Title:

Farmers' attitudes towards, and intentions to adopt, agroforestry on farms in lowland South-East and East England.

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Highlights

1.Some 60% of farmers in E and SE England might consider planting agroforestry.

2.The likely new planting would take up 4.5% of the current total farmed area.

3.Farmers believed they would be able to plant and manage new areas of agroforestry.

4.Farmers with low profit-maximising objectives were more likely to plant agroforestry.

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Abstract:

Agroforestry (AF) is a land use that incorporates trees into the production of agricultural crops and/or livestock on the same piece of land. As such, AF has the potential to contribute to national biogenic carbon capture and storage, improved soil structure and function that helps to reduce soil erosion and surface run-off and improved financial returns to farmers with minimal land loss to agriculture. To date, there has been very little uptake of AF in the UK despite awareness of these benefits and the availability of policies to support adoption. This suggests that there are barriers to the adoption of AF that policy, or market developments, have yet to address. This study set out to identify these barriers, along with potential drivers to further uptake of AF in South-East and East lowland England by means of a survey of 224 farmers and landowners in 2019 covering a range of farm sizes and types. We found that nearly 60% might consider planting small areas of AF, with plantations being the most preferred option. When raised to the regional level, this would take-up around 4.5% of the total farmed area. Financial reasons were behind some of the reluctance to plant, as well as a view that trees might interfere with other farm operations. This suggests that for AF to be a tool to help the UK Government reach their woodland planting goal to achieve their net-zero target by 2050, farmers will need both planting grants and maintenance payments if they are to plant more AF.

Keywords: Agroforestry; Farmers' attitudes; barriers to planting; Theory of Planned Behaviour.

1. Introduction

'Agroforestry (AF) is an approach to land use that incorporates trees into farming systems and allows for the production of trees and crops and/or livestock from the same piece of land' (Gordon et al., 2018). AF is a traditional land use type; many authors have pointed out that it has been practised for thousands of years in England (e.g. Carruthers, 1990) with different levels of sophistication and management demands. Several authors detail the advantages and opportunities AF expansion might create in rural England in the future, chiefly through the provision of a range of benefits not, or insufficiently, generated by current agricultural practices. For example, AF can improve farmland productivity, soil health, carbon sequestration, biodiversity, water management or livestock welfare (Raskin & Osborn, 2019; Soil Association & Woodland Trust, 2019; Newman et al., 2018; Graves et al., 2017; Gregory,1997).

According to Hislop & Sinclair (2000), there are two main types of AF relevant to the temperate climate conditions prevailing in England: silvo-arable, where crops are grown between rows of trees with the row spacing designed to allow the use of agricultural machinery; and silvo-pastoral, where trees are grown in pasture which is grazed by farm animals. A variety of AF types designed for a specific purpose exists in addition to the two main types: trees are planted on farms as windbreaks, either along field boundaries or as clumps or blocks in fields; alongside water bodies as a riparian boundary; small farm woodlands with strong edge effects; or, indeed, hedgerows with mature trees (Gordon et al., 2018). Each of these formats can deliver a range of other benefits, in addition to its main purpose (e.g. Newman et al., 2018). A recent assessment has identified global integrated land-based solutions, including AF, having the potential to sequester 1.5-15.6 Gt C eq/yr (Smith et al., 2013).

Numerous papers report on AF in England in the last 50 years, and a series of trials and experiments on AF has been carried out (Newman et al., 2018). However, the actual area of formal AF planted on commercial farms is still very small. A recent estimate made by den Herder et al. (2017) suggested that there was a total of only 157,000 ha of AF in the UK, representing just 0.9% of the total agricultural area. Around 117,000 ha of this area is represented by hedgerows on farms (Forestry Commission, 2001a, b & c). Deducting this area leaves around 32,000 ha of other AF systems, which is made up of some 17,000 ha of 'traditional orchards' with grazing by livestock (Burrough et al., 2010) and 15,000 ha of 'wood pasture and parklands' supporting livestock grazing (Maddock, 2008). Carruthers (1990) and Newman et al. (2018) point out that most of these AF areas have been in existence for several hundred years, suggesting that the recent expansion of AF area is very small. To set the above figures in context, it should be noted that the woodland area of the UK in 2017 was 3.17 M ha, covering 13% of the total land area; 978,000 ha of which was woodland on agricultural land (Defra, 2018).

Newman et al. (2018) observe that the area of the silvo-arable type of AF seems to be almost non-existent in England at present, although there is some very recent activity in experimenting with intercropping orchard fruit trees with either arable or vegetable crops, carefully designed to fit in with the CAP support regime under both Pillar 1 and Pillar 2. England has now left the EU and is in the process of developing a new agricultural support mechanism to replace the CAP. At the time of writing little concrete information is available, however, the UK Government were undertaking an Agroforestry Test aimed at informing the development of support for future AF options.

Whilst there are considerable advantages from the national and societal perspective to increasing the AF area, as mentioned above, farmers in England have not, or are not yet, contributing to increasing tree cover on agricultural land to any meaningful extent. More generally, woodland planting in England has been lower than policy goals for some time, despite both the public and the Government perceiving tree planting as the most suitable tool contributing to the Net Zero target (UK Government, 2021).

These facts have stimulated increasing interest in understanding farmers' attitudes to tree planting generally and to AF specifically, and the various constraints they felt to adopting it. Broad reviews of the barriers to AF in England have been provided by the Soil Association & Woodland Trust (2019), Burgess (2017), Graves et al. (2009) and Newman et al. (2018). These sources highlight the long lead time before sales of timber or tree products as the primary barrier, followed by the attitude of landowners towards their tenants planting trees along with other tenancy issues. Valatin et al. (2016) and Lawrence & Dandy (2014) identified farmer perception of low financial returns from AF as an additional barrier. They also note the importance of tailoring support to the different attitudes, motivations and circumstances of landowners.

A number of studies report on farmer and stakeholder attitudes to AF, sometimes with a focus on specific types of AF. The most detailed and, perhaps, insightful of these studies looks at silvo-arable systems in eastern England (Graves et al., 2017). Ducros & Watson (2002) focus on farmers planting trees by watercourses, Morris et al. (2002) investigated farmers planting hedgerows and McAdam et al. (1997) report on farmer attitudes to AF on sheep and cereal farms in Northern Ireland. Watkins et al. (1996) report on the attitudes of farmers in Nottinghamshire to farm woodland planting. Wynne-Jones (2013) explored these same attitudes in the North Wales context and Morgan-Davies et al. (2008) explore them in West Perthshire in Scotland. Finally, Thomas et al. (2015) look at what affects farm woodland expansion in Scotland.

This paper reports on a survey undertaken as part of a project that examined the potential for greenhouse gas removal by AF in lowland England over the next 30 years. Specifically, the project concentrated on lowland farming systems that cover the most productive agricultural areas of England (i.e. the area consisting of the Government Office Regions of East Anglia and the South-East) which is land that is typically considered to be least likely to be converted to large-scale conventional forestry. The key goals of the study were to identify socio-economic barriers to AF expansion and to suggest policy changes to encourage such planting.

The remainder of this paper takes the following form. The Method section details how the farmer questionnaire was both designed, following an extensive literature review and a programme of stakeholder consultation, and administered. Next, the results from the farmer survey are presented, and this is followed by a section that discusses these findings. Finally, conclusions, including for policy, are drawn.

2. Method

2.1 Data gathering procedure

Following an extensive literature review to inform the design of the questionnaire, ten likely benefits for farmers from adopting AF were identified (Table 1). They range from environmental and physical yield benefits, animal welfare improvements to farm financial performance gains.

The literature review also enabled the delineation of a series of perceived barriers that might prevent farmers from considering adopting AF on their farms (Table 2). The time lag between establishment and income arising from the tree component stood out as the most manifest barrier, followed by, for farmers with rented land, probable unfavourable attitudes of landlords towards their tenants planting trees.

In November 2018, the list of benefits from adopting AF shown in Table 1, and the perceived barriers listed in Table 2, were put for discussion to a focus group of farmers and other rural actors and stakeholders in Berkshire, England, a lowland farming area. The initial focus group consisted of nine people and, later in the day, a broader discussion group of 23 people was convened to discuss these same issues in more detail.

The findings of the literature review, the recorded discussions of the focus group and the broader discussion group, allowed the authors to prepare an initial questionnaire. This went through eight iterations and was eventually piloted with four farmers. The final farmer questionnaire (copies of which are available from the corresponding author) was a six-page A4-sized document that included a covering letter/participant information sheet on the front page explaining what the project was about and why they were being consulted. It was also explained to the potential participants that the Institution's Ethical Clearance procedure had been followed. At the foot of the covering letter page, three images of AF types were presented to attempt to show participants what AF looks like in practice in the UK. The questionnaire was folded to make an A5-sized item to be mailed out to the selected farmers.

Trees integrated into arable settings reduce soil erosion[1]

AF can be a cost-effective flood mitigation method[2]

AF can increase carbon sequestered compared with monocultures of crops or pasture[3]

AF can increase total financial yield and on-farm productivity[4]

AF can improve animal productivity and welfare by providing shelter and shade[5]

AF can increase biodiversity on farm[6]

Silvo-pastoral AF can result in earlier grass growth for livestock[7]

Benefits to agricultural crops from tillage, fertilising and weed control can benefit the tree crop[8]

Planting on lowland agricultural land means timber is produced nearer to processors and markets[9]

Trees grow better on lowland soils[10]

Sources:

[1] Defra (2018); House of Commons EFRA Committee (2016); Young (1989).

