Greenhouse gas (GHG) Mitigation and Technology Adoption Theory: Extended Grazing as a Case Study

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Abstract

Challenging EU GHG mitigation targets and an expansion of Irish milk production will bring increased focus on farm management practices and technologies that can increase both output and reduce emissions. A number of profitable GHG mitigation options are available but their adoption by all farmers is not guaranteed. Technology adoption theory can help understand the decision process of individual farmers to identify realistic mitigation potential. Using new data from Irish dairy farmers, this paper examines the adoption of the mitigation option of extended grazing. Results identify a number of farm/farmer characteristics, including accessing advisory services and off-farm employment, as statistically significant factors affecting adoption. Probabilities can be assigned based on identified characteristics, thus helping to identify realistic mitigation potential.

Keywords Technology Adoption, Agricultural Management, Dairy

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1. Introduction

Uncertainty around the rate of adoption of GHG mitigation options creates uncertainty about the mitigation potential of agriculture. While options that both reduce GHG emissions and increase productivity are more likely to be adopted (Smith et al. 2008, Smith et al. 2007), profitability does not imply adoption. A number of new technologies and management practices are available that increase farm profitability and reduce GHG emissions, but many have not been adopted by the entire farming population (OECD 2012).

Technology adoption and diffusion theory have been widely used to better understand the factors that influence an individual's decision to adopt and there is a large body of existing research on technology adoption in agriculture (Pannell et al. 2006; Keelan et al. 2010; Prokopy et al. 2008; Howley et al. 2012; Baumgart-Getz et al. 2012). Complementary but sometimes contradictory findings produced by this research suggest underlying differences in the economic, social, cultural, and institutional environment across and within countries (Feder et al. 1985).

Ireland has a stated national objective to increase the volume of milk production by 50% by 2020 (DAFM 2010) but under EU GHG mitigation targets is required to reduce non-ETS (Emission Trading Scheme) 2020 emissions by 20%, relative to 2005 levels. Agriculture is the single largest source of Irish non-ETS emissions (approximately 40%) and enteric fermentation accounts for on average 46% of total emissions from agriculture (NESC 2012; EPA 2012). The GHG mitigation option of extended grazing is particularly relevant in the context of increased animal numbers (dairy cows increased by 2% in 2013 (EPA 2015)) and as a management practice that can be readily applied (O'Brien and Shalloo 2013).

In 2012 the mitigation potential and cost of ten GHG mitigation options, including extended grazing, were presented in a Marginal Abatement Cost (MAC) curve for Irish agriculture (Schulte and Donnellan 2012). The total estimated mitigation potential was 1.1 Mt CO_2eq per annum to 2020, a 4.5% reduction compared to reported agricultural emissions in 2005. This is not an exhaustive list of mitigation options, but represented those options for which completed research and scientific data were available on the relative abatement potential and cost/benefit. While a number of the mitigation options examined reduced emissions and were profitable to the Irish farmer, 'the rate of adoption of new farm practices and technologies by farmers is difficult to project' (Schulte and Donnellan 2012, pp. 28).

The purpose of this paper is to demonstrate the potential of technology adoption theory to better understand the decision process of individual farmers and provide insight into factors impacting on the adoption rate of GHG mitigation options. Using new data on Irish dairy famers the paper specifically considers the adoption of extended grazing, a management practice that can deliver both increased farm profitability and reduced GHG emissions.

2. Background

Irish agriculture: Production, emissions and mitigation

In 2012 agriculture accounted for 30.70% (17.967 Mt CO_2) of all Irish GHG emissions, reflecting the absence of significant heavy industry and the dominance of grass-based bovine production in Ireland's agricultural sector. In 2012 over half of total Irish agricultural GHG emissions arose from the digestive process (enteric fermentation) of ruminants[1]. The long-term development of Irish agriculture is set-out in the government strategy document Food Harvest 2020 (DAFM 2010) and includes a 2020 target to increase milk production volume by 50%, relative to 2010. Achieving this national target is projected to lead to an increase in the relative number of dairy cows in the national bovine population, thus increasing GHG emissions (Donnellan and Hanrahan 2014). Provisional estimates identified an annual increase of 2.6% (0.48 Mt CO_2 eq) in 2013 GHG agricultural emissions, driven primarily by increased use of synthetic fertiliser, underpinned by higher animal numbers reflecting national plans to expand milk production following removal of milk quota in 2015 (EPA 2015).

