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Farmers' Interest in Agricultural Technology and Organic Farming: Implications for AD Adoption and Sustainable Agriculture in the UK

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Abstract

We identify the factors that attract UK farmers towards a given technology, their interest in agricultural technology and their practice of organic farming. The implications of this on the adoption of anaerobic digestion (AD) in the UK and sustainable agriculture are also discussed. Farmers were contacted by means of online survey, aided by yellow pages directory, Natural England directory, Twitter and electronic mail. A total of 283 farmers participated in the survey. The Chi square test was used to check for relationships between the variables measured at 95% confidence level ($p<.05$). Relationship strength was measured by means of Cramer's V and Phi values. The results showed several significant relationships among variables, including relationship between interests in agricultural technology and gender, level of education, and farm size; between knowledge of what AD is and gender, level of education and farm size; between interest in AD and age; between willingness to invest in AD if it improved soil properties and farm ownership; and between organic farming practice and age, farm type and farm size. Results also showed a significant presence of female farmers, young farmers (< 30 years old), high level of education among UK farmers, and low level of organic farming practice. Areas for future research and recommendations based on the results are presented in the conclusion.

Keywords: Soil, Sustainable development, Agricultural intensification, Food security, Agricultural food policy

1. Introduction

Population growth and food security concerns have led to agricultural intensification in most parts of the world. The implication of this is an increased pressure on available land resource for agricultural and non-agricultural use, land degradation, loss of biodiversity, technological innovations to enhance agricultural production and provide alternative energy sources and promotion of more environmentally friendly practices like *organic farming*. Regardless of population growth and food security concerns, agricultural technology use is considered to be part of historic agricultural development (Stone 1998; Minten and Barrett 2008; Burgess and Morris 2009; Birthal 2013; Pamuk *et al*. 2014). The definition of agricultural technology in the context of this study is the application of science, engineering and management in the production of crops and animals (Burgess and Morris 2009).While pressure on land resources for agriculture have led to various soil conservation and land use management programmes and policies, the main issue facing agricultural technology innovations is their adoption. Pamuk *et al.* (2014) stated that the main component of most agricultural development schemes is promoting the adoption of innovations. They also reported that agricultural development in poor countries is linked to low level of agricultural technology innovation and adoption. Another issue that have been associated with the adoption of agricultural innovations is 'friendliness' of innovations. Harwood (2013) reported that most agricultural technologies are not peasant-friendly and the benefits of their use are mainly experienced in large capitalised farms.

The main aim for the use of technology in modern agriculture is to increase yield and the income of farmers (Stone 1988). Areas in agriculture that have attracted investment and

innovation in developing countries are irrigation and drainage, infrastructures, fertilizer application and institutions (Birthal 2013). In developed countries like the UK, agricultural innovations have been applied to several aspects of agriculture other than irrigation, fertilizer application and drainage. These include land use changes (Burgess and Morris 2009), pest control (Sharma *et al.* 2011), organic farming (Tiffin and Balcombe 2011) and farm monitoring (Purdy 2011). Innovations in the area of renewable energy like anaerobic digestion (AD) technology, have been extensively used in agriculture for energy generation, source of income and organic fertilizer in some parts of Europe and the Unites States but are not well adopted in the UK (Zglobisz *et al.* 2010). With organic farming, the main aim is to minimise the negative impacts of intensive conventional agricultural practices, and this idea has gained worldwide support, evidenced in the UK by the presence of EU and national legislation and policies promoting the practice (Hole *et al.* 2005; Reed 2009). However, organic food supply to the UK market still falls short of non-organic food supply, with a further 1.5% decrease in sales in 2012 (Soil Association 2013).

In this paper, we aim to identify the perception and main factors considered by UK farmers in adoption of agricultural technologies and organic farming, and the implication this may have on sustainable agriculture and AD development in the UK. The study therefore serves as an important document in the development of policies, legislation and incentives for AD adoption and sustainable agriculture in the UK. It will also illustrate how the demographics of farmers can influence the agricultural technology trajectory in the UK, thereby making the study relevant to policy makers, conservationists, investors and innovators in agricultural technology. Earlier, Tiffin and Balcombe (2011) tried to identify the determinants of technology use in organic farming and computer use among UK farmers using the Bayesian model averaging. While they used models to identify the determinants of technology use in organic farming and computer use, this study focused on direct results from a survey of farmers and subsequent statistical analysis of data.

