7.2.11 “An Evaluation of the Socio-Economic Impact of the AranLIFE Project Actions”

“Final Report”

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Prepared for the

AranLIFE Project

August 2018

Executive Summary

Presently farming systems in the Aran Islands represent a marginal economic activity yet they have defined one of Europe's unique landscapes and played an important part in contributing to its biodiversity and archaeological and cultural heritage and its strong reputation as a tourism destination among domestic and international tourists. However in recent years the landscape and its biodiversity has come under threat due to a shift in farming methods and management practices. As a result of evolving market and social trends, traditional farming methods are being replaced by more commercial practices.

Broadscale voluntary Agri-environmental schemes (REPS/AEOS) have failed to counter this trend and this has led to the development of a more targeted approach whereby the Aran life project has been working with farmers to define conservation actions and scientific practices developed specifically for Aran Island habitats and farming systems.

The current market and social trends coupled with farming marginal land cause socially beneficial extensive farming practices in the Aran Islands to be financially non-viable. At the same time tourism has become increasingly more important to the islanders. Many farm households have made significant investments in tourism and have become increasingly dependent on income from tourism. Tourism, agriculture and landscape are thus inextricably linked and farming underpins the Aran Island economy in two ways, through the sale of agricultural produce and by supporting the tourism economy through its landscape. Landscape externalities are therefore important in contributing to the future of the Aran Islands economy and development as well as to the welfare of individual households. It is important also that agri environment and targeted schemes formulated by the EU and the Irish state are effective at enabling the process described above.   In this study we therefore examine the public good and tourism values associated with AranLIFE conservation actions. This work employs a survey based valuation technique (Choice Experiments) to estimate the value of the positive externalities generated by the AranLIFE conservation actions. We do this by investigating tourism preferences for a variety of characteristics or attributes associated with the Aran Islands landscape. These include the karst limestone landscape, orchid rich biodiversity, stone walls and archaeology and recreational walking trails across farm land. According to our estimates, the aggregate benefits provided by the karst limestone pavements and the orchid rich biodiversity are in the region of €59 and €83 per hectare per year respectively. From the tourist survey, we also note a WTP of €99.56 for the development of walking trails using Boreens across farm land.

These positive externality values and tourism revenues are incorporated into a Land Portfolio Allocation (LPA) model to examine the effect of various policies and subsidies on the farming practices of the 67 AranLIFE farms ('Aran 67 farms'). Results from the LPA model indicate that the suckler beef and AranLIFE Project (ALP) payment systems are crucial for the AranLIFE farms and together produce between €9,696,664 in positive cultural, karst landscape and biodiversity externality value for the community. By including the entire direct payments and administrative costs of the ALP program of €2,597,685 our results suggest that for the most conservative reported willingness to pay from survey data, the rate of return on government support for these systems is no less than 382%. Our results further suggest that landowners' preferences for producing in a manner consistent with the ALP practices are significant and represent between €0 and €10000 in non-pecuniary income with most lying between €0 and €3000. Our experiments further suggest that in the absence of direct ALP payments, at the very least payments to mitigate increased production costs associated with the ALP can provide some broader external value to the citizens of Ireland and represent sound government investment producing a more than a one for one rate of return for each Euro invested.

With such high levels of economic benefits stemming from the ALP scheme and its associated links with landscape and tourism, our recommendation is for the ALP to continue with its role as a liaison between farmers and various government and non-government institutions in pooling resources and ensuring that the activities of farmers are coordinated in the delivery of local environmental public goods. We recommend further consideration of walking trails using Boreens given the high tourist demand. Furthermore, we recommend that the AranLIFE program be extended to incorporate sustainable methods of rewarding the land managers for their contribution in implementing the ALP practices and maintaining the unique Aran Island landscape.

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1. Introduction

Small Island Economies have traditionally depended on agriculture and fishing with tourism increasingly playing an important role. In recent decades small Island communities such as the Aran Islands have had to face important challenges such as how to develop their infrastructure and island institutions to ensure they serve the tourist industry in a manner that brings real and tangible economic benefits to the islanders from increasing tourism numbers in a sustainable manner (Keane et al. 1992). Regardless of these changes, agriculture remains at the forefront of the economy of the Aran Islands. It is important for the identity of the Aran Islands through heritage, tradition, the farming vocation, landscape, biodiversity and archaeology. It is therefore essential to integrate the correct economic and development policies that span the tourism, agriculture and rural development sectors to enhance this multitude of factors. This study is primarily concerned with the interface between farming, landscape and tourism and the efficacy of agri-environment policy in achieving desirable social and economic goals. Nevertheless, with farm management practices as the primary tool that underpins the landscape, it is a constant struggle to design and implement an ideal agricultural policy that is well integrated and supports other sectors such as tourism and rural development but is able to endure evolving market trends and social structures and still manage to preserve the natural environment.

The Aran Islands represents an excellent example of a managed landscape where the natural environment has co-evolved together with the farming culture to form an interdependent alliance. Traditional farming practices in the Aran Islands were developed and implemented primarily for the purpose of producing food and sustaining a livelihood. Although these ends have undergone immense devaluation as a result of changing market trends, the externalities associated with extensive farming practices in terms of the unique landscape, its biodiversity and archaeology and its role in supporting the Aran Island tourism industry holds significant value. The problem however lies in realizing the value of the externalities such as the landscape and biodiversity and in defining their role in supporting Aran Island tourism. Their value is implicit; that is, it is not actively traded in the market and as a result there are no economic (market) incentives for farmers to continue with past practices that preserve them. Indeed many farmers may not derive benefits directly from them.

This is especially important in circumstances where the externality values associated with an area are high compared to the market value, or in situations where the non-market values are important in supporting a tourism industry which is the economic mainstay of an area. A number of studies have used stated preference valuation techniques to explore the significance of externalities and market failure concerned with landscapes (Campbell 2007; Scarpa et al. 2007; Hynes et al. 2011) biodiversity (Turpie, 2003; Yadav et al., 2013; Martin-Lopez et al., 2007) open space and recreational public access (McGonagle and Swallow, 2005; Buckley et al., 2009;

Morris et al., 2009) and the evaluation of agr-environment schemes (Kelley et al. 2013; Hynes et al. 2011) more generally.

Agri-environmental schemes have been developed to address such market failure concerns but they have not been particularly effective due to the broad nature of the schemes, flaws in policy design and/or implementation, poor sectoral agency integration and a lack of participatory approaches used in their deployment (Lohmann and Hodge 2003; Kramm, et al. 2008). Consequently there has been an increase in the number of targeted schemes which employ participatory methods. Groups such as AranLIFE use a more targeted participatory approach to land management problems and thereby deliver environmental public goods that are unique and tailored specifically to the Aran Islands landscape.

In the absence of a concerted effort to account for externalities, say using valuation there is a danger that these external benefits go ignored and therefore the Aran Islands are undervalued and the benefits associated with the intervention by AranLIFE are lost or not fully captured. Two features that distinguish the Aran Islands from areas on the mainland are 1) the high value of tourism relative to other land based industries and 2) the fact that the Islanders and farmers themselves invest much more heavily in tourism and rely on it to a greater extent and they derive a significant proportion of their household incomes from tourism.

Despite the importance of tourism to the Aran Islands, we note that not a single academic paper has evaluated the public good and externality value of the landscape to domestic or international tourists. It is important therefore to examine the relationship between the particular preferences tourists might have for the characteristics that make up the Aran Islands landscape and the farming methods and costs involved to farmers of providing these attributes that makeup this landscape. This is a novel exercise and we are not aware of any academic papers that actually do this.

Better landscapes matched to local visitor and tourist needs may increase the utility and welfare of local and international tourists as well as trip expenditures which in turn can influence local employment and welfare. It is also recognized that landscapes such as the Aran Islands provide non-use values to individuals living in Ireland and elsewhere who do not visit the Aran Islands but still nevertheless derive utility from knowing it exists.

Farmers have to weigh resource allocation decisions to ensure for public good provision against activities that produce market commodities. Policy makers also need to ensure that resources devoted to maintaining schemes such as AranLIFE represent good value for money to the Irish and European tax payer.

The land portfolio allocation model (LPA) proposed in this study helps to understand these processes and can provide fundamental insights into decisions taken by the farm household. First, it will determine whether or not the AranLIFE project actions are financially and economically viable and secondly, how market and policy trends impact on viability, land use and the associated amenity and biodiversity.

Through the inclusion of the estimated values of external benefits of the Aran Islands landscape the LPA model sets out to determine what weight and compensation should be given to biodiversity, landscape amenity or recreational walking in the interest of society as a whole. Through the proper valuation of some of the potential positive externalities that result from the Aran Life Project actions recommended practices, this report evaluates the significance of implementing the scheme on a wider geographical scale.

This report has the following aims:

1. To quantify the public good benefits associated with AranLIFE project actions;
2. To determine the supply side costs of providing the public good values associated with AranLIFE project actions;
3. To develop a Land Portfolio Allocation model to establish whether or not the AranLIFE project actions are financially and economically viable and secondly, to determine how market and policy trends impact on viability, land use and the associated amenity and biodiversity.
4. To determine whether the AranLIFE agency has been effective at promoting local agronomic practices that enhances environmental public goods that are unique to the Aran Islands.

2. Background on Agri-environmental Schemes in Ireland

Since its inception, the objective of the Common Agricultural Policy (CAP) was to improve agricultural productivity and the standard of living for the agricultural community. More recently Agri-environmental schemes were introduced following the MacSharry reforms of the CAP in 1992 to address negative environmental impacts. These changes involved a major shift in emphasis from a production oriented policy to ones designed to promote better environmental quality.

Agri-environmental schemes thus became a crucial component of the CAP which was used to pay farmers in return for the (environmental) services they provided. In Ireland, the Rural Environmental Protection Scheme (REPS) was introduced in 1994 and included a set of guidelines in terms of permissible farming practices. More recently this was followed by the AEOS and GLAS schemes.

The direct beneficiaries of these payments have been the farmers receiving them; however, in exchange positive externalities benefit society at large and these include rural landscape aesthetics, recreation amenities, wildlife preservation, improved water quality, and the maintenance of historical and archaeological features (Finn 2003).

A shift from production oriented incentives has increased the demand for environmental goods in part because of the greater visibility (Gorman, et al. 2001) and it is important therefore that society gets good value in return (Hamell 2001).

