely to have been due to the lower opportunity costs of participation for extensive farmers. This suggests there may have been issues with a lack of additionality, where farmers did not have to make many changes to join the scheme and hence the environmental improvements achieved were lower than if intensive farmers had joined in greater numbers. The success of the Burren Life Programme and the acceptable levels of administrative and implementation costs suggests that targeting schemes to spatial needs is possible and can be achieved efficiently (Cullen et al., forthcoming).

Spatially, our analysis shows that areas important to the improvement or conservation of the stock of environmental public goods, are not in discrete locations and are spread throughout the country. While there is a concentration of important areas in the west of the country, there are also numerous townlands with a high concentration next to townlands with low concentrations, suggesting that the environmental public goods analysed are localised. This suggests that optimally the targeting of schemes for these goods should be done at a small scale. On the other hand, climate stability is a global good, and hence changes made at any level will have an impact. There are also a number of other public goods related to agriculture which have not been discussed in this paper such as social public goods including rural vitality that are of concern to policy makers, however these are currently beyond the scope of this analysis. Another key implication of the spatial analysis of environmental public goods is the spatial inconsistency between the goods, each displaying different patterns in their occurrence. This suggests that although schemes generally have a large number of goals relating to different environmental public goods, it may be more efficient in terms of targeting to separate them.

The spatial analysis was limited to the data available on the public goods. Future work will expand the number of public goods analysed to include measures for all the public goods mentioned. This will allow for a broader understanding of the locality of environmental public goods that are important for maintaining and improving their stock. This could then be compared to actual participation in all schemes and measures mentioned, however, limited participation data are available. We also have not weighted the public goods in terms of their value to the public, instead assuming they have the same value. This is unlikely and the development of an index with different weightings for each good may increase the value of the analysis through further indication of the concentration of value of environmental public goods in certain areas.

Designing new AESs is challenging. There is no single ‘best’ option available to policymakers, as each option has benefits and flaws. Ideally, policies should address the spatial disparity in the concentration of specific environmental goods. However, if this is too costly, then horizontal schemes may be more efficient. Perfecting environmental policy implementation to achieve results requires identifying the correct mix of policies in order to address the specific problems faced. Solving localised problems may require targeted collaborative schemes, while addressing larger scale issues such as climate change, will require co-ordination of large numbers of farmers, either through regulation or economic means.

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