Milk production on Irish dairy farms is generally grass-based with spring calving (Ryan et al. 2010; Läpple et al. 2012). Soil type and climatic conditions have the most significant impact on Irish grassland production, with solar radiation (day length and intensity), soil temperature and soil moisture the primary determinants of grass growth. Soil temperatures are a greater constraint on grass growth during the spring while solar radiation impacts more significantly on autumn grass growth (Humphreys 2007). Soil moisture is particularly relevant to the practice of extended grazing. Excess soil moisture can reduce annual herbage production and the length of the grass-growing season and also trafficability (resistance of soil structure to damage from trafficking by animals or machinery) to limit the period during which grass can be safely grazed (Schulte 2012). Approximately 30% of milk production takes place on farms with heavy soil (poorly drained soils) (O' Donovan 2008; O'Loughlin 2013).

As grass growth is highly seasonal with little or no net growth between November and February, the typical grazing season (number of days animals spent on grass outdoors) on an Irish dairy farm runs from early spring to late autumn. In 2012 the average grazing season length amongst Irish dairy farmers was 237 days, a decrease from that recorded in 2011 (240 days), reflecting adverse weather conditions (Teagasc 2010; Teagasc 2012). At a regional level, Läpple et al. 2009) estimated a national grazing season length amongst Irish dairy farmers of 223 days, ranging from 205 days in the border, midlands, and western (BMW) region to 233 in the South and East regions. This variation is due mainly to regional differences in soil quality and climate. Other estimates suggested similar variations based on climate and soil type, ranging from 250 days (high-rainfall, heavy-clay soil) to 149 days (lower-rainfall free-draining soil) (Shalloo et al. 2004). Irish dairy farmers are working towards a research target of 300 days (Kennedy et al. 2009; Läpple et al. 2012).

Extending this grazing season length has the potential to help achieve both national milk production and GHG mitigation targets. Extended grazing was one GHG mitigation option considered in the 2012 Irish agricultural MAC curve. Lower GHG emissions arise from reduced quantities of stored manure, lower direct enteric methane emissions (improved feed digestibility and quality) and a reduction in energy use (feeding, manure management and harvesting of silage) (Schulte and Donnellan 2012). Extending the grazing season also

[1] EEA greenhouse gas - data viewer accessed 02/01/2015. N_20 and CH_4 reported in CO_2 equivalents. Sectors consistent with IPCC common reporting format (CRF) guidelines. Agriculture reported all anthropogenic sector emissions, except for fuel combustion and sewage emissions. http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

increases the amount of grazed grass in the dairy cow diet, the least expensive high-quality feed for milk production, lowering direct costs. The average cost of milk production is reduced by 1 cent per litre for a 2.5% increase in grazed grass in the dairy cow diet (O'Donovan et al. 2011; Hennessey et al. 2006) while extending the grazing season by one day is estimated to reduce costs by 0.16 cent per litre (2009) (Läpple et al. 2012). Extending the grazing season in early spring and late summer offers the best opportunity to increase the proportion of grazed grass in spring-calving dairy cows (Kennedy et al. 2005).

The estimated mitigation potential of extended grazing presented in Irelands MAC curve (0.264 Mt CO2eq) is based on an extension of the average dairy grazing season by 21 days, rising from 227 days in 2010 to 248 days in 2020. The 248 days target corresponds to that set-out in the 2020 Roadmap for the development of Irish Dairy Enterprises (Teagasc, 2013b). The GHG emissions are calculated using emission factors applied to the biological/economic/physical effects of the change in grazing season length using a whole farm simulation model (Moorepark Dairy System Model (MDSM)) (See O'Brien et al. (2011) and Shalloo et al. (2004)).