Studies evaluating the effectiveness of agri-environmental schemes are limited in number and scope and to date providing mixed results (Kleijn and Sutherland 2003; Kleijn, et al. 2001; Hoogereen, et al. 2002; Swetnam, et al. 2004; Dunford and Feehan 2001; Feehan, et al. 2002; Flynn, et al. 2002; Aughney and Gormally 2002).

The study by Flynn et al 2001 of the impact of REP schemes on birds revealed no significant difference in species richness on REPS and non-REPS farms. A similar finding was made by Feehan, et al. (2005) for their evaluation of the REP scheme on plant and insect diversity.

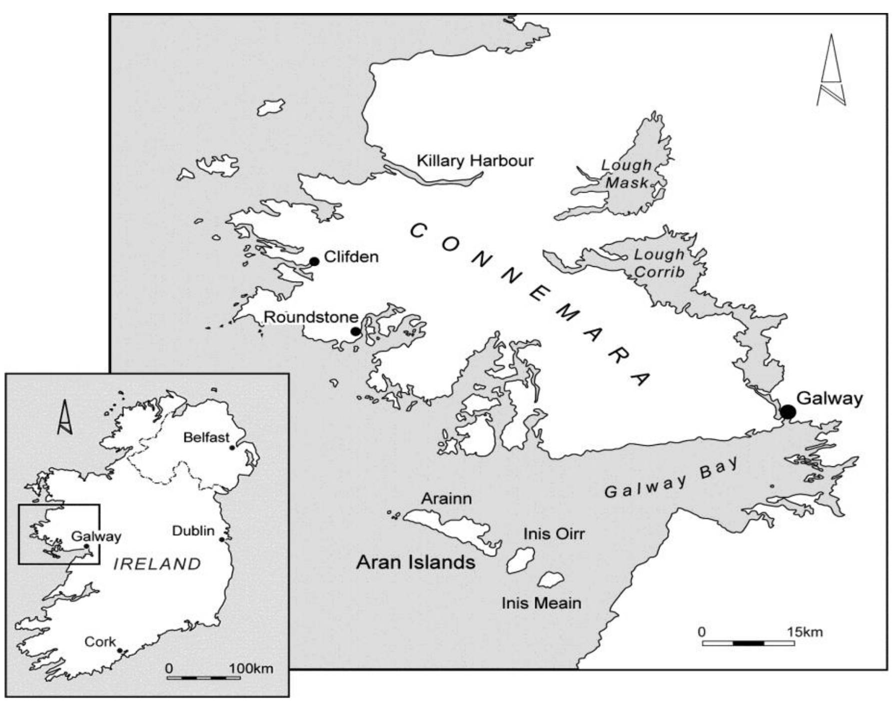
Reasons cited for the lack of scheme effectiveness include its voluntary nature which allows for erratic spatial distribution of farms that have adopted the agri-environmental schemes. This decreases the effectiveness in enhancing populations as their dispersion from one field to the next would be restricted (Geertsema 2005; Whittingham 2007; Dasgupta, et al. 2004; Hanley, et al. 1999). Farms not under the REPS scheme but receiving direct payments under the ‘Single Payment Scheme’ are obliged to observe certain conditions in their farms which are known as ‘cross compliance’. However, it is not clear whether the practices under cross compliance complement those under REPS. It is also believed that the time commitment required from farmers which is generally five to six years may perhaps be too short for appropriate levels of regeneration of populations (Berendse, et al. 2004).

One of the most important factors impeding its effectiveness could be that the environmental scheme is not well suited for the farmland or the entire region. REPS, CFP (Control of Farmyard Pollution) and cross compliance which are nationwide schemes, cannot produce the same level of outcome when implemented on different types of landscapes and ecosystems. This is a key reason why the Aran Islands region has not acquired substantial environmental benefits from these schemes and thus provides the primary motivation for designing a scheme in the Aran Islands region that is tailored for its unique ecosystem.

3. The Aran Islands

The Aran Islands are one of Europe's most important and most widely recognized landscapes. Located in the west of Ireland in county Galway, they span across an area approximately 3000 hectares. The Aran Islands have long been recognized as an international destination of high repute due to its exceptional beauty and wealth of natural, archaological and cultural heritage.

Figure 1. Map of Aran Islands (Source: Wylie 2012).



The most prominent landscape feature of the Islands is the Karst limestone landscape and high walls enclosing numerous small fields. This landscape is described as a 'glaciated karst' landscape, as it was shaped by the last glaciation and then further sculpted by thousands of years of rainfall (Moles and Moles 2002). At the time of arrival of Neolithic farmers to the region, the entire landscape was covered with woodlands dominated by pine and hazel. The farming practices over the next thousands of years led to the gradual clearing of the woodlands. With the disappearance of this abundant vegetation, the soils washed away revealing the karst limestone pavements underneath, which characterize the present landscape of the Aran Islands.

The Islands are rich in biodiversity. Its orchid rich grasslands host a number of Ireland's native flowers, and includes many of the country's orchid species.

In addition the Aran Islands host a wealth of culture that can be seen through the many archaeological features dispersed across this landscape. Remnants of many ancient structures ranging from wedge tombs, dolmens, and ring forts, to more recent stone houses, animal enclosures and a network of stonewalls demonstrates the unbroken human influence on the landscape.

The Aran Islands is best described as a managed landscape. Although a dramatic geological phenomenon is responsible for shaping the foundations of the landscape and the various habitats, it is the traditional farming practices through the millennia that have shaped and preserved the landscape. So the best way to maintain this would be to continue with the traditional farming techniques.

The ALP project provides one such example of a scheme that does attempt to develop and refine environmental management practices that are suited for the region and this study aims to capture the market and non-market values associated with this management regime. A short description of the AranLIFE project is discussed next.

4. The AranLIFE project

For the last five years, the AranLIFE project (ALP) has been experimenting on farms spanning across a total of 3,000 hectares in order to identify practical farming methods that would improve the conservation status of the Aran Island habitats. Taking into account both the market and social trends, it has examined various land use practices to ensure the preservation of the various habitats while securing a bright future for its people.

The highly applied yet participatory nature of the approach taken by the ALP involves working closely with the farmers and drawing on their traditional knowledge and skills. This information has been used to formulate management schemes that are based on traditional practices but at the same time adjusting them to modern society.

Fundamental elements of the ALP scheme include shrub control using grazing and manual clearance, improving accessand inclusion of watering systems and implementing optimal grazing regimes. To make up for the labor shortage that is required for shrub control, herding, building and maintaining stonewalls, and the provision of water to the herd, farmers are compensated by the ALP. While adoption of these farming practices is beneficial to the farmers themselves, it also has benefits that are shared by the local community and the society at large. The improvement in the visual appearance of the landscape through better farm management is a benefit enjoyed by all (Campbell, et al. 2006). But most importantly, the ALP through its farming practices aims to conserve the Aran Islands flagship heritage landscape. The value associated with the conservation of this landscape to the Irish public is multi-dimensional and is bound to be associated with substantial values (Mazzanti 2002). In addition to the use and several types of non-use benefits one derives from such sites, its mere existence is capable of providing satisfaction to a person in the form of an enhanced sense of local identity, pride and prestige. To justify the implementation of the scheme proposed by the ALP on the wider Aran Islands region, it is essential that the scheme passes the standard cost/benefit efficiency test – do the overall benefits provided outweigh the costs? In the next section that follows we report on the results of a survey technique that was designed specifically to estimate the value placed by tourists on the Aran Islands landscape. In particular, the survey was developed to focus on the features that best characterize the Aran Islands but also explored the possibility of enhancing recreational access. Presently tourists are restricted to public roads and footpaths that do not cross a farmers land. Numerous boreens do exist though that could, in theory be used to enhance recreational access. Thus the study focused only on the dominant features of the landscape the karst limestone pavement, stone walls, orchid rich grasslands, and recreational walking with the aim of estimating their overall value using willingness to pay estimates.[1]

5. Landscape Valuation

[1] It should be noted that there are several other positive externalities that result from the ALP management practices which are not included in this study for valuation.

5.1 Background

Natural resources yield tangible outputs (such as timber fodder, grain) but also provide less tangible ones such as aesthetics, wildlife, landscape amenity and recreation. Recent decades have witnessed a shift in emphasis whereby non-market benefits have received increasing attention (Hanley, et al. 1998; Bonnieux and Le Goffe 1997) using revealed and stated preference valuation techniques. Revealed preference techniques are based upon actual choices made by people, which makes the estimates more reliable and hence preferable. However, the limitation of these techniques is due to its reliance on observables. For example, the travel cost method estimates the value of a resource by aggregating the total expenses related to the trip. So, to determine the value of the natural resource it is necessary that actual visits are made and that this data is available.

To overcome this limitation, stated preference techniques have been developed where one can not only access the value of a good for which public preferences aren't available, but even place a value on hypothetical scenarios. Stated preference techniques have been used extensively to value various types of environmental benefits including the external benefits of farmland in Ireland (Hynes and Campbell 2011; Yadav et al. 2013), Great Britain (Willis, et al. 1995; Willis and Garrod 1993; Bateman, et al. 1994), Sweden (Drake 1992) and elsewhere (Bergstrom, et al. 1985; Halstead 1984; Ready, et al. 1997). Although stated preference techniques have come a long way from the introduction of the contingent valuation technique, they are not free from errors and biases and hence have received considerable amounts of criticism[2].

5.2 Choice Experiments

The stated preference technique we use in this study is known as Choice Experiments (CE)[3]. CEs rely on a set of hypothetical scenarios from which the respondent makes a choice. The number of alternatives described by a set of attributes is presented to a respondent from which he or she is asked to make a choice. A 'status quo' or a 'none of these' alternatives is also included to avoid forcing individuals to make a choice between the alternatives presented. By varying the different attributes in an alternative, the relation between the attribute level and the probability of the alternative being chosen can be analyzed using sensitivity parameters for the different attributes. Through the choices made by the respondent it is possible to evaluate the tradeoffs made between attributes and hence estimate the marginal rate of substitution between them. With cost

[2] See Appendix A for more details on some of the documented biases

[3] See Appendix A for more details on the history and development of Choice Experiments and why they are preferred over other stated preference techniques

as one of the attributes, the marginal willingness to pay for each of the attributes is thus estimated. It is also possible to use CE to estimate an amount that a respondent is willing to accept for a hypothetical scenario or policy change. In some circumstances it may be more appropriate to use WTA rather than WTP.