[2] Newman et al. (2018); Young (1989); Raskin & Osborn (2019).

[3] Carruthers (1990); Defra (2018); Upson (2014); Pantera et al. (2018); Raskin & Osborn (2019).

[4] Soil Association & Woodland Trust (2019); Defra (2018); Graves et al. (2007); Pantera et al. (2018); Raskin & Osborn (2019).

[5] Defra (2018); Gregory (1997); Pent (2017); Wynne-Jones (2013); Raskin & Osborn (2019); Lawrence & Dandy (2014).

[6] Thevathason & Gordon (2004); Varah et al. (2013); Dennis et al. (1996); Defra (2018); Newman et al. (2018); Garcia de Jalon et al. (2018).

[7] Newman et al. (2018); Sibbald (2006).

[8] Pantera et al. (2018); Torralba et al. (2016); Raskin & Osborn (2019).

[9] Newman et al. (2018); Burgess & Rosati (2018).

[10] Hislop & Claridge (2000); Palma et al. (2007).

Table 1. Possible benefits/drivers for farmers from adopting AF in temperate lowlands derived from a literature review.

Long gap until income from the tree component[1]
Attitudes of landlords[2]
Little knowledge of where advice can be obtained[3]
High establishment costs (young trees, stakes and tree protection)[4]
AF sits in a policy and delivery void[5]
AF falls into a grant funding gap[6]
Trees might affect other farm operations[7]
Little knowledge of growing trees[8]
Might impact on the value of the planted land[9]
Negative attitudes of social referents [10]

Sources:

[1] Louah et al. (2017); Soil Association & Woodland Trust (2019); Burgess et al. (2017); Valatin et al. (2016).

[2] Schirmer & Bull (2014); Doyle & Thomas (2000); Raskin & Osborn (2019); Lawrence & Dandy (2014).

[3] Garcia de Jalon et al. (2018); Soil Association & Woodland Trust (2019).

[4] Soil Association & Woodland Trust (2019); Raskin & Osborn (2019).

[5] Soil Association & Woodland Trust (2019); Newman et al. (2018); Raskin & Osborn (2019).

[6] Soil Association & Woodland Trust (2019); Burgess & Rosati (2018); Raskin & Osborn (2019).

[7] Louah et al. (2017); Graves et al. (2017).

[8] McAdam et al. (1997); Louah et al. (2017); Burgess et al. (2017).

[9] Graves et al. (2017); Burgess et al. (2017); Valatin et al. (2016).

[10] Graves et al. (2017); Hopkins et al. (2017); Burgess (2017); Schirmer & Bull (2014).

Table 2. Perceived barriers to farmers planting AF in temperate lowlands derived from a literature review (barriers are listed in approximate order of considered importance and by times mentioned in the literature).

The questionnaire was in three distinct parts. First, there were 14 contextual and socio-demographic questions about the surveyed farm business and the farmer or manager who was running it. Second, there were four questions about whether participants had any existing AF or woodland on their farms, whether they saw any opportunities/potential for adopting more and, if so, what areas and systems they might establish and for what purposes. Third, there were 15 questions designed to establish the participants' attitudes towards AF and how these might be influenced by others. These attitudinal questions were all based on 5-point Likert scales (Likert, 1932) as appropriate for use with the theoretical model employed in this case i.e. the Theory of Planned Behaviour (TPB) after Ajzen (1991) and Ajzen & Fishbein (1980). Further details on the theoretical model used are provided below.

The UK Government Office South-East and East of England Regions were targeted to select 800 farmers who were identified from the free Yell.com online database. The initial procedure was to get the farmer lists of each County Council and Unitary Authority (UA) in the European Union's NUTS

Regions South-East of England and East of England as described in the 'Counties and Unitary Authorities (December 2017) Map in the UK' from https://geoportal.statistics.gov.uk/

Using the search term 'farmers' and category 'farmers' on Yell.com for each identified County Council and UA/City/Borough Council in these two regions, gave a total of 5958 addresses, as searched for on 30 January 2019. To obtain the target of 800 addresses, the first 13% of addresses listed alphabetically in each County/UA were extracted and combined into a final sample.

The questionnaire, with a covering letter explaining the survey objectives and a reply-paid envelope for its return, was sent out to the 800 farmers on 11 April 2019. To maximise response rate, a reminder letter was sent out on 16 May 2019 and a further reminder letter together with a duplicate questionnaire was sent on 13 June 2019. All respondents were thanked. The questionnaire was also made available online through the Twitter and Facebook pages of the authors' institution for two 14-day periods in May and June 2019 (10-24 May and 3-17 June). Data from the returned questionnaires was entered into an excel database; this was then checked by a senior member of the research team. The survey was closed on 1 August 2019, 16 weeks after the initial mailing. Following this procedure, a total of 191 'clean' replies by post were available for analysis, along with a further 33 responses from the online response platform.

In total, 224 completed questionnaires were available for analysis by 1 August 2019. The crude response rate for the postal survey was 23.5%. After allowing for people who were no longer in farming (i.e. letters being returned stating addressee 'not known', 'gone away', 'deceased', 'non-farmers' or 'retired'), the actual response rate was 24.4%. This rate is relatively high for voluntary postal surveys of farmers, though not as high as that obtained by Tranter et al. (2004) in a survey of farmers' attitudes to CAP reform.

2.2 Survey representativeness

Some socio-demographic characteristics of the sample were examined to see if the sample was representative of the population of farmers from which it was drawn. Table 3 shows four characteristics of the respondents and their farm businesses: total area farmed; the proportion of area farmed that was owner-occupied; the proportion of respondents over 50 years old; and the total number of regular workers including the respondent and their family.

Survey farmers had a mean total area farmed of 395 ha and their mean total number of regular workers including themselves and their family was 3.2. Official June Survey 2019 statistics show that for the South-East and East of England Regions the corresponding means were 102 ha and 3.6 respectively (Defra, 2021) suggesting that survey respondents had larger farm sizes than the regional mean. The proportion of the survey respondents' area farmed that was owner-occupied was 74.8%; the national comparison for England was 67.2% (Defra, 2020). Just over 70% of the survey farmers were over 50 years old which compares well with official statistics showing that the median age of farmers in the UK was 60 years old, with only 35% under 55 years old (Defra, 2020).

	Mean	Minimum	Maximum
Total area farmed (ha)	395.0	2.0	2631.00
Proportion of area farmed owner-occupied (%)	74.8%	1.00	100.00
Proportion of respondents over 50 years old (%)	70.1	-	-
Total number of regular workers including respondent and their family	3.2	0	40

Table 3. Some key respondent characteristics.

As with all surveys, there is a possibility of 'non-response bias' i.e. those that did not respond to the survey are different in some pertinent way from those who did respond. We compared the characteristics shown in Table 3, for the fastest tertile of respondents, against the slowest of responses received. This test assumes that the respondents replying last are likely to be more similar with those who did not respond than those who replied earlier (Barclay et al., 2002; Groves, 2006; MacDonald et al., 2009; and Jones et al., 2015). In this study no statistically significant differences between the 'early' and 'late' respondents were found for: total area farmed (t=-0.72, P=0.4715); the proportion of farmed area owner-occupied (t=-0.15, P=0.8823); and the number of full-time workers (t=-1.25, P=0.2132). However, using Chi Square a significant difference was found in the proportion of farmers over 50 years (X2=7.68, P=0.0056), with slightly fewer farmers over 50 years in the late responder group compared to the early group. Overall, there is no reason to suppose that respondents who did not respond to the survey are significantly different from those that did.

2.3 The theoretical model of farmer decision-making

2.3.1 Introduction

To better understand the factors that determine farmers' propensity to adopt AF, and the decision-making process that is involved, we decided to use expressed intention to adopt as the conceptual framework. Because the farmer survey could not measure actual behavioural response, expressed intention approximates the decision-making process. These expressions of intention were based on the responding farmers' expectations of both the technical requirements of adoption and the accompanying costs and benefits. To identify the factors determining the likely adoption of AF, we chose the Theory of Planned Behaviour (TPB) which models intention based on both the internal (such as psychological), and external (such as cultural and demographic) factors (Ajzen, 1991; Fishbein and Yzer, 2003) believed to influence decision-making.

2.3.2 The Theory of Planned Behaviour

TPB has been used widely to try to explain human decision-making behaviour in many fields of activity, including agriculture and food production. For example, TPB was used by Lapple and Kelley (2013) to understand factors determining the adoption of organic farming by farmers, by Alarcon et al. (2014) to examine the disease-control decisions of pig farmers, by Jones et al. (2015) to assess dairy farmers' intentions to reduce the use of antibiotics, and by Jones et al. (2016) to assess organic dairy farmers' intentions to adopt herd-health prevention measures.