Technology adoption research

While extended grazing has been identified as profitable, similar to many other profitable mitigation options, adoption by all farmers is not guaranteed. However, if viewed as a utility-maximising rather than purely profit-maximising individual, the farmer may be seen to act rationally by not adopting a technology with clear monetary benefits (Becker 1962)**.** For example, extended grazing is a time-intensive mitigation option and non-adoption is the rational choice for many individual farmers based on their particular time-leisure trade off. For additional insight into the impact of such non-monetary factors affecting adoption we can draw on insights from technology adoption research.

Most technology adoption studies assume the underlying theoretical model of the profit-maximizing or utility-maximizing farmer (Feder et al. 1985). A farmer is assumed to adopt a new technology where there is an expected benefit or increase in utility (Caswell et al. 2001). Across agricultural technology adoption research generally, adoption has been found to be determined by the characteristics of both the specific technology and the characteristics of the farm and farmer (Pannell et al. 2006; Keelan et al. 2010; Prokopy et al. 2008; Howley et al. 2012; Baumgart-Getz et al. 2012). Explaining the farmer's adoption decision typically involves the selection of a number of potential independent variables based on prior theorising and empirical testing usually via logit or probit regression (Knowler and Bradshaw 2007; Keelan et al. 2010). The two models generally produce similar results with limited theoretical justification for choosing one model over the other (Mercer 2004). Some limitations are associated with treating adoption as dichotomous choice, not least defining adoption and failure to capture the dynamic nature of adoption. However, data may be more readily available to support this methodology (Mercer 2004; Doss 2006).

While there is considerable research available on the factors affecting adoption, the studies have produced a range of complementary, but sometimes contradictory, findings. Differences in the economic, social, cultural, and institutional environment across and within countries therefore explain some of these differences (Feder et al. 1985). This suggests that while existing research is useful, additional primary or country-specific technology adoption research is necessary. On this basis this paper tests the hypothesis that farm and farmer characteristics specific to Irish dairy farmers impact on the adoption of the GHG mitigation option of extending the grazing season.

3. Data and Methods

The impact of farm and farmer characteristics on the adoption of extended grazing practices among Irish dairy farmers are tested empirically by the following model:

$$P\,\{y_i = 1|\, x_i\} = F(x_i, \beta)$$

This binary choice probit model describes the probability that y_i=1 for the given function F(.), the vector x_i contains the individual farm and farmer characteristics and F is a function of the cumulative distribution function, bound by the interval [0,1]. Beta is the parameter in the model to be estimated. The probability that a farmer has adopted an extended grazing season depends on specific characteristics included, such as age, education, farm size, etc.

A standard normal distribution was assumed, specified as a log-likelihood equation and estimated using a Maximum Likelihood Estimation (MLE) model. The model coefficients cannot be interpreted in the same manner as an OLS regression so it is necessary to use marginal effects to interpret the results of the model. Goodness of fit was considered using the pseudo R^2 and McFadden R^2 values. As the data contains a high proportion of zero observations on the dependent variable such values are not expected to be very high. Likelihood ratio tests were used to determine whether or not certain variables are necessary in the model, i.e. restricted versus unrestricted models.

Data

Data comes from a face to face Agri-Environment survey of 1,000 Irish farmers, undertaken during the period October to December 2012. The sample was selected to be nationally representative of the Irish farming population. The survey contained forty-six questions primarily designed to extract data on attitudes and responses to agri-environmental issues. Information on farm and farmer characteristics included farm size, activity, animal number, soil type, labour hours, farm income, off-farm income, education and age. The survey included specific questions on GHG mitigation actions, with this paper focussing on the option of extending the grazing season. The location of each respondent was recorded at Electoral Division (ED) level[2].