CEs first originated in the fields of marketing and transport, and only recently have they been used in the valuation of non-market goods in environmental and health economics. After its first use by Adamowicz, et al. (1994) to value various characteristics of water based recreational sites, choice experiments have been adopted extensively by other environmental economists to value various environmental goods. Some of these include a study by Campbell, et al. (2006) to value landscape benefits stemming from the REP scheme in Ireland; The valuation of external benefits resulting from changes in the management of public forest landscapes (Hanley, et al. 1998); and the valuation in southern Sweden to identify the value of various characteristics of wetlands (Carlsson, et al. 2003).

In the CE that was conducted for this study, photomontages were used to supplement the description of the different attributes included in the alternatives. One advantage of this approach is that it is able to bring the field to the respondent instead of taking the respondent to the field which would be quite impractical and costly (Garcia Perez 1998). Additionally, such field visits cannot be controlled where in the respondent may gather information that is beyond what is to be assessed. Furthermore, various aspects of the environment such as the weather may have significant impacts upon the presentation of the commodity.

5.2.1 Model Framework

When a respondent n is provided with J sets of alternatives from which to choose form, the alternative chosen, say i, corresponds to the highest level of utility of all the alternatives in the choice set. The utility obtained by respondent n is made up of an observable component V_{ni} which is the deterministic part of the indirectly utility function and a random component ε_{ni}

$$U_{ni} = V_{ni} + \varepsilon_{ni}$$

Where U_{ni} is the indirect utility of individual n from choosing option i. The assumption here is that the respondent n chooses alternative i if and only if

$$Prob\left(U_{ni} > U_{nj}\ \forall J \neq i\right)$$

As the utility function U_{ni} has a random component ε_{ni} we can only use probabilistic statements about the choice outcomes. For the standard logit model, we assume that the distribution of this random component is independently and identically distributed (IID) following a type 1 extreme value distribution, such that the probability can be written as:

$$Prob_{ni} = \frac{\exp(\mu V_{ni})}{\sum_{j=1}^{J} \exp(\mu V_{nj})}$$

Where μ is a strictly positive scale parameter, inversely proportional to the deviation of the error distribution.

$$Var(\varepsilon_{ni}) = \frac{\pi^2}{6\mu^2}$$

μ is usually normalized to one.

5.3 Survey Design and Methodology

Using the literature and two focus groups in the Aran Islands involving local experts, farmers and members of the public a number of key attributes were identified to be used as part of the CE for both the tourist survey and the farm survey. These attributes included – the rocky karst limestone pavements, the biodiverse orchid rich grasslands, Boreen walking trails, Archeology and stone walls on farm land and a cost attribute (See appendix A).

Using image manipulation software, photomontages were created to aid the written descriptions of the potential outcomes resulting from management (and lack of management) under the ALP.

This study involved two surveys, a tourist survey and a farm survey. CE were used as part of both surveys. The tourist survey used a WTP approach whereas the farm survey employed a WTA approach. An example of a choice card used in the farm survey is given in Appendix A.

5.3.1 Experimental Design

Each choice set consisted of three alternatives. The first two alternatives labeled Option A and Option B were experimentally designed while the third alternative labeled 'Status Quo' was fixed in every choice set. The Status Quo alternative represented a scenario with no management in either of the attributes and was associated with 'zero' expected annual cost. While this was the case for the Status Quo alternative in every single choice set, the other two alternatives were allowed to vary.

Before the choices were made, respondents were familiarized with all the attributes and their likely conditions with and without management. They were then provided with a sample choice task and were told that the alternatives represented the Government's available environmental policy options[4]. With respect to respondents involved in the tourist survey respondents were made aware that,

> "Maintaining good environmental standards and keeping the management practices in place required financial support. So each of the management options also had a particular cost involved."

Respondents were reminded that the Expected Annual Cost attribute represented a monetary value that the respondent would personally have to pay per year as an additional tax contribution which would be ring fenced for a trust fund dedicated exclusively for the Aran Islands.

The respondent was then provided with a sequence of six different choice tasks and asked to choose their preferred alternative in each case.

For the farm survey respondents were familiarized with all the attributes and their likely conditions with and without management. They were then provided with a sample choice task and were told that the alternatives represented the Government's available environmental policy options. Respondents were told that the Expected Annual Cost attribute represented a monetary value that the respondent would personally be willing to accept by way of payment in order to supply management effort to support these actions. The respondent was then provided with a sequence of six different choice tasks and asked to choose their preferred alternative in each case.

5.3.2 Sampling Method

For the tourist survey a total of three trained interviewers administered the survey between July 2015 and October 2016. All of the 258 in-person interviews were conducted on the ferry boat between Ros á mhíl and Kilronan port on Inis mór and were randomly chosen. The average age of the respondent was 42years and the average household income was €58,887 (Table 1).

[4] See Appendix A for the Sample Choice Task shown to respondents

Table 1. Descriptive Statistics of the Sample

Variable	Definition	Mean	Median	Standard Deviation	Minimum	Maximum
Age	Age of Participant	42.10 years	39 years	17.46 years	Under 20	Over 65
Income	Total Income of Household	€58,887	€54,600	€39,730	€3,900	€117,000
Education	Highest Completed	3.69	4	0.652	1	4

- The income question had classes. For the estimation, the midpoints were used
- Education (Primary = 1, Junior Certificate = 2, Leaving Certificate = 3, On the job training/professional qualification of degree level = 4, College/University Degree (B.Sc., B.A., etc) = 5, Post graduate (M.Sc., Ph.D., etc.) = 6)

5.4 Analysis and Results

5.4.1 Willingness to Pay estimates for the Aran Islands landscape

The results of the choice experiment are used to estimate the indirect willingness to pay for the conservation of the Aran Islands landscape through the implementation of management schemes. According to the results of the Multinomial Logit Model shown in Table 4, all five attributes (karst limestone pavements, biodiversity and orchid rich grasslands, walking trails and archeology and stone walls and the expected annual cost) included in the choice experiment are statistically significant at less than one percent level of significance. This shows that each of these attributes had a significant impact on the choices made by the respondents. The positive sign on all the coefficients except the cost attribute indicates that respondents were more likely to choose an alternative that had a management scheme in place. Consequently, the negative sign on the "Expected Annual Cost" coefficient reveals that respondents were less likely to choose an alternative that was associated with a higher expected annual cost. From these results our estimated marginal willingness to pay per person per year to conserve the karst limestone pavements is € 59.39, the marginal willingness to pay to conserve the biodiverse orchid rich grasslands is € 83.28, the marginal willingness to pay for the provision of walking trails using Boreens across farm land is €99.56 and the marginal willingness to pay for the provision of archeology and stone walls is €96.25.

Table 2. Results from the Multinomial Logit Model (Tourism Survey)

	Logit Estimates
Expected Annual Cost	-0.00700*** (0.00190)
Karst Limestone Pavement	0.41552*** (0.08442)
Biodiversity: Orchid Rich Grasslands	0.5827*** (0.0858)
Walking trails	0.6966*** (0.06468)
Archeology and stone walls	0.67340*** (0.0898)

Standard errors are reported in parentheses.
*** indicates significance at 1%
** indicates significance at 5%
* indicates significance at 10%

The marginal willingness to pay estimates may appear to be rather high at first glance. However, given that the Aran Islands representsone of Ireland's most important Heritage sites with both natural and cultural significance it seems plausible that these values reflect the true value of the Aran Island landscape. Moreover, these values are comparable to the willingness to pay values obtained by several authors in various landscape valuation studies.[5]

5.4.2 Willingness to accept estimates for the Aran Islands landscape

The results of the choice experiment conducted with Aran Island farmers are used to estimate the willingness to accept payment for provision of conservation actions to conserve the Aran Islands landscape through the implementation of management schemes. A farm survey was conducted to provide input to the Land Portfolio model and a choice experiment was also part of this survey which was targeted at both ALP and non ALP farmers from the Aran Islands. The survey included 84 famers and was carried out in February 2018 over two days in Inis mór by four trained staff. The farm survey is referred to in later sections as the A84 land uses. According to the results of the Multinomial Logit Model shown in Table 5, all three attributes (biodiversity and orchid rich grasslands, archeology and stone walls and the expected annual cost) included in the choice experiment are statistically significant at less than one percent level of significance.

[5] Refer to Appendix A for a comparison of WTP values with other landscape valuation studies.

This shows that each of these attributes had a significant impact on the choices made by the respondents. Direction of the attribute influence was consistent with economic theory. Higher conservation payments ('*Cost*') significantly increased likely participation in conservation actions contracts. Provision of biodiversity and orchid rich grasslands significantly reduced the likelihood of participation. Provision of archeology and stone walls significantly increased the likelihood of participation. The results indicate that *ceteris paribus* to get respondents to accept conservation actions involving provision of biodiversity and orchid rich grasslands would require an annual payment of €160.57. The results also show that *ceteris paribus* the provision of archeology and stone walls as part of the management agreement reduces the payment that farmers require by €108.99 per hectare. The possibility of a management scheme which involved walking trails or karst limestone pavement does not appear to significantly influence farmer's choice.

Table 3. Results from the Multinomial Logit Model (Farm Survey)

	Logit Estimates
Expected Annual Payment	-0.0038*** (0.00108)
Karst Limestone Pavement (High)	- 0.11781 (0.15555)
Biodiversity: Orchid Rich Grasslands	-0.5425*** (0.1569)
Walking trails	0.0786 (0.11081)
Archeology and stone walls	0.36826*** (0.15156)

Standard errors are reported in parentheses.
*** indicates significance at 1%
** indicates significance at 5%
* indicates significance at 10%

6. Aran Islands Land Use Model

6.1.1 Empirical methodology

A number of theoretical and empirical techniques motivate us to consider a micro-level household modeling approach to the Aran Islands land use/policy support context. Many studies of land use are summarized by Barbier's (2001) synthesis model and demonstrate how 'first wave' statistical approaches were able to relate land use to a variety of key household preference and landscape amenity drivers in addition to traditional suitability and soil quality features. This motivates us to include land owner preferences for land uses (φ) and the third-party's' willingness to pay for the external cultural and biodiversity value (ω) associated with Aran Islands farming for conservation methods.