TPB posits that a person's 'intention' to carry out a particular behaviour is the most accurate predictor of whether they actually will do it. TPB also highlights three particular determinants of an individual's intention to perform a particular behaviour (Ajzen, 1991):

i) attitude towards the expected outcome of an action/behaviour (Outcome Attitudes) i.e. what they expect the outcome of their behaviour will be and the value placed on it;

ii) beliefs about what valued others expect them to do in relation to the behaviour (Normative Referents/Subjective Norms); and

iii) beliefs about their ability to implement the behaviour (Perceived Behavioural Control).

TPB, as a result, attempts to measure the extent to which these (above) and other determinants, such as socio-demographic factors, and more general attitudes, impact intention to adopt. According to TPB theory, the more positive a person's attitudes to an outcome, the more favourable the perceived opinions of their peers and the stronger the person's belief that they can control their actions, the stronger the intention to undertake a behaviour is likely to be and, therefore, the greater the likelihood they will undertake it (see Figure 1).

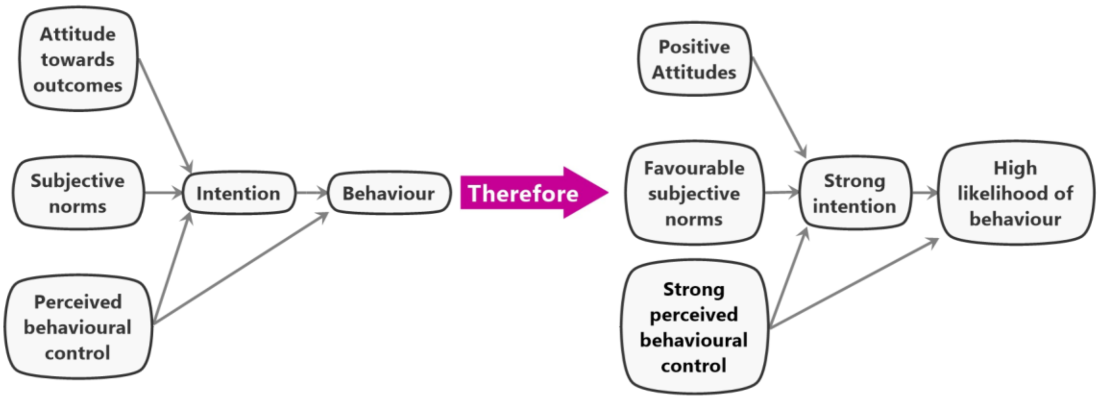

Figure 1. The components of TPB and their relationship to behavioural intent.

2.3.3 Model specification

A full specification of the elements of the TPB model is shown in Figure 2. The TPB model contains three broad dimensions i.e., Outcome Attitudes (OA), Subjective Norms (SN) and Perceived Behavioural Control (PBC). The OA dimension is the sum of two sub-components: belief strengths (bs) i.e., the expected probability of an outcome occurring, and outcome evaluation (oe) i.e. the value placed on the outcome (utility).

$$OA = \sum_{i=1}^{n} bs_i * oe_i \qquad (1)$$

where i = beliefs about outcome i.

For experimental measurement both bs_i and oe_i are based on respondent self-rating, using a 1 to 5 scale. Fishbein & Ajzen (2010) identify two dimensions of OA, i.e. ‘instrumental’ and ‘experiential’. Instrumental attitude is contingent on the outcome, or payoff, of undertaking the behaviour, while experiential attitude is based not in the payoff but on the experience of undertaking the behaviour itself. In this study, only instrument attitudes were surveyed as the primary focus is on the payoff from possessing trees rather than the husbandry experience itself.

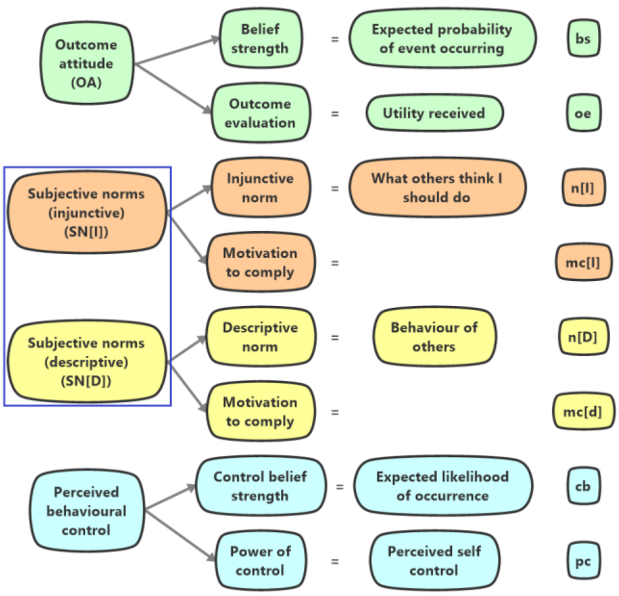

Figure 2. The full specification of the TPB model used.

The Subjective Norms (SN) dimension captures respondent perceptions of the social pressure that arises from others about a behaviour that the respondent may, or may not, be considering - in this case planting AF on their farm. The SN construct is the sum of two related norms, injunctive SN(I) and descriptive SN(D). Injunctive norms are respondent perceptions about what others think they should do (or their level of approval of the respondent undertaking an action), while descriptive norms are respondent perceptions about what others will themselves do. Each of these two norms is based on two components i.e. the strength of the normative beliefs about the opinion or actions of others (n[I] or n[D]) and motivation to comply with, or replicate, these (mc[I] or mc[D]). Therefore,

$$SN[I] = \sum_{i=1}^{n} (n[I]_i * mc[I]_i) \qquad (2a)$$

$$SN[D] = \sum_{i=1}^{n} (n[D]_i * mc[D]_i) \qquad (2b)$$

Where i is a vector of different social referents.

The Perceived Behavioral Control (PBC) dimension captures respondents' perception of factors that might either facilitate or impede their performance of a behaviour. The PBC dimension is derived from two sub-components: control beliefs (cb) i.e. beliefs about the likelihood of occurrence of different control factors (i) and the power of control (pc) i.e. the ability of these control factors to facilitate or impede the performance of the behaviour. Two dimensions of PBC were identified by Fishbein and Ajzen (2010): 'capacity' i.e. a respondent's perception of their ability to perform a behaviour; and 'autonomy' i.e. level of discretion or control over performing a behaviour, but these are pooled in this case.

$$PBC = \sum_{i=1}^{n} (cb_i * pc_i) \qquad (3)$$

Where I = control factor.

Ajzen (2005) assumed that all other factors which may impact on intention, such as respondent socio-demographic characteristics and the structural and economic environment in which decisions are taken, are mediated through the three aggregate TPB constructs. However, Lo et. al (2014) and others have demonstrated that contextual factors may be only partially mediated by TPB constructs and can also operate directly on intent. As our objective was to identify all drivers and barriers to intention to plant AF on farms, the unmediated effect of these contextual factors is also tested.

2.3.4 Constructing the TPB variables

Measuring intent

Survey respondents were given three separate statements expressing varying degrees of intention to plant AF in the next 5 years and asked to indicate the extent to which these statements reflected their intentions. A difference in the degree of intention was reflected in these statements through the use of the terms 'I might', 'I will try' and 'I intend'. The intention here was that if responses to these three statements were materially different from one another, then all three would be tested, as dependent variables, in regression models with potential determinants of intention. The dependent variable/intention statement that was best predicted by the explanatory variables, as expressed by the model R-square statistic, would be used in the final analysis. However, if these three statements were highly correlated with one another, then they could be assumed to capture the same latent phenomenon, and so any one of them would suffice in the regression-based TPB analysis. Spearman's Rho correlations between these dependent variables ranged from 0.6 to 0.8 with all coefficients significant at $p<0.0001$. Mean statement rank scores varied between 2.9 and 3.27. We thus concluded that the three intention variables are heavily correlated and largely capture the same phenomenon. Combining these variables into a composite would likely add little new information, so a single variable that declared the highest certainty of intent, i.e. 'I intend to plant farm woodland or AF', was used in all subsequent analyses.

OA variables

For testing the role of OA in determining intention to plant farm woodland/AF, a range of OA statements was available in the survey, each capturing different beliefs about the outcome of planting AF and the valuations put on them. We combined these individual measures into a composite construct of outcome attitude through aggregation to increase the efficiency of the statistical analysis. As the TPB model identifies two forms of measures, direct and indirect, separate composite constructs were created for these. To test the coherence of these direct and indirect constructs, Cronbach's Alpha was calculated (see Table 4). An Alpha statistic of >0.7 would indicate an acceptable degree of coherence within the group of variables forming the composite (Bland and Altman,1997). In this study, a coefficient of 0.79 was obtained for the indirect measure, with no single contributing variable scoring less than 0.75. For the direct measure, the Alpha coefficient was 0.71, with no contributing variable scoring less than 0.58. While both composite outcome attitude measures correlated significantly with Intent (Table 7), OA-Indirect correlated more highly and so this was taken forward into the regression analysis (see below).

Measure	Number of questions (i) included in the composite measure	Sample mean for the composite measure	Sample median for the composite measure	Maximum permissible range for composite measure	Cronbach's Alpha (Standardised)
Outcome Attitude (Indirect)	8	22.7	22.0	8 – 40	0.797
Outcome Attitude (Direct)	5	14.61	15.0	5 – 25	0.710

Table 4. Mean, median and maximum permissible range for the direct and indirect composite OA measures, plus Cronbach's Alpha coefficients.