For the purpose of this paper respondents who identified their main activity as mainly dairying and/or if dairy animals constituted half or more of all animals, were considered dairy farmers, providing a sample size of 207 dairy farmers. The sample is considered representative of the Irish dairy farming population.

3.1 Explanatory Variables

The farm and famer explanatory variables hypothesised to affect adoption of extended grazing included farm size, off-farm income/employment, age, education, use of advisory services and discussion group membership (See Table 1).

[2] EDs are the smallest legally defined administrative areas in the Irish State for which statistics are published by the Irish Central Statistics Office (CSO). There are 3,440 legally defined EDs in the State.

3.2 Dependent Variables

One of the primary difficulties when treating adoption as a dichotomous choice is how to define adoption. Extended grazing is labour/management/time-intensive rather than capital intensive and thus adoption cannot be identified with a specific capital investment decision, i.e. extended grazing is a technology not embodied in any physical item (Sunding and Zilberman 2001). While recognising that partial adoption is likely to occur for divisible technologies such as extended grazing, the data available for this paper do not capture the extent or intensity of adoption and hence adoption cannot be defined as a level of use, e.g. the amount or share of farm area utilising extended grazing (Feder et al. 1985). Finally, extended grazing could be considered a 'grassland management' practice, with adoption dependent on or enhanced by adoption of other complementary management practices (Feder et al. 1985). In many instances the farmer is required to make a sequence of decisions on adoption and intensity of use for new technologies and management practices (Doss 2006). For example, land drainage and reseeding may be necessary prior to adoption of extended grazing, and grass budgeting an on-going complementary practice. Unfortunately the data available for this paper do not capture such complementary management practices and thus we focus exclusively on extended grazing as a dichotomous choice.

In this paper adoption is defined based on regional-specific average grazing season lengths identified by Läpple et al. (2012). The main data source used in the analysis by Läpple et al. (2012) was the Irish National Farm Survey (NFS) (Connolly et al. 2010). The NFS is collected as part of the EU Farm Accountancy Data Network (FADN) and surveys approximately 1,100 Irish farms each year, representing a farming population of 110,000 farms. Using 2009 NFS data this study reported grazing season length (days) for four regions based on counties (Border, midlands, and western (BMW) region = Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan, Galway, Mayo, Roscommon, Longford, Offaly, Meath, Westmeath, and Dublin; Southwest region = Kerry, Clare, Limerick, and Tipperary; East region = Kildare, Wicklow, Laois, Carlow, Kilkenny, and Wexford; and South region = Waterford and Cork).

Survey respondent location is identified by ED level, assigned to the relevant county and finally assigned to one of these four regions. Adoption is defined where the reported grazing season length is equal to or greater than the average grazing season length associated with their particular region. (BMW = 205 days; Southwest = 223 days; East = 233 days and South = 233 days).

Table 1. Explanatory variables used in regression model (Source: Agri-Environment survey 2012)

Variable	Description	Mean	Minimum	Maximum
size	Farm size in hectares Scale: 15-200 ha	59.40	15	200
size2	Farm size squared	5062.92	225	40000
age	Age of farmer Scale 1-5	3.11	1	5
hhold	Household size (including respondent)	3.60	1	10
educ	Formal education (Above second level) 1=Yes; 0=Otherwise	.25	0	1
agrieduc	Agricultural education Short course, certificate, third level) 1=Yes; 0=Otherwise	.82	0	1
offfarm	Off farm job or income 1=Yes; 0=Otherwise	.13	0	1
peer	'It makes sense for me to join if my neighbours are joining' 1=Yes; 0=Otherwise	.51	0	1
discuss	Membership of Farm discussion group 1=Member of discussion group; 0=Otherwise	.46	0	1
environ	Very/Fairly concerned about the environment in general 1=Yes; 0=No	.91	0	1
reps	Participation in REPS (Rural Environment Protection Scheme (REPS) 1-3 1=Yes; 0=Otherwise	.39	0	1
noplan	Continue farming with no significant changes (next 5 years) 1=Yes; 0=No	.21	0	1
Lifestyle_environment	Farming as a lifestyle and a positive attitude towards the environment	5.32e-09	-5.06	2.94
production	Focus on production and output regardless of negative environmental consequences	0	-4.18	2.74
cautious	Cautious approach to farming and adopting new ideas and practices	-3.39e-10	-3.80	3.48