Prior models with a micro modeling approach include engineering/costs studies (Moulton and Richards 1990); mathematical programming approaches (Adams, et. al. 1993); dynamic systems models (Evans, et al. 2001); agricultural household models (Ahn, et. al. 1981; Benjamin 1992; Taylor and Adelman 2003); discrete and continuous population models, respectively (Alonso 1964; Berliant and Fujita 1992; and Solow 1973). Another approach, different in theoretical form but similar in its motivation of focusing on individual households include the random utility models (Parsons, et. al. 2000). These approaches guide our constructions of the production and utility functions applied in our model, and motivate us to consider a standard profit maximization approach for land owner decision making.

We employ a model which incorporates several elements from these earlier approaches and is described as a Land Portfolio Allocation model (Blank 2001). In this vein three types of empirical methodologies are employed to calibrate and evaluate this micro-simulation model; results from these analyses are provided in Section 6. First, we conduct a by-farm preference calibration exercise exploring the extent to which agent decision makers can be parameterized to reproduce the A84 land uses. Second, simulation experiments explore how the land uses and generated amenity externalities respond to individual parameter perturbations representing policy interventions, changes in market conditions, or sensitivity analyses; we simultaneously calculate the rate of return on government support payments relative to the public good externalities provided. Third, we conduct a Monte Carlo analysis randomly and simultaneously perturbing key experimental parameters over 1000 separate simulations. These preference calibration and simulation experiments allow us to address our three research questions regarding the optimality of the A84 decisions, the response of agents to changes in policy support and structural parameters, and regarding the rate of return obtained for direct and indirect government support payments.

We begin with a traditional representation of a land owner agent's k's expected utility:

$$E[U_k] = E[\pi_{k,j}(p_j, Y, F, C)] - \rho \cdot \sigma^2_{k,\pi j}[\pi_{k,j}(p_j^2, Y^2, F^2, C^2)] + \phi_{k,j} \tag{1}$$

E represents the expectations operator, U_k is agent k's risk adjusted annual utility derived from applying their inputs, and $\pi_{k,j}$ represents the annual net monetary payoff which is a function of output Y, fixed costs F, and marginal costs C; where outputs j are derived from the use of input endowments. Following Parks (1995) ρ is a risk aversion vector including a parameter for each of the j agricultural activities (zero for risk neutral, positive for risk averse), $\sigma^2_{k,\pi j}$ is the variance of payoffs for *k*'s portfolio which is a function of output price variance and assuming no covariance among output prices for alternative activities, and φ is preference for supplying inputs to a particular activity.

Importantly, to calibrate preferences and determine what might lead a A84 farmer agent to adopt or abandon ALP land uses, we must compare the payoffs reported for the activities actually undertaken *j* to estimated counterfactual payoffs they might receive for pursing alternative actions *j'*. For actual actions we can measure net risk adjusted margin given that we have data on output prices, price variances, output quantities, subsidies received and input costs incurred. To determine counterfactual net margins, we must econometrically estimate counterfactual output, Eq. (2) $\hat{Y}_{k,j'}$, and fixed, switching and marginal costs, Eq. (3) $\hat{F}_{k,j'}, \hat{C}_{k,j'}$ for all actions not undertaken, i.e. for all $j' \neq j$. The annual counterfactual parcel output generated by applying inputs is,

$$\hat{Y}_{k,j} = A_{k,j} \cdot L_{k,j}^{\beta_{lj}} \cdot M_{k,j}^{\beta_{mj}} \cdot H_{k,j}^{\beta_{hj}} \cdot IN_{k,j}^{\beta_{inj}} \tag{2}$$

In Eq. (2) $\sum_v \beta_v = 1$ where inputs include $v \subset (l, m, h, in)$, respectively, labor, land, herd, and investment, and $\hat{Y}_{k,j}$ can be off farm labor supply or agricultural output produced in a commercial manner or in a manner consistent with the ALP; this allows 9 total possible activities. Further, the values for total factor productivity *A* and the marginal rates of substitution $\beta \subset (\beta_l, \beta_m, \beta_h, \beta_{in})$ are obtained via econometric analysis of national farm survey data for 326 similarly endowed farms (i.e. NSF326). We next assume agents are aware of the linear cost functions associated with production activities. We use actually observed or estimated marginal cost *C* and fixed cost *F* switching costs associated with each of the eight possible agricultural production activities; for off farm activities costs are represented as commuting costs C_T. This provides a by-farm *k* and by-activity *j* total cost function of the form,

$$TC_{k,j} = \gamma_{k,off} \cdot \kappa \cdot C_T + (1 - \gamma_{k,off} - \gamma_{k,fa}) \cdot (F_{k,j} + C_{k,j} \cdot \gamma_{k,ALP} \cdot Y_{k,j}) \tag{3}$$

We next describe the econometric methodology used to obtain parameters from the Farm Accountancy Data Network (FADN) data set of relevance to Aran Islands type farms, i.e. NFS(National Farm Survey) 326 dataset. This provides a number of parameters including marginal rates of substitution and wage rate used to calibrate our A84 simulation model.

6.1.2 Counterfactual returns

Estimating counterfactual *output* requires estimates of by-activity total factor productivity (TFP) and MRS among inputs. We employ the Olley and Pakes (1996) correction method whereby investment and fourth order polynomial terms are used to correct for any unobserved productive variation effects. We estimate counterfactual *marginal costs* and counterfactual *fixed costs* which are switching costs and are most directly related to the cost of acquiring a new activity specific herd, and the herd sizes are most directly related to available forageable land due to legal requirements. Thus, counterfactual fixed costs can be calculated with estimates of land-endowment-dependent herd sizes and the per head cost of livestock net of the sale of the current activity herd. In each by-activity NSF326 sub-sample we have greater than 30 farms / observations which allow us to use traditional significance measures. With estimates of counterfactual outputs and costs, counterfactual estimated net returns for all alternative actions *j'* can be determined for each A84 farm.

Combining estimates for output $\hat{Y}$, marginal costs $\hat{C}$, and fixed switching costs $\hat{F}$, and given information about whether off farm labor is supplied, and given known subsidies paid for a particular activity, we can subtract gross estimated costs from gross output returns providing the counterfactual payoff margin Eq. (4). We assume for each counterfactual activity $Y = \hat{Y}, F = \hat{F}$, and $C = \hat{C}$ and $\gamma_{off}, \gamma_{fa} \subset (0|1)$. We then substitute the counterfactual profit and risk adjustment Eq. (4) below into Eq. (1) and assume $\varphi = 0$ to obtain a counterfactual utility margin at Eq. (5). Agent *k*'s expected profits are,

$$E(\pi_{k,j}) = (1 - \gamma_{k,off} - \gamma_{k,fa}) \cdot p_j \cdot p_{ALP} \cdot Y_{k,j} - TC_{k,j} + s_{k,j} + \gamma_{off} \cdot w \cdot L + \gamma_{k,fa} \cdot s_{k,fa} \qquad (4)$$

And, adjusting for risk yields utility,

$$E\left[\hat{U}_k\right] = E\left[\hat{\pi}_{k,j}\left(p_j, \hat{Y}, \hat{F}, \hat{C}\right)\right] - \rho \cdot \sigma^2_{k,\pi j}\left[\hat{\pi}_{k,j}\left(p_j^2, \hat{Y}^2, \hat{F}^2, \hat{C}^2\right)\right] \qquad (5)$$

By comparing the values represented by Eq. (5) to those determined for their actual undertaken activity (for which we have profit margin, part 1 of Eq. (5), and for which we can calculate the second risk term) we identify the utility maximizing land use and can conduct experiments to determine whether owners may increase utility by switching to alternative actions given support payment or market changes.

6.1.3 Preference calibration

To evaluate our first research question regarding the optimality of the A84 decisions and to quantify the empirical descriptiveness of our model, we compare the actual and counterfactual payoffs assuming the preference φ for the observed ALP activity *j* at Eq. (1) equals zero. For this and later preference calibrations we assume a baseline set of parameter values that are derived from the company registration office (CRO) or ALP internal data sources. These six key baseline parameters are reported in the top part of Table 4. If the maximal utility is counterfactual with these representative parameters and with *φ=0*, this is an indication of non-optimal decision making; i.e. the farmer agent is not undertaking the maximal utility activity. We then calibrate the model by estimating the preference parameter *φ* for each farm *k*, in order to reproduce the actual decisions of the A84 (which includes both ALP and non-ALP farmers from the Aran Islands). This calibration involves redefining the preference parameter as $\varphi = \varphi + \varphi_{\Delta}$, i.e. it is increased for the known/observed ALP action by €1, until the payoff for the observed ALP activity is maximal compared to the counterfactuals; the counterfactual payoffs are those that could be obtained by switching to other ALP agricultural activities, commercial version of any agricultural activity, supplying labor off farm, or remaining unemployed and accepting farm assist payments. The estimated preference values obtained provide an estimate of the monetary value of an individual farmers' preference for pursuing the observed ALP activity.

Parameter	Value
s_{ALP}	€750 (per farm)
s_{REPS}	1 (% of actual)
w	€13.50 (per hour)
$Prob_{off}$	1.00
p_{ALP}	1.10 (% of non-ALP)
γ_{ALP}	1.25 (% of non-ALP)
$\omega_{Amenity}$	€5496.46 (per Ha)
(upper bound)	*{€10,992.92}* (per Ha)
$\omega_{Tourism}$	€71.47 (per Ha)
$\overline{L}$	2000 (hours)
s_{fa}	€204 (per week)
φ_{Δ}	€1
C_T	€0.43 (per min.)
p_{Beef}	€713 (per Head)
$p_{Suckler}$	€442 (per Head)
p_{MixG}	€277 (per Head)
$\rho_{B,SB,MG,D}$	1e-08*[1,1,1,1]
σ^2_{Beef}	6944 (€^{2})
$\sigma^2_{SucklerB}$	4720 (€^{2})
σ^2_{MixG}	2723 (€^{2})

Table 4. Key experimental and other model parameters

6.1.4 Model experiments and sensitivity analysis

The first method we employ to address research question two regarding the sensitivity of production decisions to policy incentives and key structural parameters, could be described as numerical comparative statics. Experiment 1 individually varies the ALP payment rate, s_{ALP}, by reducing it to zero; these variations are consistent with proposed or observed changes to farm support respectively, (DAFF, 2008 and 2011). Experiment 2 increases the average off farm wage *w* and probability of securing off farm employment $prob_{off}$; these changes would be consistent with current, as opposed to post-recession changes in off farm labor market conditions (Meredith, 2010). Experiment 3 involves reducing the output price premia p_{ALP} that ALP products receive at market, making their sale price twice that for currently produced products. Marketing research associated with the other programs such as the Burren Life program has shown that these products are usually able to earn a premia. This experiment is designed to investigate to what extent this higher profitability influences producers' decision making. Importantly, each of these experiments varies only one or two parameter(s) at a time and leaves the others at the baseline value used when fitting farmers' preferences.