2. Methodology

2.1 Study Area and Sample Size

The study was UK focused, covering England, Scotland, Northern Ireland and Wales. Figure

1 shows the approximate location of counties where participating farms are sited. The figure demonstrates a wide distribution of sample farms though with most located within England. Although the points on the map represent the approximate location of farms, not all farmers shared the county where their farms were located. Thus, the map represents only the location of farms where the respondent correctly answered a question pertaining to county location. While eight farmers completely skipped the question on county location, a further 45 wrongly provided answers like ‘UK’ or ‘n/a’, and some gave only country names.

283 farmers (from an invited sample of more than 500) completed the survey, which ran for four months in 2014. Their demographic information and other characteristics are presented in sub-section 3.1.

2.2 Data Collection and Measurements

An online questionnaire was designed based on qualitative data collected from structured interviews with 21 AD stakeholders in the UK. The procedure for the interviews and information on the stakeholders has been reported in Duruiheoma *et al.* (2014). This pilot study provided insight into relevant issues and aided the wording used in designing the questionnaire. The questionnaire consisted of both open and closed questions and the variables included are presented in Table 1.

A novel approach to surveying farmers was used. This involved the use of a yellow pages business directory for the UK, Natural England farms directory, e-mail and Twitter. The directories were used to search for names, contact details (telephone number and e-mail), and addresses of farms across the UK, while e-mail and Twitter were used to send out a survey link to farmers. The use of yellow pages is well recognised for farm surveys (Burton and Wilson 1999), but this study was not over-reliant on it. In order to use Twitter, a dedicated Twitter account was created and names of farms were searched through the Twitter page *'search option'*. Although the twitter account was originally intended to search for farm names, it also served as a *snow-balling* sampling method, because when one farm or farmer is followed on Twitter, followers of the farmer or farm appear as a suggestion to follow on the Twitter page labelled as *'who to follow'*. In other words, by following one farmer or farm, Twitter automatically suggest another farm or farmer to follow.

2.3 Data Analysis

The Chi-square test was used to check for relationship between independent and dependent variables, at 95% confidence level ($p<0.05$) using SPSS version 22.0 statistics software. The test is 2-sided (non-directional), and in each case the null hypothesis (Ho) states that there is no relationship between variables being tested, while the alternate hypothesis (Ha) states that there is a relationship. If the observed p was less than 0.05 the Ho was rejected and Ha accepted, and vice-versa. Phi and Cramer's V were used to measure the strength of relationships, while Fisher's test and Likelihood ratio were used to compare the p value to the rejection level when basic Chi Square assumptions were violated (Field 2009; Pallant 2013). Descriptive statistics and charts were used to present the distribution of results across variables.

Figure 1. Distribution of participating farms across the UK

2.4 Strengths and Limitations

The use of yellow pages for farmer surveys has come under criticism as it mainly contains commercial farms (Burton and Wilson 1999). The use of Twitter allowed inclusion of both commercial and small farmers. Small farmers in this context are those farmers that see farming as a 'life style' rather than a form of commercial business as described by Burton and Wilson (1999). Also the recruitment approach allowed for random sampling which strengthens the findings of this study. It also shows the importance of social media in conducting research. Finally, the method used was time saving, flexible, and encouraged farmer participation since the response rate increased when Twitter was used in recruiting farmers.

The main limitation of the study is that data flow could not be easily monitored. It was difficult to know which farm had participated since their names were not asked and questionnaires were not distributed face-to-face. Also, those farmers that skipped some questions would probably not have done so with face-to-face.