The majority of respondents to the Agri-Environment survey (79%) farmed between 20-100ha, consisting mainly (61%) of agricultural land with some/very limited agriculture use, e.g. poor drainage, mountain areas. Over half (54%) were in the 45-64 age group, with almost a third (30%) one/two person households. A similar percentage participated in REPS 1-3 (39%) and REPS3/AEOS (35%), but only 20% participated in both schemes. Of those that participated in both agri-environmental schemes the majority (92%) also self-reported a general concern for the environment. Of those planning to increase intensity of production over the next five years (22%) only one fifth had off-farm employment as one might expect. Somewhat unexpectedly only one-third (34%) of those planning to increase intensity of production were involved in discussion groups, considered an important source of information for those planning expansion (Hennessy and Heanue 2012).

Furthermore, a number of attitudinal variables were constructed using a principal component analysis (PCA). The primary purpose of a PCA is to identify associations or correlations between a number of variables to identify a smaller number of common factors. These constructs or variables are then used in the model of adoption to capture the impact of respondents' attitudes and motivations.

Table 2 details the thirteen statements describing different motivations and attitudes towards a range of farming and environmental issues, with responses recorded on a Likert score between Strongly Disagree (1) to Strongly Agree (4). The statement recording the highest percentage of strong agreement (4) 'I enjoy farming much more than I would other potential sources of employment' highlights the view of farming as a lifestyle rather than simply a job. The second highest level of agreement related to the statement 'Farmers are good caretakers of the countryside'. This positive attitude to the environment was reinforced by the low level of agreement for the statement 'Farmers should be allowed to maximise their income irrespective of the environmental consequences'.

Table 2. Overall mean scores

	Mean Score	% Strongly Agreeing
I enjoy farming much more than I would other potential sources of employment	3.54	59%
Farmers have a strong positive role to play in protecting the environment	3.55	55%
I have to keep my farm running to ensure I have something to pass on to my children	3.44	52%
Farmers are good caretakers of the countryside	3.50	51%
To be successful in farming it is important for me to adapt and use new technologies	3.43	50%
I am good at finding different types of information to help me run my business	3.35	42%
I don't think it is a good idea to take too many risks when it comes to farming	3.12	31%
It is important for me to be respected by other farmers	3.19	27%
My economic future on this present farm is bright	3.00	20%
It makes more sense for me to join a scheme if my neighbours are also joining	2.57	17%
I am cautious about adopting new ideas and farm practices	2.72	15%
We need to produce more food even if some damage is caused to the environment	2.67	15%
Farmers should be allowed to maximise their income irrespective of the environmental consequences	2.50	13%

The results from the PCA are presented in Table 3. The thirteen attitudinal statements were condensed into three separate constructs or variables, based on eigenvalue greater than one and rotated using the varimax method. A standardised factor score was applied to each construct (mean of zero and a standard deviation of one), with a higher score indicating a higher the level of agreement. The correlation between these component scores and each of the thirteen attitudinal statements are identified by factor loadings.