We also perform a sensitivity analysis for the key model parameter γ_{ALP} which represents the increased cost of pursuing ALP agricultural activities in comparison to the commercial form of the same agricultural activity. We reduce the ALP cost parameter to $\gamma_{ALP}=1.125$ and $\gamma_{ALP}=1.05$, set s_{ALP}=0, hold preferences at their calibrated values, and set all other parameters at baseline. This sensitivity analysis explores the extent to which preferences alone, in the absence of support payments, might produce ALP viability.

6.1.5 Monte Carlo simulations

The second method we use to address research question two is Monte Carlo simulation analysis. This involves performing 1000 simulations in which the six key experimental parameters reported in the top of Table 4 are perturbed from baseline values. Multiple parameters may be simultaneously varied by multiplying them by a random variable lying within the range 0 to 2; these represent reductions or increases in their value of up to 100%.

We evaluate the results of these simulations with one qualitative and two quantitative methods. Our first qualitative analysis graphically plots the outcome descriptors; number of agricultural producers (ALP or commercial) against the total externality produced, for each simulation. Qualitative groupings of results can then be observed. Our first quantitative analysis then calculates median values for observed groups of the above outcome descriptors and for the experimental parameters, and performs across groups Wilcoxon hypothesis tests to determine the statistical dissimilarity of these groups, and the parametric sources of any outcome differences. The second quantitative method correlates three z-score normalized dependent variables representing either number of agricultural producers, the total externality produced, or an average of these normalized measures against z-score normalized values for the key experimental parameters that were perturbed. The 1,000 Monte Carlo simulations provide 1,000 observations for analysis. The three dependent variables provide three sets of results identifying the sensitivity of simulation outcomes to key model parameters with all estimated coefficients lying in the same scale.

6.1.6 Calculating the rate of return on government support

In order to address research question three and evaluate the rate of return (RoR) provided by government support payments, we compare the estimated public good externality α provided by Eq. (6) for a given set of agents' production decisions to the direct and indirect costs borne by the exchequer to support these programs. These are represented as,

Eq. (6) represents the total public good landscape amenity and tourism spend externalities produced by farms operating one of the four possible Irish agricultural activities in a way consistent with the ALP,

$$\alpha = \omega \cdot \sum_k M_{k,ALP}(s_{k,ALP}) \tag{6}$$

Eqs. (7) and (8) represent the rates of return on government support without and with indirect costs,

$$RoR_{DC} = \alpha \Big/ \left(\sum_k \left(s_{k,ALP}\right) + s_{ALP}^{sunk} \right) \tag{7}$$

$$RoR_{Total} = \alpha \Big/ \left(\sum_k \left(s_{k,ALP}\right) + s_{ALP}^{sunk} + IDC \right) \tag{8}$$

The direct and indirect costs are exogenous amounts. Direct costs are known to include two payments, $DC = \sum_k \left(s_{k,ALP}\right) + s_{ALP}^{sunk}$= €950,000/yr, where $s_{k,ALP}$ represents the direct variable cost participation payment to farms and s_{ALP}^{sunk} reflects sunk costs spent to initiate the program and identify the initial ALP farms. Indirect costs represent administrative and subsequent data collection costs and were shown to be IDC = €1,647,683.3/yr, or €2.6M for the program duration. Importantly, we can calculate the RoR for the baseline fitted preferences simulation, for each of the five experiment simulations, and for the sensitivity analyses.

6.2 Results

We first discuss the results of estimating the A84 farmers' production preferences. We next conduct five simulation experiments and a 1,000 run Monte Carlo analysis using the preference calibrated model to determine the sensitivity of land uses and externality generated to key policy and structural parameters. We also calculate the rates of return of government support programs given support amounts that are predicted to change across various simulations. This rate of return compares the amount of public good externality produced by farms employing ALP conservation actions to the support payments spent as represented by Eqs. (4) and (5). Finally, we perform a sensitivity analysis for a key unobservable parameter for robustness.

6.2.1 Preference calibration results

Assuming all ALP farmers' preferences φ for their observed ALP action are zero, and observing the resulting production decision provides an indication of how many farmers are operating in a strictly utility maximizing way. In this case only 1 out of 84 farms participate in the ALP, a total of 80 farms pursue the conventional version of their current ALP suckler beef activity, and three would optimally switch to conventional beef[6]. This suggests that preference calibration is crucial for providing an accurate account of 31 of the 32 AranLIFE participants' activities. Or equivalently, participating in the ALP is not strictly utility maximizing for the vast majority of farms if one excludes stakeholders' preferences for producing in a way consistent with the ALP approach. Crucially, this also implies that the ALP payment absent preferences was insufficient to overcome the increased cost of the ALP method.

Next, we calibrate the preference parameter for all ALP farms resulting in correct predictions of all farms actions. We observe that the majority of estimated preference values for pursuing the ALP actions lie between €0 and €10,000 across the farms, with the majority of preference values lying between €0 and €3,000; see Figure 2. Approximately three farms display outlier risk adjusted preferences.

[6] The preference calibration exercise includes the sample of all 84 ALP and non-ALP farmers from the Aran Islands and the Land Portfolio Allocation model is used to evaluate preferences for observed ALP practices and project actions.

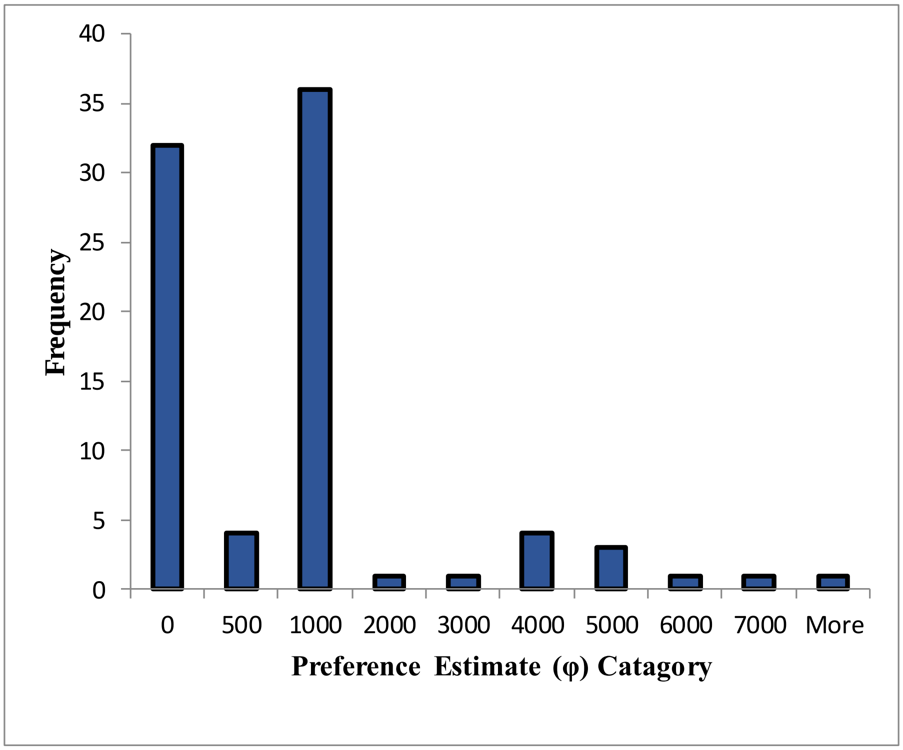


Figure 2. Histogram of estimated preferences for observed practices of Aran 84.

Intuitively, a value for this preference parameter that is greater than zero indicates that the ALP activity undertaken is not the strictly utility maximizing activity a producer may pursue, and that to continue producing as they are they must be deriving preference value equivalent to the magnitude of the parameter in order to offset negative profits. Alternatively, this parameter (to the extent it is positive) could be thought of as the estimate of the opportunity cost of pursuing a particular ALP activity given individual farms' available endowments.

6.2.2 Model experiment results

We next report the results of numerical comparative statics experiments for three key policy and model structural parameters. For all experiments only one, or in one case two, parameters are perturbed; all others are set to the baseline values used when calibrating preferences. We focus on output product choice decisions, decisions to maintain/abandon the ALP, and decisions to pursue off farm employment. Additionally, given information about which farms maintain the

ALP, we can estimate the amenity externality produced, and the rate of return for government ALP support payments. To determine the monetary value of the environmental amenity externalities produced by Aran farmers we need to multiply the hectares of usable land the Aran farmers keep in the ALP times the per hectare willingness to pay for the Aran landscape identified in Section 5.4. Importantly, the amenity/tourism value of the Aran Islands is not directly part of the owner's payoff structure, so a positive externality value represents an uncompensated externality. Further, to determine the rate of return for various experimental outcomes, we assume that only the variable cost part of the government payments s_{ALP} are reduced when a farm abandons the ALP, and that the initial sunk cost of program start up for these farms $s_{k,ALP}^{sunk}$ cannot be avoided, see Eqs. (7) and (8). Thus, when calculating the rate of return of government support for the experimental outcomes below, the total program cost may only be reduced by the per farm direct payment, multiplied by the number of farms that have abandoned the program.

When calibrating the preference parameters, we are able to reproduce the actual actions of all A84 farms; i.e. 32 farms are predicted to pursue the observed ALP activity, and the remaining pursue a conventional production activity (i.e. suckler-beef). In this baseline case, which produces the maximal externality, a positive externality value of α_{Amenity} = € 9,696,663.84 per year is produced compared to direct program payments of €950,000 per year. These numbers indicate that these programs are producing positive externality rates of return of 1,021% per Euro of ALP payment investment for average externality values. The motivation for using lower bound values is to provide the most conservative possible estimate. Including annualized indirect costs these rates of return for the total become €9,696,663.84 / €2,597,685.3 or 373%. Including tourism income results in a total positive externality of €9,912,957.86 and compared to direct and indirect exchequer costs yields a rate of return of 382%.