Table 1. Variables contained in survey questionnaire

Variables	Units
Independent variables	
Gender	1 'Male', 2 'Female'
Age	1 'Less than 30', 2 '30-40', 3 '41-50',4 '51-60', 5 '61-70', 6 'Above 70'
Farm type	1 'Arable', 2 'Livestock (dairy and meat)', 3 'Mixed (arable and livestock)', 4 'Horticulture', 5 'Other'
Education	1 'GCSE or equivalent', 2 'A levels or equivalent', 3 'Diploma', 4 'Degree', 5 'Postgraduate degree', 6 'Other'
Farm ownership	1 'Farm owner', 2 'Manager', 3 'Tenant', 4 'Other'
Farm size (in hectares)	1 'Less than 30ha', 2 '30-60ha', 3 '61-90ha', 4 'Above 90ha'
Farm topography	1 'Upland', 2 'Lowland'
Dependent variables	
Knowledge of what sustainable agriculture means	1 'Yes', 2 'No'
Practise organic farming	1 'Yes', 2 'No'
Overall interest in agricultural technologies	1 'Very low', 2 'Low', 3 'Medium', 4 'High', 5 'Very high'
Knowledge of what AD is	1 'Yes', 2 'No'
Interest in AD (only farmers who know what AD is)	1 'Yes', 2 'No'
Willingness to invest in AD if it improved soil properties (only farmers who know what AD is)	1 'Yes', 2 'No', 3 'Neither yes or no'
Factors considered in the use of a particular agricultural technology	1 'Affordability', 2 'Knowledge of its benefits', 3 'What other people say of the technology', 4 'Simplicity of the technology', 5 'Efficiency of the technology', 6 'availability of government support'

3. Results

3.1 Characteristics of Participants

The characteristics of the farmers and their farms are presented in Table 2.

The results show that more male farmers participated in the study than females (slightly over 2 to 1, with 195 males and 85 female farmers). Perhaps, the idea of female farmers being seen as 'invisible farmers' (Sachs 1983; cited in Riley 2009) is now phased out as the ratio of male to female farmers suggests a recognition of the role of female farmers in shaping the UK

agricultural sector. When the gender of farmers was compared to farm ownership, 48 female farmers (56.5% of total) said they owned their farms while 106 male farmers (54.6% of total) said the same. Since the results of the test showed significant relationship between farm ownership and gender (observed p=.042) and strength of this relationship was small to medium (Cramer's V= .171), it indicates that a higher proportion of female farmers are farm owners in the UK. Farm mangers was the second highest category, and had a higher percentage of male (20.1%) than female farmers (12.9%). A similar pattern occurred under 'tenant farmers'. The main groups identified for those indicating 'other' under farm ownership, were sons, daughters, and spouses of farmers.

Table 2. Characteristics of participant and percentage distribution

Variables	Options provided	Response percentage
Gender	Female	30.4%
	Male	69.6%
Age	Less than 30	21.9%
	30-40	22.9%
	41-50	24.4%
	51-60	20.8%
	61-70	9.3%
	Above 70	0.7%
Farm type	Arable	16.0%
	Livestock (dairy and meat)	42.3%
	Mixed (arable and livestock)	33.8%
	Horticulture	4.6%
	Other	13.5%
Level of education	GCSE or equivalent	8.4%
	A levels or Equivalent	9.1%
	Diploma	23.6%
	Degree	42.9%
	Postgraduate degree	12.4%
	Other	3.6%
Farm ownership	Owner	55.4%
	Manager	18.2%
	Tenant	11.1%
	Other	15.4%
Farm size	Less than 30ha	15.5%
	30-60ha	14.4%
	61-90ha	10.8%
	Above 90ha	59.4%
Farm topography	Upland	18.5%
	Lowland	81.5%

Age was fairly evenly distributed as seen in Table 2 except for the age groups '61-70' and 'above 70'. This might be expected as these two age groups would contain more retired

farmers, and they mainly owned their farms. An important observation was the percentage of those ‘under 30’ (21.9%). This age group was not exclusive to sons and daughters of farmers, as 39.3% of this group said they owned their farms, equalling the number of those that were within the ‘other’ ownership category. Age showed a significant relationship with farm ownership ($p< 0.0001$) and medium to large strength of association (Cramer’s V=.241) with older farmers being more likely to be owners. Thus, it is reasonable to expect a similar relationship in a wider sample of UK farmers.