Table 3. Factor Loadings

	lifestyle_environment	production	cautious
Farmers should be allowed to maximise their income irrespective of the environmental consequences	0.0006	**0.5477**	-0.0271
I enjoy farming much more than I would other potential sources of employment	**0.3916**	-0.0582	0.1117
Farmers are good caretakers of the countryside	**0.3807**	-0.0795	0.0229
I am good at finding different types of information to help me run my business	0.3386	0.0668	-0.0979
My economic future on this present farm is bright	0.2942	-0.0776	0.1211
Farmers have a strong positive role to play in protecting the environment	0.3679	-0.2217	-0.0321
To be successful in farming it is important for me to adapt and use new technologies	0.3286	0.2018	-0.3294
I have to keep my farm running to ensure I have something to pass on to my children	0.3411	0.1731	-0.2019
I am cautious about adopting new ideas and farm practices	-0.0396	-0.1157	**-0.5363**
It is important for me to be respected by other farmers	0.3643	0.0289	0.2269
We need to produce more food even if some damage is caused to the environment	-0.0247	**0.6274**	-0.0047
It makes more sense for me to join a scheme if my neighbours are also joining	0.052	0.3891	0.24
I don't think it is a good idea to take too many risks when it comes to farming	0.0567	-0.0268	**-0.6442**

The first component was labelled ‘lifestyle_environment’ to reflect the importance of farming as a lifestyle and a positive attitude towards the environment. This component had a high factor loading on the statements ‘I enjoy farming much more than I would other potential sources of employment’ and ‘Farmers are good caretakers of the countryside’.

The second component was labelled ‘production’ to reflect high factor loading on the statements ‘Farmers should be allowed to maximise their income irrespective of the environmental consequences’ and ‘We need to produce more food even if some damage is caused to the environment’. This component also reveals a strong negative attitude towards environmental protection.

The third component was labelled ‘cautious’ to reflect the high negative factor loading on the statements ‘I am cautious about adopting new ideas and farm practices’ and ‘I don’t think it is a good idea to take too many risks when it comes to farming’.

The overall Kaiser–Meyer–Olkin measure of factor suitability was 0.7694, with values greater than 0.5 considered acceptable and values 0.70 to 0.79 middling (Kaiser, 1970). Cronbach's Alphas of 0.716 (lifestyle and environment focus), 0.768 (production focus), 0.547 (cautious approach) indicates a good degree of consistency in responses used to derive the three factor variables.

4. Results and Discussion

Results of the probit models on the likelihood of a farmer adopting extended grazing are presented in table 4. The model coefficients cannot be interpreted in the same manner as an OLS regression so marginal effects are also presented.

Table 1. Results of the probit model on the probability of extended grazing season adoption

Variable	Coefficient	Z-statistic	Marginal Effect
Farm size	.005	0.30	.001
Farm size squared	.000	0.38	.000
Age	.138	0.67	.033
Household size	.134	1.26	.032
Education	.200	0.44	.048
Agricultural education	1.063**	2.04	.256**
Off-farm employment	1.383**	2.00	.332**
Farm followers	-1.296***	-2.61	-.311***
Membership of farm discussion group	.99 ***	2.87	.238***
Concern for the environment	-.884	-1.26	-.212
Participation in REPS (1-3)	-.994***	-2.73	-.239***
Continue farming with no significant changes	-.936**	-2.42	-.225***
Lifestyle and environment focus	.097	0.98	.023
Production focus	.339**	2.02	.081**
Cautious/Risk-adverse approach	.237*	1.63	.057*
Constant	.091	0.07	
Loglikelihood	-45.431582		
LR chi2(15)	44.41		
Pseudo R2	0.3283		

*** p<0.01, ** p<0.05, * p<0.1

Agricultural education had a positive and statistically significant impact on adoption of extended grazing. Those with agricultural education were 26% more likely to achieve a grazing season greater than the average for their particular region. Formal education did not have a statistically significant impact on adoption. Education can provide the farmer with an increased ability to understand and evaluate information on new technologies, allowing them to adopt new profitable technologies quicker (Nelson and Phelps 1966).Agricultural education provides greater agricultural awareness, experience and skills, making farmers with agricultural education more receptive to new ideas and willing to consider different farming systems (Keelan et al. 2010).