This use of indirect measures of attitudes is consistent with the argument of Singh (1988) and others that attitudes can only be measured indirectly. While Ajzen and Fishbein (1980) state their belief that direct measurement is possible, they do concede that use of direct measures provides very little information about why respondents judge outcomes positively or negatively. Reliance on indirect measures of attitudes is therefore seen as preferable in this case, first because of the greater observed statistical association of these with intent, and second, because they allow for the specific attitudes that drive intention to be mapped.

Normative belief variables

Internal consistency measurement of the subjective norm variables is not strictly required, as it is quite permissible for there to be divergence in perceived level of approval for the target behaviour among the different referents. However, in our study, the Cronbach's Alpha tests on these composite indicators in fact showed a high degree of internal consistency, suggesting that levels of approval, or otherwise, of the target behaviour were perceived to be consistent across all social referents. Direct and indirect measures of the two forms of normative belief indicators (Injunctive and Descriptive) were recorded. Taking the direct measures first, Cronbach's Alpha for the Injunctive norm was 0.86, while there was only a single component variable for the Descriptive norm. For the Indirect measures, the Cronbach's Alpha for the Injunctive norm was 0.74, with no single component variable scoring less than 0.70 and the Descriptive norm 0.83. No component variables had to be dropped from any of the four composite variables to increase internal consistency. All four subjective norm variables correlated positively and significantly with intent (see Table 5), but the two direct variables were by some margin the most highly correlated, so they were retained for further analysis.

Measure		Number of questions (i) included in the composite measure	Sample mean for the composite measure	Sample median for the composite measure	Maximum permissible range for composite measure	Cronbach's Alpha (Standardised)
Subjective norms (Injunctive)	Direct	3	7.95	9.00	3 – 15	0.861
	Indirect	8	27.67	28	8 – 40	0.744
Subjective norms (Descriptive)	Direct	1	3.24	3	1 – 5	N.A.
	Indirect	3	9.11	9	3 – 15	0.833

Table 5. Mean, median and maximum permissible range for the direct and indirect composite SN measures, plus Cronbach's Alpha coefficients.

Perceived Behavioural Control variables

Perceived Behavioural Control was measured by a combination of two component dimensions (E. 3), i.e. control beliefs and power of control. Cronbach's Alpha score for the combined PBC measure was 0.87, with no single component having an Alpha coefficient less than 0.84 (Table 6).

Measure	Number of questions (i) included in the composite measure	Sample mean for the composite measure	Sample median for the composite measure	Maximum permissible range for composite measure	Cronbach's Alpha (Standardised)

Perceived Behavioural Control	7	59.0	57.0	7 – 175	0.867

Table 6. Mean, median and maximum permissible range for the composite PBC measures, plus Cronbach's Alpha coefficients.

2.3.5 Correlation of TPB variables with intent.

Table 7 (see also Figure 3) shows that four of the six composite TPB variables were significantly correlated with intent. Those that were not correlated were the two indirect forms of Subjective Norms (i.e. Indirect injunctive and descriptive). These two variables were, therefore, dropped from further analysis. Both the indirect and direct forms of Outcome Attitudes were significantly correlated with intent, but also significantly correlated with one another. Direct OA was also dropped from further analysis as it was less strongly and negatively correlated with intent.

Pearson Correlation Coefficients							
Prob > |r| under H0: Rho = 0							
	OA_I	OA_dir	SNI_D	SND_dir	SNI_ind	SND_ind	PBC
OA_dir	-0.66870						
	<0.0001						
SNI_dir	0.61051	-0.51516					
	<0.0001	<0.0001					
SND_dir	0.65145	-0.59238	0.63652				
	<0.0001	<0.0001	<0.0001				
SNI_ind	-0.15804	0.04208	-0.26328	-0.19628			
	<0.0351	0.5792	0.0004	0.0081			
SND_ind	0.06577	-0.11427	0.20182	0.11490	0.33620		
	<0.3777	0.1267	0.0054	0.1154	<0.0001		
PBC	0.51412	-0.44084	0.42982	0.44073	0.05577	0.18523	
	<0.0001	<0.0001	<0.0001	<0.0001	0.4610	0.0131	
Intent	0.45015	-0.34716	0.50235	0.61500	-0.07642	0.10937	0.54772
	<0.0001	<0.0001	<0.0001	<0.0001	0.3065	0.1362	<0.0001

Table 7. Pearson correlation coefficients for OA, SN and PBC measures with intent.

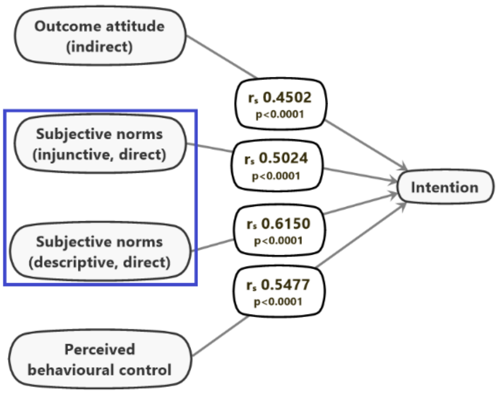

Figure 3. Correlation between direct OA, SN and PC variables with intent.

2.4 Regression model specification

The TPB variables found to correlate with the intent variables were used in a regression model, together with an array of socio-demographic variables to test the conceptual model and, more broadly, to identify those variables that acted as drivers of, and barriers to, intention to plant new areas of farm woodland/AF in the next five years. The intent dependent variable in this case was a 5-point ordinal scale, where 1 = Strongly disagree and 5 = Strongly agree and, as such, was an ordered (indexed) response variable, representing an underlying (unobserved), latent, utility variable (McKelvey and Zavoina, 1975). In order to take advantage of the ordinality of the data, an Ordered Probit regression was undertaken using Stata v16. Responses to the dependent variable were not evenly distributed among the categories, particularly categories 4 and 5. Categories 4 and 5 were thus merged, along with categories 1 and 2, to create a 3-category ordinal variable with the first category normalised to zero (i.e. variable categories are 0, 1 and 2). The ordered probit regression can be presented as:

$$Y_i^* = \beta_i x_i + \varepsilon \qquad (4)$$

Where: $_i$ = individual farmers: 1, 2 . . . N

x_i= a vector of explanatory variables

β_i= a vector of parameters to be estimated and,

ε_i= normally distributed error (or disturbance)

The vector x_i included the four TPB dimensions, plus a vector (A') of the attitudinal and socio-demographic factors listed in Appendix A i.e.:

$$x_i = OA + SN(I) + SN(D) + PBC + A' \qquad (5)$$

All other statistical analysis was undertaken using the analytics package, SAS.

3. Results

3.1 Existing forestry or woodland

Of the 224 survey respondents, 173 (77.2%) reported already having forestry or woodland on their farm. Of the 51 farmers who had no areas of woodland or forestry on their farm, only three indicated that they had previously investigated undertaking such planting. Table 8 shows the type and areas of woodland and forestry that farmers reported possessing.

Type of forestry or woodland	Number of farms with each type of AF/woodland (N)	Median number of plots per farm	Average area on each farm (ha)	Min. plot size (ha)	Max. plot size (ha)
Silvo-arable AF	14	2	12.3	0.2	100.0
Silvo-pastoral AF	14	3	5.1	0.1	20.0
Windbreaks	20	3	4.1	0.5	20.0
Woods or plantations	149	3	33.3	0.1	850.0

Table 8. Number of plots and average area of different types of woodland and AF on the survey farms.

As Table 8 shows, the median number of plots of woodland/AF on the farms is relatively small and relatively uniform, albeit that there is a relatively small number of farms with much larger numbers of plots. The average areas of AF and windbreaks are also small, with the largest being silvo-arable at 12.3 ha. The most common tree planting format was farm woodlands, with 67% of the sample having this land-use type. A relatively small number of blocks were planted, but these summed to relatively large areas per farm at 33.3 ha, on average.

	Very clear / possible opportunity	Uncertain	Probably or definitely not possible
Local market opportunities for timber	25.1	32.8	42.1
Local market opportunities for wood-fuel	52.5	21.8	25.7
On-farm potential for wood-fuel use for heating	54.4	19.4	26.2
On-farm potential for timber for fencing/building	21.8	27.7	50.5
Shooting or other recreational activities	64.2	11.8	24.0

Table 9. Perceived development opportunities from the output from existing woodland or AF on survey farms (per cent).

Table 9 shows farmer perceptions of the diversification and economic development opportunities that woodland/AF on their farms could contribute to. The development opportunities most commonly perceived as feasible by surveyed farmers for their farms were recreational activities (64%), followed by the potential for either marketing of wood or, use on-farm, for fuel. Only a quarter of respondents, or less, saw development opportunities for marketing timber or on-farm uses for it.

3.2 Future possibilities for adopting forestry and woodland.

Asked if they would consider planting new, additional, areas of woodland or forestry on their farms, 91 farmers, or 41% of the sample, said flatly ‘no’. The likelihood of a farmer saying ‘no’ to future planting varied according to whether they already had woodland, with an increased likelihood of saying ‘no’ to future planting if they had no existing woodland (χ^2=9.63, P<0.0019).