The results revealed a high level of educational attainment amongst UK farmers, with up to 75% of the sample population having at least a diploma. This is a significant rise in educational attainment of UK farmers when compared to study carried out between 1995-6 which showed that only 36% of 196 UK farmers surveyed had a formal Higher/Further education qualification (Gasson 1998). The highest response on educational level was ‘degree’ at 42.9%. When this was compared with gender, results showed that 80.9% of female participants had at least a diploma or higher qualification, compared to 77.8% of male participants. Since the Chi-square test result also showed a significant relationship with a small to medium strength ($p=0.005$; Cramer’s V=.247) between gender and level of educational attainment, it is less likely that this relationship between gender and level of education among UK farmers happened by chance due to sampling. Distribution of educational level across age groups showed that those above 70 and those between ages 61-70 were least educated, while those under age group ‘41-50’ were most educated with 84.9% having at least a diploma. The relationship between level of education and age was also significant with observed $p=0.021$.

Livestock farms were the most common farm type in the sample, while horticulture was the least (Table 2). Farm type showed a significant relationship with farm size ($p < 0.0001$) and a medium to large relationship (Cramer’s V= .270). Unsurprisingly, arable farms had the largest farm sizes, with 87.2% being 61ha and higher, followed by mixed farms with 81.2%. Responses also showed that more than half (59.4%) of farms were above 90ha, exceeding the average UK farm size of 77ha as of June 2012 (DEFRA 2012). The vast majority of the farms surveyed (81.5%) were located on lowlands.

3.2 Analysis Pertaining To Sustainable Agriculture

When asked whether they knew what sustainable agriculture means 95.7% of participating farmers answered ‘yes’ and 4.3% ‘no’. Since participants were not asked to define sustainable agriculture this does not necessarily imply that the vast majority that said yes actually know what sustainable agriculture means but rather that they think they know. Responses were tested against the independent variables and no significant relationship was observed. Knowledge of what sustainable agriculture means was further tested with the practice of organic farming and again showed no significant relationship. However, organic farming practice did show a significant relationship with age, farm type and farm size (Figures, 2, 3 and 4 respectively). A total of 80.1% of responses indicated ‘no’ to organic farming practice, while 19.9% indicated ‘yes’.

Organic farming was significantly associated with age ($p<0.0001$) and the strength of

association was medium to large (Cramer's V=.350). The results reveal that organic farming was more common for participants aged 61-70 (53.8%), followed by 51-60 (29.8%). The practice was least common among participants older than 70 followed by those younger than 30.

Organic farming was also significantly associated with farm type ($p<0.0001$) with a small to medium strength of association (Cramer's V=.281). The highest percentage of 'yes' responses came from horticulture farmers (100%), while 'no' response was most common with arable farmers (97.4%). Organic farming was also more common with mixed farmers (22.8%) than livestock farmers (18.7%).