Our first experiment involves setting the ALP payment, s_{ALP}, to *zero*; all other parameters are kept at their baseline values. In this case, all but 1 farm abandons ALP practices, implying that the externality produced is predicted to eventually fall to zero (due to the small size of the one remaining farm). Although all farms abandon the ALP, 80 switch to the commercial version of the suckler beef activity, and three switch to commercial beef production.

Our second experiment *increases* the off-farm wage by 50%, and the probability of finding off farm employment increases to 1 (i.e. certainty); this would be consistent with a fast-growing Irish economy which has recently become more likely. In this case, 15 farmers are predicted to seek off farm employment, 40 are predicted to pursue commercial suckler beef activity, and 29 retain their reported ALP activity. The externality falls to α = €9,349,373.1 and externality plus tourism income falls to α = € 9,557,920.44 and rate of return produced is 367%.

Our third experiment reduces the price of premium to a baseline $p_{ALP} = 1.05x$ i.e. $p_{ALP} = 1x$. Our findings indicate, 52 producers pursue commercial suckler beef, the 32 retain their ALP activity.

This suggests that the total externality and rates of return will be unchanged from baseline. The intuitive explanation for this is that this price change is small compared to preferences or the payment value.

The results of all these experiments and the calibrated baseline case are graphically displayed in Figure 3 as open circles; Note Experiment 3 overlaps with the calibrated preferences case. In this figure the horizontal axis represents the total externality values produced and the vertical axis represents the number of farms remaining in the agricultural sector, either in a commercial form or consistent with the ALP. These experimental outcomes can be used to categorize the outcomes of the Monte Carlo simulations we describe next.

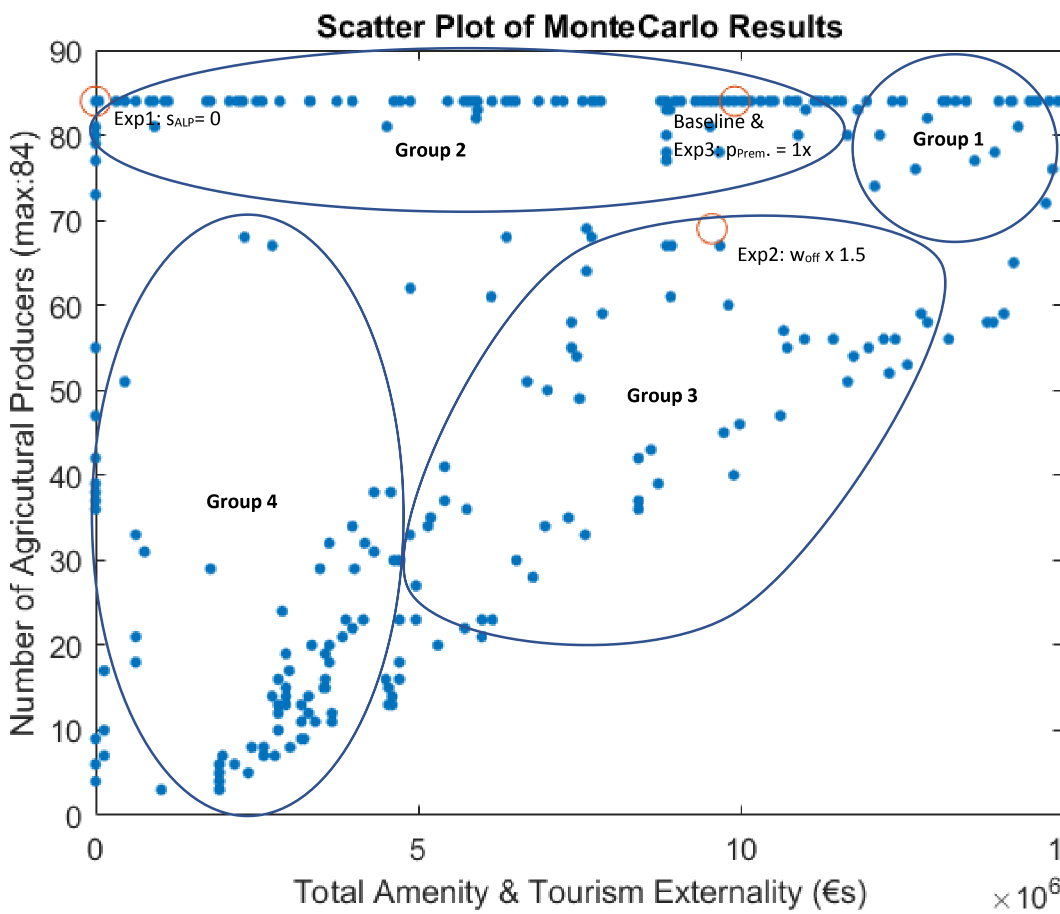


Figure 3. Scatter plot of experiments and Monte Carlo simulation outcomes

6.2.3 Monte Carlo results

We summarize the results of our Monte Carlo study with one qualitative and two quantitative analyses.

Qualitative results. Figure 3 also provides a visual representation of the results of 1000 simulations which randomly perturbed the six key experimental parameters listed at the top of Table 4. Markers lying on the vertical axis indicate commercial agricultural producers who do not create an externality value. On the figure dots represent one of the Monte Carlo simulation outcomes. Because of there being only 84 farms with a fixed amount of available land, there are a limited amount of discrete simulation or experimental outcomes, making the small number of Monte Carlo simulations, i.e. 1000, comprehensive enough. This also results in each dot potentially representing multiple outcomes. The most obvious feature of this figure is that there is a set of four farms that are able to maintain at least commercial agricultural activity in the face of all parameter perturbations, i.e. no dots lie below 4 on the vertical axis.

Upon closer inspection one can further see that the outcomes seem to be grouped in four areas which are approximately demarked with the large ovals in the figure. These areas are labeled Groups 1 to 4, and within these groups of simulation outcomes we observe common dynamics. Specifically, Group 1: Superior provides the maximal externality, Group 2: Ag. Transition represents farms transitioning from ALP to commercial agricultural activities, Group 3: Off Farm represents farms transitioning from ALP or commercial activity directly to off farm activities, and Group 4: Mixed represents a mixture of the previous cases with no systematic pattern. Group 1, top right, represents outcomes with more than the current number of farms participating in the ALP and thereby providing superior externality value, i.e. more than €11m. Group 2 includes the outcomes located along the top part of the figure in which there are always more than 75 agricultural producers of either type, and which includes the calibration and the experiment 3 outcomes on the same location. As one considers simulation outcomes moving to the left in this area, the externality value is falling as farms transition from ALP agricultural practices to commercial agricultural activities. The Experiment 1 outcome is also roughly in this area and represents complete conversion of ALP farms to commercial agricultural activity. Group 3 includes farms along an upward sloping line spanning the lower middle to the top right in the figure. Outcomes moving toward the bottom left in the figure represent, among other things, ALP farms transitioning directly out of the program to off farm activities or unemployment, without transitions through the commercial form of agriculture. Finally, Group 4 are outcomes associated with low to moderate numbers of agricultural producers, but producing highly variable amounts of externality values. There are varied transitions of farms in this area, moving among ALP and commercial version of suckler beef or beef, or to off farm employment or unemployment with little obvious systematic commonality.

Quantitative results. Our first quantitative analysis of the Monte Carlo simulation results considers summary statistics for the parameters associated with outcomes lying in particular groups. The sample sizes, median parameter values, and Wilcoxon p-values indicating the statistical distinguishability of parameters across groups are provided in Tables 5 and 6. Table 5 gives the Figure 3 group median values, while Table 6 gives p-values for pair wise comparisons of the simulation outcomes and parameters associated with each group, and Table 7 provides results of OLS regressions relating three simulation-outcome dependent variables with the model parameters that were perturbed. Unless stated, all significance discussion and relative magnitude descriptions employ 5% levels.

Table 5. Median parameter values for Figure 3 Monte Carlo simulation outcomes across Groups 1–4.

Group	Nobs	Number Ag.	Median Extern. (€)	s_{ALP} (€)	w_{off} (€/hr.)	Prob. Employ.	Price Prem. (€)	γ_{ALP}(%)
Group 1	437	84	18,372,000	1.37	9.67	1	0.98	0.76
Group 2	331	84	7,824,500	0.59	10.31	0.89	1.01	1.63
Group 3	154	23	4,244,900	1.05	23.27	0.92	.93	1.17
Group 4	57	5	1,936,600	0.20	25.57	0.99	1.02	1.36

Table 6. P-values for Wilcoxon pairwise by-group tests of group parameter differences.

Groups Compared	Number Ag.	Total Extern. (€)	s_{ALP} (€)	w_{off} (€/hr.)	Prob. Employ.	Price Prem. (€)	γ_{ALP}(%)
Group1 to Group 2	0.15	0.00	0.00	0.34	0.05	0.75	0.00
Group 1 to Group 3	0.00	0.00	<0.001	0.00	0.47	0.12	<0.001
Group 1 to Group 4	0.00	0.00	0.00	0.00	0.79	0.45	<0.001
Group 2 to Group 3	0.00	0.01	0.00	0.00	0.34	0.21	0.00
Group 2 to Group 4	0.00	0.00	0.00	0.00	0.43	0.36	0.06
Group 3 to Group 4	0.00	0.00	0.00	0.00	0.87	0.10	0.32

Tables 5 and 6 together indicate that, in terms of outcome variables, Group 1 includes significantly *more* agricultural producers than all other groups, except for the Group 2 comparison; and includes *higher* externality values compared to all other groups. For parameters, Group 1: Superior involves *higher* s_{ALP} than all Groups, *higher* probability of employment compared only to Group 2, but *lower* off farm wage compared to all but Group 2. Lastly, the cost γ_{ALP} is *lower* than all other groups.

Group 2: Ag. Transition involves significantly *more* agricultural producers and *higher* externality values compared to all but Group 1. For parameters, Group 2 involves *lower* s_{ALP} than all but Group 4, which is even lower. Further, Group 2 displays *lower* off farm wage, and *higher ALP costs* γ_{ALP} compared to all other groups.