The reasons given for unwillingness to consider further planting are shown in Table 10. The most influential reason, with an average ranking score of 4.25 out of 5, is the perception that the financial returns are too low, with the next most influential reason being that woodland/forestry would interfere with other farm operations, followed by the length of the wait, after establishment, for financial returns.

	Proportion of respondents (%) indicating:			
	‘Not very’ or of ‘No’ importance	Neither important nor unimportant	‘Very’ or ‘Quite’ important	Mean ranking score
Capital costs for establishment are too high	16.2	13.2	70.6	3.90
The wait for income is too long	12.7	9.9	77.5	4.06
I don’t have knowledge of tree management	28.4	37.3	34.3	3.03
Attitude of landlord/tenancy constraints	46.4	13.0	40.6	2.83
Uncertainty about the market for the products	11.9	25.4	62.7	3.72
It would interfere with other farm operations	14.3	9.1	76.6	4.12
It would impact the resale value of my land	22.1	22.1	55.9	3.59
Financial returns are too low	7.0	11.3	81.7	4.25
Lack of equipment for woodland management	16.7	33.3	50.0	3.42
Insufficient grant support for capital expenditure	13.2	23.5	63.3	3.75

Note: Rank score 5=’Very important’.

Table 10. The reasons given by respondents for not considering planting a new area of farm woodland/AF on their farms (respondent ranking of each reason).

Of the 133 farmers (around 60% of the respondents) who indicated that they would consider planting further woodland/AF, the planting formats they would prefer are show in Table 11.

Type of forestry or woodland	Number of farmers Indicating each type	Median number of individual plots	Mean total area that might be planted per farm (ha)	Most common current use of land that might be planted
Silvo-arable AF	20	2	16.0	Arable
Silvo-pastoral AF	20	1	8.0	Grassland
Windbreaks	23	1	4.8	Grassland/arable
Woods or plantations	81	2	6.0	Arable (some indicated as marginal)

Table 11. Additional areas of woodland/AF that farmers indicated they might be willing to plant in the future, by planting format.

Farmers would most commonly be willing to plant new areas of woodlands or plantations, but relatively small areas of this on average (6 ha). The largest average areas planted would be silvo-arable AF, but a relatively small number of farmers would choose this option i.e. only some 9% of all respondents.

When these intentions are ‘extrapolated’ to the combined UK Government Office South-East and East of England regional levels, using farm holding and farmed area estimates (24,978 holdings and 2,548,141 ha total farmed area) provided by the 2019 June Survey (Defra, 2021), we find that some 114,457 ha of new woodland/AF might be planted. This is 4.5% of the total farmed area of these two regions combined; just over 45% of this would be woods or plantations on farms.

Farmers who indicated they might consider establishing a new area of woodland or AF on their farms were also asked what the reason would be, based on a list of 12 options; they were given the opportunity to list more than one option.

By far, the most commonly-reported reason for the proposed planting was the improvement of wildlife habitats on the farm (77%). This was reported twice as many times as the next most common use, offsetting GHG emissions. Equal in third place (32%) were on-farm use of wood as fuel and provision of commercial recreation (e.g. shooting). The least popular reason was flood control, cited by just 7% of the sample. Shelter for crops and livestock was a fairly common purpose cited.

3.3 Outcome Attitudes to adopting AF.

Survey respondents were asked to indicate what they believed to be the likely outcomes associated with having farm woodland or AF on their farms (see Figure 4). To facilitate this enquiry, and provide consistency in the issues covered, respondents were asked to indicate the extent to which they agreed or not with eight statements suggesting different outcomes resulting from having farm woodland or AF (see Figure 4). Respondents were also asked to rank the importance of each of these outcomes and these ranks are also shown in Figure 4.

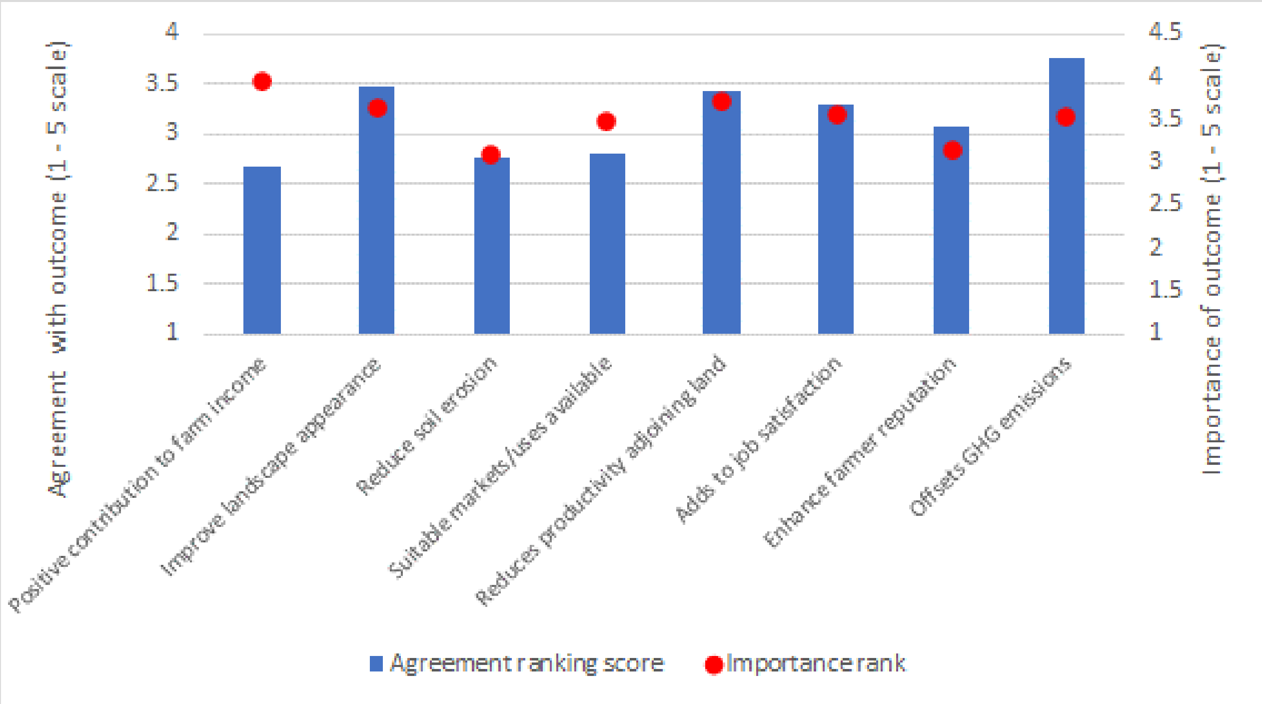

Figure 4. Outcome attitudes to adopting farm woodland or AF.

Widespread agreement across the sample is apparent that adopting farm woodland or AF would lead to carbon offsetting and improve landscape appearance. On the downside, it was also a widely held view that AF would reduce yields on adjoining land due to competition for water, nutrients and light. There was less universal agreement, although still believed by most sample farmers, that AF adds to job satisfaction and would enhance their reputation as farmers. There is much less acceptance that AF can make a positive contribution to farm income, reduce soil erosion, or that there are suitable markets available for AF products, or even on-farm uses for these. In terms of the importance of these issues, by far the most important is the contribution of AF to farm income. This, coupled with the fact that AF is widely considered not to contribute positively to farm income, suggests that this perception is a significant barrier to adoption. A further barrier to adoption, and for the same reasons, is the perception that AF reduces the productivity of adjoining land. In terms of the positives of AF, the most important are the potential for improvements in landscape appearance, job satisfaction and GHG emissions offsetting through carbon sequestration. The least important feature of AF was reducing soil erosion and reputational enhancement.

It is instructive to note the differences in outcome attitudes on the Indirect OA measure (which is the most highly correlated with intent to plant) between those who reported a willingness to consider planting additional areas of farm woodland/AF and those who did not. TPB theory would suggest that those who do not consider planting additional areas would have less favourable attitudes towards the outcomes of planting than those who did i.e. they would find planting less satisfying, less advantageous, less necessary, less important and less pleasant. The mean aggregate Outcome Attitude rank score of the group that would not consider planting was 22.15, compared to 27.30 for the group that would consider planting. This difference was found to be statistically significant ($t=-7.00$, $df=194$, $P<0.0001$, variances equal).

Of the different attitudes contributing to this composite variable, there were significant group differences for four of the five, with no significant difference found for the perceived pleasantness of planting and the most marked difference for satisfaction. The significance of these differences was tested using Mann-Whitney U test (two-sided).

3.4 Subjective Norms

This analysis is focused on the direct Injunctive and Descriptive forms of Subjective Norms, as these were found to be more highly correlated with intention to plant woodland/AF than the indirect forms. However, before analysing these direct measures, it would be instructive to examine the indirect measures, as these allow us to explore survey farmers' perceptions of the extent to which their different social referents would approve of them planting additional areas of woodland/AF on their farms in the next five years. The respondents generally viewed all their social referents as likely to view such planting positively. In TPB terms, these questions captured Injunctive, passively expressed approval. The highest perceived approval levels, by some margin, were attributed to scientists/researchers and members of the general public. The views of these groups were also among the highest in importance in the minds of survey farmers. The lowest perceived approval ratings were attributed to neighbouring farmers, input suppliers and buyers, but the opinions of these social referents were of relatively low importance. It is interesting to note that while the views of farm advisers and friends and family were considered of relatively high importance, they were not considered to be anything like the most positively disposed to additional woodland/AF planting.