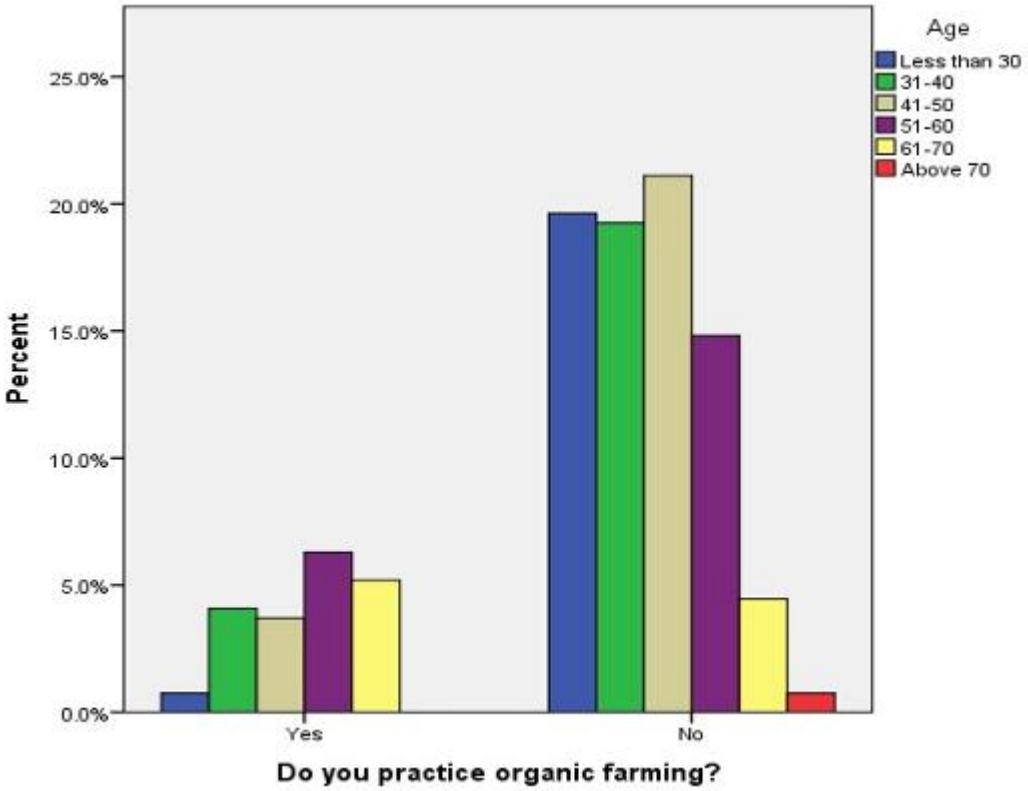

Figure 2. Distribution of organic farming practice across age groups

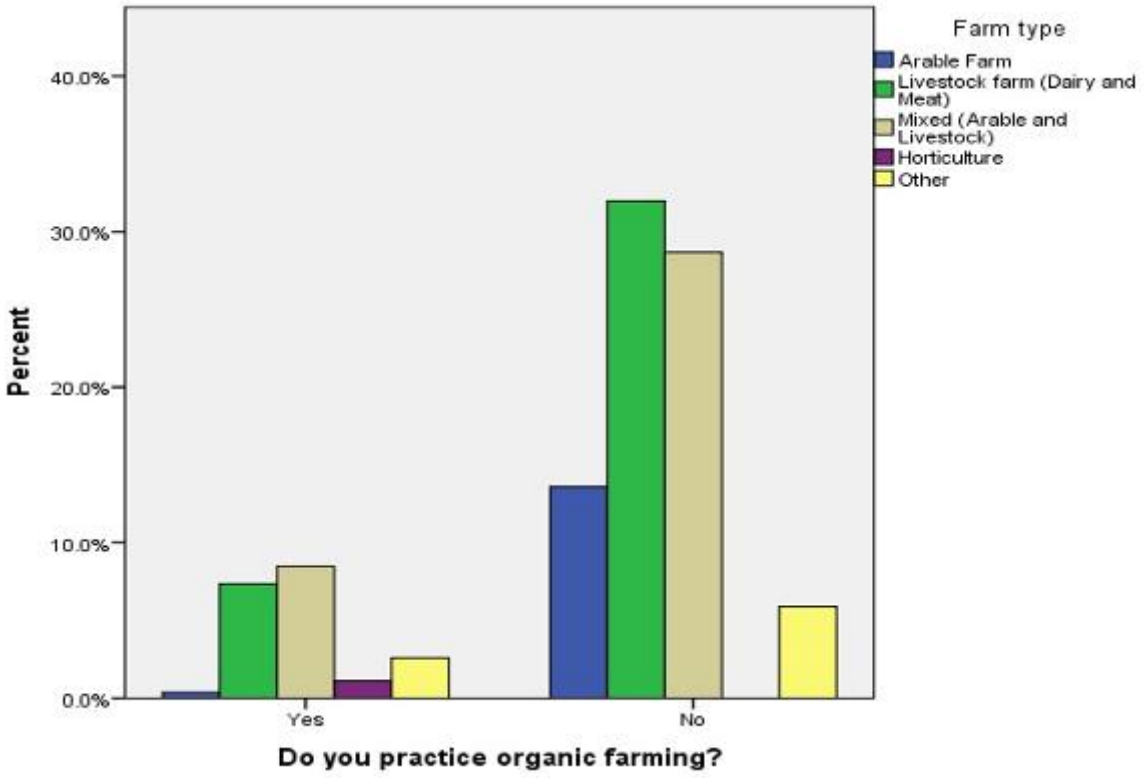

Figure 3. Distribution of organic farming practice across farm types

When tested against farm size, organic farming practice showed a significant association ($p<0.0001$) with small to medium strength (Cramer's V= .257). The results suggested that organic farm practice was more prevalent on smaller farms because the percentage of 'yes' responses decreased with increasing farm size.