Group 3: Off Farm involves significantly *fewer* agricultural producers compared to Group 1 and 2 and *more* than Group 4. Further, it has significantly *lower* externality values than Groups 1 & 2 but *higher* externalities than Group 4. For parameters, Group 3 involves *higher* s_{ALP} than Groups 2 & 4, but a lower value than Group 1. Further, it has *higher* off farm wage than Group 1 & 2 but lower than Group 4 and a *higher* γ_{ALP} cost parameter than Group 1 but lower value than for Group 2.

Group 4: Mixed involves significantly *fewer* agricultural producers and produced externalities than all Groups. For parameters, Group 4 involves significantly *lower* s_{ALP} compared to all Groups, and *higher* γ_{ALP} costs compared to Group 1 but lower than Group 2. Further, this group has a *higher* off farm wage compared to all Groups.

Our second quantitative analysis pools all 1000 simulation outcomes and correlates three z-score normalized dependent variables, the number of agricultural producers, the total amount of externality produced, and an average of these two outcome variables, with normalized values for the six experimental parameters. The dependent variables considered are represented as the two axes in Figure 2, and a higher value for the average of the two variables would be associated with points in the top right of the figure toward Group 1. All variables are normalized by calculating z-scores across the simulation runs. A benefit of this normalization is that the estimated coefficients on parameters allow us to effectively compare the relative influence of the parameters because all source data lie within the same scale. Further, given that parameters are randomly perturbed around the baseline values in the process of Monte Carlo simulation, violations of the normality requirement for employing a z-score can be avoided. Table 7 summarizes these econometric results; significance is defined at the 5% level unless mentioned.

Table 7. Results correlating Monte Carlo outcomes and model parameters; t-crit. = 1.96

Dependent variable (abs. t-stat)	Constant	s_{ALP} (€)	w_{off} (€/hr.)	Prob. Employ.	Price Prem. (€)	γ_{ALP}(%)
Num Ag.	0.00 (0.00)	0.05 (2.27)	-0.68 (30.22)	8.3e-4 (0.04)	0.03 (1.42)	-0.03 (1.41)
Tot. Externality	0.00 (0.00)	0.45 (19.2)	-0.41 (17.60)	0.02 (0.83)	0.02 (0.97)	-0.27 (11.39)
Num. Ag. X Tot. Ext.	0.00 (0.00)	0.25 (12.96)	-0.55 (28.38)	0.02 (0.83)	0.03 (1.42)	-0.15 (7.72)

For the first dependent variable, the number of agricultural producers, this outcome is only significantly positively influenced by the s_{ALP} parameter, and is significantly negatively influenced by w_{off}, and only marginally by the higher ALP production cost parameter γ_{ALP}. The largest overall effect is negative and follows from the off-farm wage. The results are mostly intuitive, higher wages pull producers off their farms and reduce the number of active farms. Similarly, the significant positive effect of the s_{ALP} payment is also intuitive, higher payments for this activity make it more profitable. Note that dependent variable, number of agricultural producers, pools both the ALP and commercial farms. But s_{ALP} only affects ALP farms, and must therefore be operating through its influence on these farms being pulled away from off-farm activities.

For the second dependent variable total amenity and tourism externality produced, the outcome is again significantly positively influenced by s_{ALP} and is significantly negatively influenced in decreasing order by off-farm wage w_{off} and higher ALP production cost parameter γ_{ALP}. The largest overall effect is positive and follows from the ALP payment. The results are intuitive, higher wages for off-farm employment pull producers off their farms and reduce the number of externality-generating producers, while higher ALP production costs push producers into non-externality generating commercial activity, or more often off the farm altogether. Alternatively, higher ALP farm payments help support ALP activities, resulting in more externality.

The final dependent variable is a composite of these earlier two. Because the variables are normalized and may be positive or negative, an average is the most appropriate interaction term. The analysis indicates that this composite variable is significantly positively influenced by the s_{ALP} payment, and is significantly negatively influenced in decreasing order by w_{off} , the γ_{ALP} cost parameter. The largest overall effect is negative and follows from the off-farm employment wage. The intuition is similar, higher wages pull producers off their farms and reduces the number of externality-generating producers, while higher ALP production costs push producers off the farm or into non-externality generating commercial activities. Alternatively, higher ALP payments help support ALP activities yielding more ALP agricultural producers and externality.

6.2.4 Sensitivity analysis results

The final simulations are akin to a sensitivity analysis on one of our key assumptions which cannot be verified with field data. We investigate the extent to which the magnitude of the additional cost of producing in a manner consistent with the ALP, γ_{ALP}, impacts our predictions about land uses and the amount of public good externality produced.

We consider if farmers might purse activities consistent with the ALP given their estimated preferences, in the absence of the ALP payment, if additional costs of producing with this method were not so high. Intuitively this tells us about the extent to which ALP practices can be maintained without direct payments and despite higher production cost by relying on owners' preference for this form of production technique and the non-pecuniary utility this production technique provides. We remove the s_{ALP} payment and reduce the higher cost of the ALP method compared to traditional methods to 12.5% and then 5% from the 25% higher cost in the baseline case. Calibrated preferences and all other model parameters from the baseline case are maintained. Earlier, when costs were 25% higher, removing the ALP payment results in all but 1 ALP farm switching to conventional or off farm activities.

For the first sensitivity experiment we set $\gamma_{ALP} = 1.125$ or to12.5% higher ALP costs and eliminate the s_{ALP} payment. We observe that the results are identical to the Experiment 1 case in which 80 farms switch to commercial suckler beef, 3 switches to commercial beef, and one remains in the ALP. Due to the small size of the one remaining ALP farm, the externalities and externalities + tourism income fall to essentially zero. Thus, without the ALP payments and when the ALP is only 12.5% more costly than a conventional approach, nearly all farms are predicted to find it optimal to cease producing the public good externality.

Finally, we reduce the higher ALP cost to $\gamma_{ALP} = 1.05$ or to 5% higher, which again produces similar results. Thus, without the ALP payments and when the ALP is only 5% more costly than a conventional approach, producers do not find it optimal to produce in the ways consistent with the ALP and would optimally be expected to cease producing the public good externality, all else being equal.

7. Recommendations and Conclusions

With respect to willingness to pay (WTP) and willingness to accept (WTA, the choice modelling method used in this study produces what appear to be reasonable results. Willingness-to-pay and Willingness-to-accept are price-sensitive and the results of this present study are comparable with those noted in the literature for similar valuation studies (Yadav et al. 2013; Kelley et al. 2013; Hanley, et al. 1998; Campbell, et al. 2006). The positive WTP values stated by the respondents suggest that the Aran Islands landscape carries significant value and thus deserves to be well protected. We report marginal willingness to pay estimates of €59.39 and €83.28 for the conservation of karst limestone pavements and biodiverse orchid rich grasslands and marginal willingness to pay estimates of €99.56 and €96.25 for the provision of walking trails and for the conservation of archaeology and stone walls.

From the farm survey our findings reveal that conservation actions involving provision of biodiversity and orchid rich grasslands is the most expensive option requiring an annual payment of €160.57 per hectare. On the other hand provision of archeology and stone walls as part of the management agreement is the least costly option. The possibility of a management scheme which involved walking trails does not appear to significantly influence farmer's choice.

We set out to achieve two primary objectives with our micro-level modeling evaluation of the AranLIFE program. First, our methodological objective was to construct and calibrate an individual household portfolio theory model and to integrate non-market production values into its theoretical structure. Second, our quantitative objective was to perform numerical comparative statics experiments and Monte Carlo simulation analysis with the calibrated model with the goal of addressing three research questions. The questions included first, how optimal are stakeholders' agricultural management decisions, to what extent does their preferences for production account for non-profit maximizing decisions, and how significant are farmer heterogeneities? Second, we asked, how might these ALP farms respond to policy changes or variations in market conditions as represented by variations in key model parameters? And finally, we considered how the public good externalities produced by the ALP farms compare to the program's exchequer costs?

First, our calibrated micro-simulations produce dynamics consistent with the production decisions of the 84 Aran farms of interest. Further, preference calibration is shown to be critical for reproducing the farmers decisions, as 83 of the 84 farms are shown to not be pursuing the utility maximizing activity; i.e. for 83 farms non-zero preferences are required to reproduce their observed action. Upon calibration of preferences, farmers are found to be somewhat heterogeneous, but roughly 2/3 had preferences lying in the range €0 to €3,000; however, there are a few large outliers. Once calibrated, the model predicts 32 producers participate in the ALP and the externality and tourism spend public good values produced a total of over €9m per year compared to the annual direct and indirect exchequer cost of €2,597,685.3 for the program. The rates of return of this program on an annual basis range from an upper bound of 1,045% if excluding sunk indirect costs, the most conservative estimate comparing the public good externality plus tourism revenue to the sum of direct and indirect costs results in a lower bound rate of return of 382%. The conclusion we must reach regarding research question one is that farmers do not appear to be acting in a strictly utility maximizing or rational way, their preferences do appear to be related to their behavior, and the farmers as a group are fairly heterogeneous in their preferences. Further, the decentralized AranLIFE program clearly supports stakeholders' preferences to produce in a manner consistent with ALP, and without it, even with current preferences, for many it would be optimal to change their behavior.

Regarding research question 2, we do observe that farmers' production decisions, as simulated by our calibrated model, are quite sensitive to policy and model structural parameters. In terms of our first outcome variable, the total number of commercial and ALP agricultural producers, the overall the largest effect is negative and relates to the off-farm wage, while smaller in absolute terms the largest positive effect is related to the s_{ALP} payments. The results indicate that as ALP payments increase and off farm wages decrease we will observe increases in the number of agricultural producers, or at least decreases at a slower rate. However, the ALP payment increase will be required simultaneously with off farm wage increases if maintaining or increasing the public good externality is the policy objective.

In terms of our second dependent variable and the stated goal of this agri-environmental scheme, the amount of landscape amenity and tourism externality produced, the largest driver of externality is observed to be positive and related to the s_{ALP} payment for participating in the ALP. The second and third largest effects are negative and relate to the off-farm wage potential as well as higher cost of the ALP production activity, respectively. Given the potential for increased Irish growth compared to the period since 2007, to achieve public good externality targets, maintaining or increasing the ALP payment directly to farmers, and helping them mitigate the costs associated with producing this way, will be required as GDP and off-farm wages pick up.