Turning to the direct subjective norm measures, and beginning with the Injunctive form, survey farmers were asked for their level of agreement with the assertion that three groups associated with them, or their farm, would approve of, or expect, them to plant new areas of woodland/AF on their farms. The responses to these questions are shown in Table 12.

	Average rank agreement score
People who have something to do with my farm expect me to establish an area of farm woodland or AF	2.27
People in the industry, whose opinions I value, would approve of me establishing an area of farm woodland or AF on my farm	2.99
People who are important to me think that I should establish an area of farm woodland or AF on my farm	2.71

Note: Rank score 5 = 'Strongly agree'.

Table 12. Survey farmers' level of agreement with the assertion that each of three groups of people associated with them would approve of them planting new areas of woodland/AF.

As Table 12 shows, the average level of agreement with each statement is not high i.e. with all averages lying in the zone of neutrality. However, that said, the high level of correlation of this measure with intention to plant AF, must mean that the distribution of rank scores about this mean is predictive of intention to plant additional woodland/AF.

To explore Descriptive norms, direct form, survey farmers were asked to express their level of agreement with the statement: ‘Farmers like me will be adopting farm woodland or AF in the next 5 years’. The level of agreement with this statement, expressed as an average rank score is 2.74, in the zone of neutrality. But, again, it is the distribution about this mean that is key i.e. farmers expressing higher levels of agreement also demonstrate greater intention to plant.

3.5 Perceived Behavioural Control

There was a high level of expectation, as measured by the PBC variables capturing expected likelihood (of occurrence), that planting additional areas of woodland/AF would be feasible and that those who would be responsible for planting knew what needed to be done (Figure 5). There was also a fairly strongly held view that having more woodland/AF would require more farm labour than was currently available on farm. However, this negative view towards labour requirements was not considered to be particularly impactful, perhaps due to the relative ease of hiring contractors and casual staff. The perceived feasibility of having more woodland/AF is also reflected in the low level of concern about the need for advisory support to make the operation possible.

This perceived lack of requirement for advisory support was considered quite impactful, suggesting that a lack of available advisory support would not be an important barrier to the adoption of AF, at least for some (Figure 5). There does not appear to be a widespread belief across the sample that the financial costs of planting/managing woodland/AF would be prohibitively high and so this factor was given a relatively low impact ranking. It should be recognised, however, that these perceptions may differ markedly between those who are open to planting more woodland/AF and those who are not, in which case they could, for some, be influential determinants of intention to plant further areas.

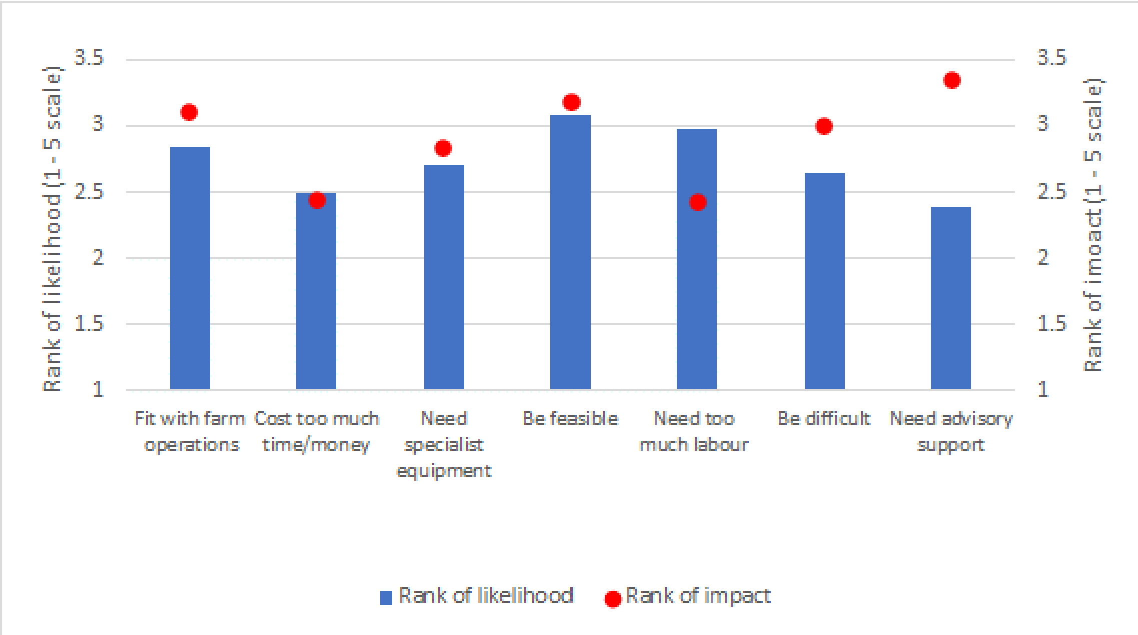

Figure 5. Expected likelihood of a range of potential outcomes from planting woodland/AF and the importance of these outcomes.

3.6 Intent to plant farm woodland/AF in the next five years.

Survey farmers were asked for their level of agreement with a statement expressing intention to plant farm woodland/AF in the next five years on their farms. The most common response to the statement was neutrality (35%), followed by strong disagreement; only around 24% of respondents expressed any level of positive agreement with this statement.

3.7 Background attitudes

The farming goals that survey respondents prioritised were explored by presenting a series of seven statements expressing different goals such as: ‘I want to get as much profit as I can’ or ‘I want to be seen as a good farmer’ and asking respondents to indicate their level of agreement with them. As Figure 6 shows, there is a uniformly high level of agreement with all the statements, with only one statement (the goal of profit maximisation) ranked lower than four (rank score), and only just below four in this case. A very similar set of ranks was also found when farmers were asked to ascribe importance ranks to each of these farming goals.

What we see evidenced here is multi-goal farming, with farmers trying to simultaneously balance the pursuit of profit with job satisfaction, productivity, good husbandry, image projection and environmental concerns. Based on this evidence, it seems that the business of farm management has now become rather more complex than in the past. It is certainly no longer the case that farmers view success solely in terms of physical yields or profit levels.

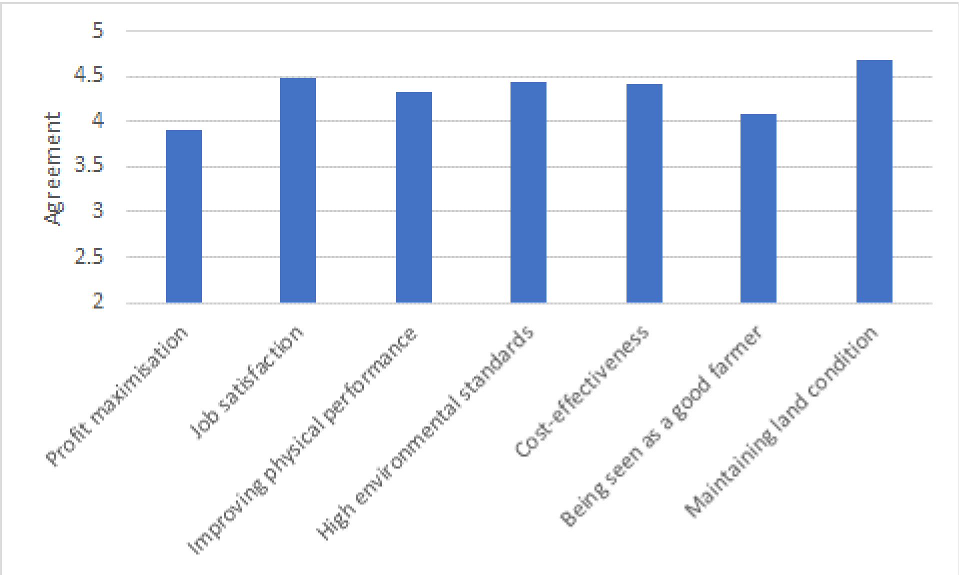

Figure 6. Survey farmers' agreement levels with a series of statements relating to farming goals.

3.8 Drivers of intention to plant

The drivers of, and barriers to intention to plant woodland/AF were explored though the use of an Ordered Probit regression model based on the TPB variables together with a set of socio-demographic variables. Table 13 shows a selection of results of the regression i.e. those variables that were found to be significant determinants of intention to plant. In the model outputs shown in Table 13, the sign of the parameter estimate shows how the associated explanatory variable is related to intention. The sign indicates whether a unit increase in the value of each determinant variable (e.g. an upwards shift on a rank scale, or a change from 0 to 1 for a binary variable) is likely to increase or decrease the likelihood of adoption. To illustrate, a negative sign means that a unit increase in the score for this variable yields a decrease in the likelihood of adoption.