While formal education may be associated with the capacity to search and order information, peer networks provide information to individuals about the advantages and disadvantages of a technology specific to their own particular situation (Rogers 1983; Ryan and Gross 1950; Cotlear 1986). Farm discussion groups are one example of a peer network and membership facilitates both social (learning-by-interacting) and experiential (learning-by-doing) learning (Hennessy and Heanue 2012). Those who participated in such discussion groups were 24% more likely to adopt extended grazing. Generally, membership of discussion groups has been found to impact positively on technology adoption (See Hennessy and Heanue (2012) for discussion relevant to Irish dairy farming).

Educated farmers are more likely to be early adopters and can provide an example to other less educated farmers (Okoye 1998; Weir and Knight 2000). Responses to the statement ‘It makes sense for me to join if my neighbours are joining’ was included as a variable to understand if those adopting considered themselves followers rather than leaders. This was identified as a statistically significant negative factor impacting on adoption, i.e. those farmers ‘following’ their neighbour (farm-followers) were 31% less likely to adopt extended grazing.

Those dairy farmers with off-farm employment were 33% more likely to adopt extended grazing. This finding is counter to that initially hypothesised when considering extended grazing as a labour intensive technology (Fernandez-Cornejo et al. 2005) and could be expected to be more likely to occur where the technology is capital intensive (Gedikoglu et al. 2011). However, in a study of commercial dairy farms O’Donovan (2008) identified a lower labour requirement per cow as herd size increased. Where extended grazing is considered as part of a general expansion in output, including herd size, the impact of adoption on farm labour could therefore be neutral or even reduced. Off-farm employment would thus be facilitated rather than restricted by adoption of extended grazing. Where labour demand does increase as part of dairy expansion, the contribution of hired labour is expected to increase relative to the farmers’ own labour or family members’ labour (Shalloo et al. 2012). Expansion, facilitated by the adoption of extended grazing, and the increase in hired labour therefore may also have the effect of facilitating off-farm employment of the owner-farmer.

Previous participation in the Rural Environment Protection Scheme (REPS) was found to decrease the likelihood (24%) of adoption of extended grazing. At a practical level, restrictions imposed under REPS, such as constraints on fertilizer use, may have restricted the extension of the grazing season. A prioritisation of farm production over environmental impacts was found to have a statistically significant positive impact on the adoption of extended grazing. This production was considered acceptable regardless of the environmental consequences. Among respondents, a general concern for the environment had a negative impact on adoption of extended grazing, although this was found to be insignificant.

While a particular focus on production had a positive impact on adoption, those planning to continue farming with no significant changes over the next 5 years were less likely to adopt. Those who had a more cautious approach to new technologies were more likely to adopt extended grazing. This may reflect the interpretation or view that extended grazing is an old or established rather than new technology.

5. Conclusion

The results presented in this paper are generally consistent with the available literature and support the hypothesis that farmer characteristics impact on the adoption of new technologies and management practices (Pannell et al. 2006; Keelan et al. 2010; Prokopy et al. 2008; Howley et al. 2012; Baumgart-Getz et al. 2012). While the results remain specific to Irish dairy farmers and the GHG mitigation option of extended gazing due to underlying socio-economic fsctors, they are important in the context of expanding Irish milk volumes and challenging national GHG mitigation targets. Associating probability of adoption with particular farmer characteristics supports the identification of effective policy interventions to realise identified GHG mitigation potential.

The results of this paper suggest that information may continue to act as a barrier to adoption of extended grazing, but informal methods can prove an effective solution. In particular, the practical setting of farmer discussion groups can provide an effective solution to help farmers overcome uncertainties around the impacts of extended grazing in their particular circumstances.

As the likelihood of adoption increased amongst those farmers with a greater focus on expanding production education efforts should continue to emphasise the productivity advantages of extended grazing. It is worrying that many respondents prioritised expanding production in general at the expense of negative environmental consequences. It is important to recognise and balance the negative environmental impacts of extended grazing more generally against its GHG mitigation potential, e.g. compaction and leaching (Schulte and Donnellan, 2012). While encouraging adoption of GHG mitigation options such as extended grazing is necessary, it must do so in the context of overall environmental sustainability.

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