Finally, considering a composite dependent variable which averages the normalized number of agricultural producers and the magnitude of the externality suggests that the largest effect will be negative and related to the off-farm wage, the second largest is positive related to the ALP payment, while the third is negative and is related to the ALP higher cost parameter.

In summary, the numerous experiments and the analysis of Monte Carlo results suggests that the manipulations predicted to provide the largest policy impacts in terms of positive externalities will be policies targeting the ALP payments, off farm wage rates, as well as the costs associated with ALP style activities.

Finally, regarding research question three, for most experiments and Monte Carlo outcomes, as long as at least a subset of producers retain the ALP, the rate of return for exchequer support payments range from a lower bound of 373% if including all sunk and indirect costs and excluding tourism income, to an upper bound of 1045%. In the case where all farms abandon the ALP, the externality value falls to zero, and with sunk exchequer payments, the rate of return becomes negative.

Limitations of our approach are centered on a few primary issues. First, estimating the non-pecuniary preference value of individual land owners for pursuing particular production techniques is difficult. This is because a number of household specific preferences must be aggregated into one preference measure that can be represented in monetary terms. Our approach of aggregating these items is appropriate given the absence of more specific information regarding an appropriate disaggregation of household production preferences. Next, much of our analysis relies upon cross sectional variation among ALP or National farm survey farmers given the absence of longer time series data. Our analysis could of course be strengthened once additional time series data becomes available. This would allow more appropriate panel estimation techniques to be applied when estimating counterfactual production value and costs. Finally, there may be more relevant independent variables useful for predicting production value and costs for counterfactual activities. Although some of this predictor information may be available for the National Farm Survey, we are limited by what is reported for our farms of interest, the Aran 84. As an attempt to control for this unobserved variation constant terms are included in all econometric exercises. Although there are commonly known limitations to the use of constant terms in regressions to control for observed variation, this technique also has known advantages. Interestingly, in all cases these terms appeared to have an insignificant impact of simulation outcomes, suggesting a limited effect of unobserved variation. Finally, it should be noted that the externality values associated with the AranLIFE farming system estimated in this study are limited mostly to the visual impacts made by the karst limestone pavements and orchid rich grasslands, archaeological sites, and walking trail features such as boreens, etc.. Many other ecosystem services such as better water quality and health of livestock, which are by products of the ALP system, are not factored into the total externality value. Furthermore, the survey was limited to Adult visitors to the Aran Islands and the aggregated externality value is normalized to the population of Irish taxpayers. Additionally, lower bound values for numbers of visitors and tourism spend are employed. Hence, the true externality value is most likely larger than what is used to calculate the rate of return in this study given that on average more visitors and spend will occur, and due to the significant numbers of both domestic and international underage visitors to the area.

The AranLIFE project has developed an innovative participatory model that engages local farmers and best scientific practice to deliver ecosystem goods and services from a unique landscape. This model provides useful lessons for landscapes around the world that are reknown for the provision of ecosystem services that are not confined to the market. Clearly from a societal point of view the activities conducted by Aran Life farmers are worthy of support. With such high levels of economic benefits stemming from the ALP scheme and its associated links with landscape and tourism, our recommendation is for the ALP type approach to continue with its role as a liaison between farmers and various government and non-government institutions in pooling resources and ensuring that the activities of farmers are coordinated in the delivery of local environmental public goods. However, given the public good nature of benefits associated with Aran Islands perhaps the greatest challenge facing farmers in the Aran Islands is how to effectively capture the benefits of tourism through the market while at the same time allocating sufficient labour resources to ALP conservation actions. Although many of the farmers do benefit from market based tourism, we suspect that more could be engaged in this process. Although not all farmers endorsed the development of recreational walking trails across farm land, we recommend further consideration of walking trails using Boreens given the high tourist demand. Furthermore, we recommend that the AranLIFE program be extended to incorporate sustainable methods of rewarding the land managers for their contribution in implementing the ALP practices and maintaining the unique Aran Island landscape. In this regard finally in order to ensure farm households more effectively capture market based tourism we recommend that Aran Island farmers should consider developing a local informal institution. This will assist them to ensure that their activities are sustained by the benefits of Island tourism yet remain locally governed.

Appendix A.

Biases Related to Stated Preference Techniques

The most prominent criticism relates to the hypothetical nature of the survey technique which normally results in ‘hypothetical bias’. Critics argue that because both the provision and payment for the good are hypothetical in nature, it is likely that the values obtained are also hypothetical. The existence of hypothetical bias has been well documented (List and Gallet 2001; Murphy, et al. 2005) where the values obtained are on average 2.5 to 3 times the actual values (Harrison and Rutstrom 2002). The degree of hypothetical bias is particularly higher when respondents perceive an ‘important ethical dimension’ in the good being valued (Johansson-Stenman and Svedsater 2003). The cost of acquiring a ‘warm glow’ (Andreoni 1990) through the ‘purchase of moral satisfaction’ (Kahneman and Knetsch 1992) is much lower in a hypothetical survey which promotes higher willingness to pay values.

History and Development of Choice Experiments

Choice experiments can be traced back to Lancaster’s (1966) “characteristics theory of value” which claims that the utility individuals derive from a good is based upon various characteristics and attributes embedded in it. Changing the attributes of these alternatives may cause the individual to alter his/her choices from one alternative to another that consists of the preferred combination of attributes. It is the preferences of individuals that determine the level of utility for each alternative, and the likelihood that an individual chooses a specific alternative is a function of his/her level of utility for that alternative.

Probabilistic discrete choice models were pioneered in the field of psychology by Thurstone (1927) and were later introduced into economics by Marschak (1960) in the form of random utility models; and then further developed by McFadden (1974) and Manski (1977). Thurstone (1927) modeled individual choice with respect to a process where the alternative with the highest perceived value is chosen by the individual. This process can be interpreted as a model of economic choice by translating the perceived values as utility levels under the assumption that individuals behave as utility maximizers, (McFadden 2001).

Binary discrete choice elicitation schemes have been used extensively in the past decade for environmental valuation. This is mostly due to the approval of such elicitation mechanisms by the NOAA Panel (Arrow, et al. 1993). The incentive compatibility of dichotomous choice type questions was the primary reason for endorsing such valuation elicitation techniques. Choice experiments however are an extension of such elicitation schemes, but with multiple options which has several advantages over the traditional contingent valuation technique (List, et al. 2006; Adamowicz, et al. 1994).

The validity of traditional contingent valuation techniques that require respondents to choose 'all of the good' or 'none of the good' have constantly been questioned due to the presence of 'embedding effect'[7]. With the CE technique, which has each alternative broken down into its attributes, tests of scope seem to be a natural part of the technique (List, et al. 2006). Another advantage lies in the fact that more information can be elicited from a respondent in terms of their marginal value for various attributes of the commodity instead of its total value (Alpizar, et al. 2001). Finally, it has also been asserted that the ease of acquiring information regarding the valued good helps minimize the level of hypothetical bias that has constantly plagued stated preference techniques (List, et al. 2006).

The approach taken by choice experiments appears to be a more natural and realistic way to aid people to make decisions. Rather than limiting the decision between whether or not to purchase the good as a whole, it is normally the case that one makes a tradeoff between the various attributes between the available goods before making a purchase. A study by Huber, et al. (2002) shows that respondents find the CE technique more realistic and also feel more confident when making decisions.

[7] The embedding effect which has been discussed extensively in the contingent valuation literature occurs when the willingness to pay for a good is not significantly different from the willingness to pay for another good that is embedded in the first good. The latter good may be included within the first good in terms of time, area, etc (Harrison 1992).

Example of a Choice Card used in the Tourist Survey

Features	Option A	Option B	Option C
Karst limestone pavement	Moderate management	No management	No new management
Biodiversity: orchid rich grasslands	High management	Moderate management	
Walking trails	No	Yes	
Archaeology on farmland	High management	No management	
Cost	€50	€15	
I prefer			

Example of a Choice Card used in the Farm Survey

Features	Option A	Option B	Option C
Karst limestone pavement	Moderate management	High management	No new management
Biodiversity: orchid rich grasslands	No management	Moderate management	
Boreen walking trails	Yes	No	
Archaeology & stone walls	Moderate management	No management	
Payment received / effort value	€100	€100	
I prefer (indicate with an x)			

Comparison of Willingness to Pay values with Similar Landscape Valuation Studies:

A Payment card contingent valuation method was used by Bowker and Didychuk (1994) to elicit the external benefits of farmland preservation in a sub region of Eastern Canada. Individuals were asked how much they were willing to pay to preserve certain portions of the existing 95,000 acres of farmland in the region. According to their results, the average annual household contribution to preserve 23,750, 47,500, 71,250, and 95,000 hectares of farmland were $49.07, $67.64, $78.49, and $86.20 respectively.

Hanley, et al. (1998) employed a choice experiment to estimate the external benefits caused by changes in public forest landscape as a result of different management practices in the UK. The three attributes were species mix (evergreen only versus a mixture of species), shape (straight edges versus organic edges), and felling (large versus small scale clear felling). Marginal willingness to pay for felling, Shape and Species mix were £12.83, £17.82 and £16.79 respectively. Assuming a linearly additive utility function, the average household willingness to pay per year for their preferred forest management practice (which entailed contoured edges, a diverse species mix and selective felling), over and above a forest with straight edges, only evergreen trees, and patch felling was £38.15.

Another choice experiment was conducted in Ireland by Campbell, et al. (2006) to quantify the landscape benefits resulting from the implementation of the REP scheme. According to their results, the total willingness to pay per person per year for the different farm landscape attributes categorized as Rivers and Lakes, Hedgerows, Farmyard tidiness, Cultural heritage, Wildlife habitats, Stonewalls, Mountain land, and Pastures was €249.44, €77.20, €70.18, €60.64, €54.32, €52.00, €42.81 and €36.63 respectively. When aggregated, the annual willingness to pay per person for all of the landscape benefits from REPS farms adds up to be €643.22.

Finally, a choice experiment was conducted by Carlsson, et al. (2003) in southern Sweden to identify and value the various characteristics of wetlands other than their ability to reduce the run-off of nutrients. While they found certain characteristics of wetlands such as a fenced waterline, and the introduction of crayfish to provide a disutility to the public, a high level of biodiversity, improved condition for fish, and walking facilities were valued at 673.22 SEK (€66.85), 348.48 SEK (€34.60) and 648.06 SEK (€64.35) per person.

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