Effect	Description	Parameter estimates	Std error	Z value	Pr > z
SN_I_dir	Subjective norm (Injunctive)	0.1567152	0.0611276	2.56	0.010
SN_D_dir	Subjective norm (Descriptive)	0.691593	0.1721224	4.02	0.000
PBC	Perceived Behavioural Control	0.0221213	0.0067889	3.26	0.001
Profit	Business is currently profitable	-0.7007808	0.3640678	-2.30	0.021
Q32_fx	Respondent wants to be seen as a good farmer	-0.3962815	0.1837572	-2.16	0.031
Q5_d	Other ownership arrangements (not: sole proprietorship, family partnership, or Company)	2.03616	0.6994672	2.91	0.004

Log likelihood = -95.424911; N = 146. Pseudo R2 = 0.3918

Table 13. The results of the Ordered Probit model testing for significant determinants of intentions to plant additional woodland/AF.

Table 13 shows that three of the TPB variables are positive drivers of intent to plant i.e. the two versions of subjective norms and perceived behavioural control, while no predictive relationship for outcome attitudes was observed. One other variable is seen to have a positive relationship with intention to plant, this being the ownership arrangements. Intention to plant is increased where the farm has what might be termed ‘non-standard’ ownership arrangements, for example, farms owned by charitable trusts or public bodies. Current profitability of the farm and the desire of the farmer to be perceived positively by others are seen to be negatively associated with the intention to plant. This implies that the more profitable the farm, the lower the likelihood of planting, perhaps because farmer motivation for profits is strong, or because the land is highly productive. The latter finding suggests that planting woodland or AF on the farm is not perceived to be the mark of a ‘good farmer’. This suggests that survey farmers’ own perception of a ‘good farmer’ is someone who keeps their land productive for food or feed crops.

To gauge the magnitude of the effects of IVs on intention to plant, it is necessary to calculate marginal effects of the IVs i.e. the partial changes in the probability of an outcome (which represents the probability of falling into a particular DV rank), caused by a change in the value of an explanatory variable. These marginal effects (see Table 14) were calculated as:

$$\text{Prob}\ (y = j|\text{x})$$

where: j = the different levels of the DV (0, 1 & 2). The sum of the marginal effects associated with each explanatory variable is equal to zero, because any increase in the likelihood(probability) of falling into one category of the DV, as a result of moving between levels of an IV is offset, by compensating decreases in the likelihood of falling into other categories. The marginal estimates are derived as margin at means (MEM).

Effect	Description	P(y = 0|x)	P(y = 1|x)	P(y = 2|x)
SN_I_dir	Subjective norm (Injunctive)	-0.0592837 *	0.0287645 *	0.0305191 *
SN_D_dir	Subjective norm (Descriptive)	-0.2616221 **	0.1269396 **	0.1346826 **
PBC	Perceived Behavioural Control	-0.0083683 **	0.0040603 *	0.004308 **
Profit	Business is currently profitable	0.2490066 *	-0.0921078 *	-0.1568989 *
Q32_fx	Respondent wants to be seen as a good farmer	0.149909 *	-0.0727361	-0.0771729 *
Q5_d	Other ownership arrangements (not: sole proprietorship, family partnership, or Company)	-0.3879096 **	-0.288573	0.6764827 **

Significance: 5% (*); 1% (**)

Table 14. Marginal effects for explanatory variables on the likelihood of planting additional woodland/AF.

The marginal effect of the dummy variables presented in Table 14 (i.e. PROFIT; Q32_fx; and Q5_d) captures the effect on the DV of a discrete change of the dummy variable value from zero to one. As Table14 shows, a 1 unit increase in the value of SN_I_dir (Subjective norm direct) increases the likelihood of falling in the highest DV category (i.e. the highest level of intention to plant) by 3% and decreases the likelihood of falling into the lowest intention category by 6%. The effect of the descriptive form of the subjective norms (perception that others will be planting trees) SN_D_dir, is even more marked, with a one-unit increase in the value of this variable increasing the likelihood of falling into the highest intent category by 13%. PBC has only very marginal effects on the likelihood of falling in categories of intention i.e. less than 1% in any case. Business profits have a marked effect, with a switch from low profitability to high profitability (binary variable) decreasing the likelihood of falling into the highest intention category by 15%. Respondent desire to be seen as a good farmer increases the likelihood of falling into the lowest intent category (reluctance to plant) by 15%. However, the most marked effects result from ownership arrangements, with unusual forms of ownership of farms increasing the likelihood of falling into the highest intention category by 68%.

4. Discussion

4.1 The TPB dimensions

Outcome attitudes

The outcome attitudes variable was not found to be a significant determinant of intention to plant in the presence of other explanatory variables. It is not uncommon in the literature for the OA variable to have low or no explanatory power as studies by, for example, Bozionelos and Bennett (1999) and Jones, et al. (2015) found. However, the non-significance of the attitude variable is unexpected, and so some examination of the possible reasons is necessary. Introducing AF generates a wide range of acknowledged outcomes, some environmental, some financial. Every effort was made to capture all of these outcomes so that no important dimensions were neglected. The Cronbach's Alpha test shows that there is a high degree of coherence between these eight outcomes in terms of respondents' acknowledgement and valuation of them. In effect, respondents that value outcome 'A' highly tend also to value outcome 'B' etc. However, this coherence does not mean that all outcomes are good determinants of intention. In a situation where attitudes to just one or two outcomes determine intent, the presence of six other outcomes with low discriminatory power will simply swamp the others, such that the composite variable as a whole has low discriminatory power. The importance weights applied to each outcome can only go so far in avoiding this problem.

Subjective norms

We examined the survey farmers' perceptions of the extent to which their social referents would approve of them planting more woodland/AF on their farms in the next five years and found that they thought that all of them would approve. However, the highest perceived approval levels were attributed to scientists/researchers and the general public; they also thought that neighbouring farmers and input suppliers and buyers would not approve so much of this possible action.

Perceived Behavioural Control

As measured by the Perceived Behavioural Control variables, there was a high level of confidence amongst the study farmers that they could plant more woodland/AF, and that they thought they knew how to do it. There was some worry that doing this would need more farm labour than was available, but this was not seen as too impactful, perhaps because they thought they could hire-in contractors to enable this to happen.

4.2 Non TPB-mediated determinants of planting

The study backs up the claims of Lo, et al. (2014) that some socio-demographic factors have a direct impact on intention and are not (wholly) mediated through the TPB variables. In the present case, these unmediated variables are: tenure type, the profitability of the farm business and the perceived self-image of the farmers' actions.

Tenure type

A higher likelihood of planting AF was found for farms with rented land that had 'non-standard' ownership arrangements rather than more traditional owners. This included ownership by utility/transport companies, charities, such as the National Trust, and public bodies, such as the Ministry of Defence. This result is explicable in terms of the reduced primacy of income generation in the farming goals of these owners and their increased interest in the provision of public goods, such as biodiversity enhancement, carbon sequestration and amenity. *A priori,* it might be expected that these differences in farming goals might be reflected in the different attitudes to the outcomes of planting AF i.e. more favourable attitudes towards expected non-monetary benefits.

There were several statements in the questionnaire reflecting 'public good' AF outputs, such as improved amenity, carbon sequestration etc. So, why were they not mediated by the OA variable in this case? In fact, there is no reason to suppose that they were not, but the OA variable itself was not a significant determinant of intention to plant and so was excluded from the regression model. In this event, factors that would normally be mediated through the OA variable, will be directly expressed in the model, including different attitudes towards public goods provision through the tenure variable and, perhaps, the variable capturing the current level of profitability of the farm business. This latter variable may, of course, be a proxy for the productive capacity of the land.

Self-image

The self-image variable captures the level of agreement with the statement 'I want to be seen as a good farmer'. This variable is negatively related to intention, meaning that the more strongly farmers want to be seen as good farmers, the less likely they will be to want to plant AF. We have no direct information on what these farmers perceive to be the characteristics of a good farmer, but many obviously believed that planting AF on agricultural land obviously is not something that a 'good' farmer would do.

There are three pieces of evidence found in this study that support the above view. First, when asked to rank the importance of a set of different farming goals, maintaining land in good agricultural condition came out top (see Figure 6). Second, the adoption of AF was not generally seen as something that would especially enhance the reputation of any farmer (see Figure 4). Finally, AF is not seen as something that is particularly useful for preventing soil erosion i.e. protecting the productive capacity of the land. Burgess (2017), Lawrence and Dandy (2014) and Valatin et al. (2016) also showed that, by farmers, maintaining land in good agricultural condition is viewed in terms of maintaining its productivity and its readiness to be productive for commercial crops and that land bearing forestry is not seen as agricultural. This traditional view of what the good farmer does is still ubiquitous and is reinforced to some extent even in policies such as the European Union's CAP and its focus on the GAEC cross-compliance conditions on maintaining the productive capacity of the land, to the exclusion of other values.

This view is consistent with a number of past studies that have shown that a priority for farmers is maintaining the productive capacity of their land e.g. Burgess (2017). This is similar to the comment of a respondent with a 400 ha cropping farm: 'Farmers need to feed the demands of an ever increasing world population as cheaply as possible.' This variable is a form of a self-identity measure and, it has been argued that self-identify has different motivational roots to outcome attitudes, in being based on self-verification, rather than instrumental motivations (Rise et al., 2010). In confirmation, a number of studies have found that self-identification predicts actions even after the TPB dimensions have been taken into account (Sparks and Shepherd, 1992; Rise et al., 2010). It is, therefore, quite legitimate to include this variable alongside TPB variables in the regression model and, quite unsurprising, that its inclusion increases model R2.

4.3 The finances of AF

The impact of any perceived belief about the poor financial performance of AF, according to TPB theory, should be mediated by the compound OA variable. It was precisely for the purpose of capturing any negative attitudes towards the financial viability of AF that the following statement was included among the OA measures: 'AF would make a positive contribution to my farm income once operational.'

The fact that this OA variable is non-significant in the regression model, and because we have no non-mediated financial perception variable separately expressed in the regression model, means that financial perceptions were not captured. This would be a major limitation, in view of the fact that negative attitudes towards the finances of AF have been identified, in several other studies, as a significant barrier to AF adoption (Burgess et al., 2017, Graves et al., 2017 and Valatin et al., 2016). This resonates with the statement of a respondent with a 100 ha general cropping farm who said: 'I can't see agroforestry working due to the long time between planting and the production of something saleable.' However, we can look outside of the TPB analysis for clues to the importance of this issue. First, farmers who do not intend to adopt areas of AF in the future identified low financial return as a key justification and, second, there is a strong opinion amongst the whole sample that adoption of AF will not make a positive contribution to farm profit and, at the same time, a very low ranking of the significance of the impact of this. It might also be suggested that the tenure variable discussed above is also, at least in part, acting as a proxy for negative financial attitudes in the regression model i.e. farmers with stronger non-profit motivations are more favourable to AF planting.

4.4 Other issues from the study to consider.

The survey results presented here provide no evidence that differences in farming goals have any influence over the intention to plant AF, primarily because farmers are not motivated by a single primary goal i.e. the majority have multiple goals, each of relatively high importance. If the data presented in Figure 6 reflect different farmers each weighting heavily just one farming goal, then the average rank scores would not be so high. This result is consistent with the findings of Gasson and Errington (1993) that farmers are multi-goal driven. The observation that farming goals are not a key driver of intention to plant AF supports the work of Doyle and Thomas (2000) and Valatin et al. (2016). This difference may be explained by the changing attitudes of farmers over time towards trees.

One finding of the study that is both intriguing and difficult to explain is that the farmers most likely to be willing to plant AF in the future are those farmers that already have AF on their farm. This is borne out by a respondent with a 480 ha mixed farm, who said they would plant-up 20 ha as: 'Farm woodlands are a very good idea especially on arable farms on appropriate land.' Could it be that these farmers are more familiar with the primarily non-monetary benefits of AF, such as landscape enhancement, windbreaks, flood control etc and so value them more? Or does this simply reflect the fact that farms with forestry or woodland have more marginal land than farms that don't have forestry? Does having once overcome the psychological barrier to turning food-producing land over to non-food producing uses make it easier to do it a second time? Or, does inheriting land with trees, alter the perception of what a good farmer does (i.e. they also manage trees)? Past studies shine a little light on this question e.g. Carruthers (1990) and Doyle and Thomas (2000).

4.5 How much AF would farmers adopt soon?

Our responding lowland farmers in England held a rather polarised view on planting woodland/AF in the future, with nearly 60% saying that they would consider it under the current policy environment. At the same time, 40% said they definitely would not plant. When the areas that survey farmers stated they might plant were raised to the level of two surveyed Government Office Regions, it was found that this would be 4.5% of the total farmed area.

4.6 What does the AF adopter look like?

From the study outcomes, we can characterise the farmer most likely to adopt AF as someone who is not a top financial performer, where the farm owner is a public body or charity, or where the farmer views the land as providing ecosystem services in addition to provisioning, where the decision-maker perceives their social referents to be in favour of AF planting or, more importantly, where some amongst them are themselves intending to plant AF and where the decision-maker believes that there are no technical obstacles to adoption. The finding that the attitudes of traditional landlords would not be against the planting of trees by their tenants, in contrast to the findings of Lawrence and Dandy (2014), suggests that the future AF adopter may no longer need to be a sole owner-occupier.

4.7 Methodological critique

The survey of farmers was carried out very carefully and followed all recommended procedures from the literature. All data entry was also double-checked. However, it is possible that the sample of respondents' bias towards larger farms could also bias their responses positively in favour of intention to adopt AF. For example, it is a reasonable assumption that larger farms are more likely to have 'spare' parcels of land which could be made available for AF and, also, larger farms are less likely to be labour-constrained as forestry management competes for labour with other activities on the farm. As a result, if this were the case, then the study estimates of likely future planting and farmer willingness to adopt AF, would likely be overestimated. However, several results from the survey analysis suggest that this is not the case. First, farm size was not found to be a significant determinant of intention to plant. Second, while there was some agreement that planting AF increased demands on farm labour, this was viewed by farmers as being an unimportant consideration, perhaps because of the perceived ease of hiring contractors to carry out forestry management operations.

5. Conclusions

The Committee on Climate Change (2020) recommended to the UK Government a suite of measures they should implement in order to meet their net-zero commitment by 2050; one of these was to increase tree cover from the current 13% of the total land area to 19% by an ambitious tree planting programme. Following an extensive consultation exercise amongst the farm and forestry sectors, in May 2021 the England Trees Action Plan was produced (HM Government, 2021). In the ETAP, the

Government commits to increasing the rate of tree planting in England to 30,000 ha per year by 2024 and will spend £500 million in this period to help achieve the target. Interestingly, HM Government (2021) stated that: ‘Agroforestry will also play an important role in delivering more trees on farms and in our landscape, improving climate resilience and encouraging more wildlife and biodiversity in our farming systems’. Realising that a number of barriers to farmers planting trees exist, as recommended by Lawrence and Dandy (2014), a series of planting grants are to be instituted as well as maintenance payments. In addition, improved advice and guidance on forestry matters will be provided. The latter are two ways that Valatin et al. (2016) suggested farmers and landowners could be ‘nudged’ to plant more trees. This study suggests that these measures will be only partially successful in addressing the barriers to the adoption of AF.

Farmers will likely welcome the introduction of establishment grants, but this study does not suggest that establishment cost is an important barrier and that this money would have been better spent enhancing revenue flows from the newly introduced AF, especially in the early years. Whilst annual maintenance grants will also be welcome, they are unlikely to do much to offset the widespread perception in the farming sector that replacing the production of food or feed with AF is likely to result in a high opportunity cost to society. The current study also does not support the long-held view that a lack of knowledge of forestry management operations, and inadequate sources of management advice, is another major barrier to AF adoption by farmers. Some of the key barriers identified in this study are not addressed in the above proposed support measures at all, for example, the widespread perception in the industry that putting forestry on good agricultural land is something that good farmers simply do not do. Based on these observations, the authors are not convinced that the current Government’s good intentions and measures to encourage farmers to adopt AF will be any more successful than those of the past.

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Appendix A. The socio-demographic variables used in the TPB regression analysis.

Variable name	Description of variable	Format
Q1_a	Total area farmed	Interval scale
RENTED	Has an area of rented land	Nominal (binary)
Q2_a	Specialist dairying	Nominal (binary)
Q2_b	Lowland sheep/cattle	Nominal (binary)
Q2_c	Cropping	Nominal (binary)
Q2_e	Mixed farming	Nominal (binary)
Q3_a	Full-time farmer	Nominal (binary)
Q5_a	Sole proprietorship	Nominal (binary)
Q5_b	Company	Nominal (binary)
Q5_c	Family partnership	Nominal (binary)
Q5_d	Other ownership arrangement	Nominal (binary)
Age	Respondent age	Interval scale
Q7_a	Formal agricultural education	Nominal (binary)
Q10	Proportion of income from non-ag sources (high/low)	Nominal (binary)
SUCCESSOR	An identified successor is present	Nominal (binary)
Q13_a	Member of agri-environment scheme	Nominal (binary)

Q15_a	Presence of existing woodland on farm	Nominal (binary)
Q16_a	Has local market opportunities for timber	Ordinal scale
Q16_b	Has local market opportunities for fuel wood	Ordinal scale
Q16_c	On-farm use for wood	Ordinal scale
Q16_d	On-farm use for timber	Ordinal scale
Q16_e	Shooting/recreational opportunities	Ordinal scale
Q32_ax	Respondent is profit maximiser	Ordinal scale
Q32_bx	Respondent seeking job satisfaction	Ordinal scale
Q32_cx	Respondent seeking to improve physical yields	Ordinal scale
Q32_dx	Respondent seeking high environmental standards	Ordinal scale
Q32_ex	Respondent seeking greater cost effectiveness	Ordinal scale
Q32_fx	Respondent wants to be seen as good farmer	Ordinal scale
Q32_gx	Respondents wants to maintain land in good condition	Ordinal scale
PROFIT	Farm is making an operating profit	Nominal (binary)
STILL_IN	Respondent believes they will still be farming in ten years	Nominal (binary)
OA_dir	Composite TPB variable – Outcome Attitudes – direct measurement	Interval scale
SN_I_dir	Composite TPB variable – Subjective Norms – Injunctive form – direct measurement	Interval scale
PBC	Composite TPB variable – Perceived Behavioural Control	Interval scale

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