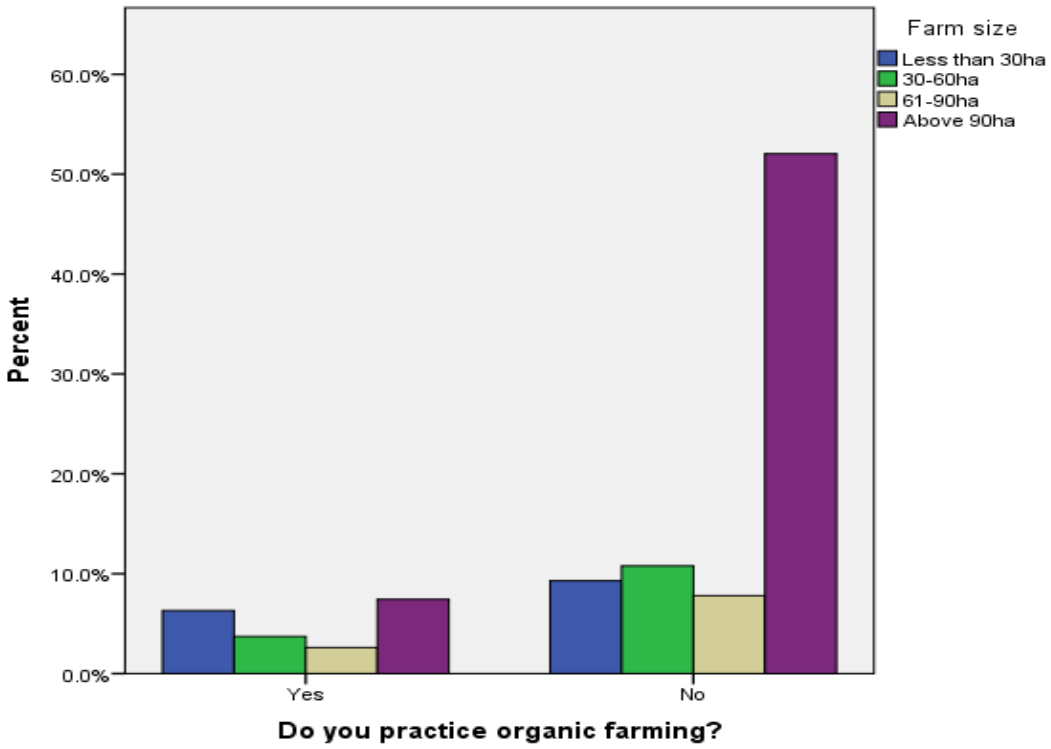

Figure 4. Distribution of organic farming practice across farm sizes

3.3 Analysis Pertaining To Agricultural Technology and AD

Figure 5 shows the overall interest in agricultural technologies among the sample of farmers. 47% indicated 'High' interest, while 23.9% and 24.4% said 'very high' and 'medium' respectively. Table 3 shows a significant relationship between overall interest in agricultural technology and gender, level of education and farm size.

The strength of association with gender is medium to large (Cramers' V=.310) and the distribution across gender showed that 80.6% of male farmers had either a high or very high interest compared to 51.4% in female farmers. So among UK farmers, we can expect a greater interest in agricultural technology in male than female farmers. With level of education, the strength of association is also medium to large (Cramer's V= .188). The distribution across level of education was without surprise because interest in agricultural technology increased with level of education with 75.9% of postgraduate degree holders indicating 'high' or 'very high' compared to 75%, 58.4% and 56.3% for those with degree, A level or equivalent and GCSE or equivalent respectively.

The value was highest for diploma holders with 80% indicating 'high' or 'very high' interest, and the reason for this is probably due to the higher percentage of male farmers with diploma than female farmers, recalling that male farmers showed higher interest in agricultural technologies than female farmers. Similarly, farm size showed a medium to large association (Cramer's V=.198) with interest in agricultural technology. The percentage of 'high' and 'very high' responses collectively increased with farm size, a finding with similarities to Harwood's (2013) report on the suitability of agricultural technologies with larger farms.

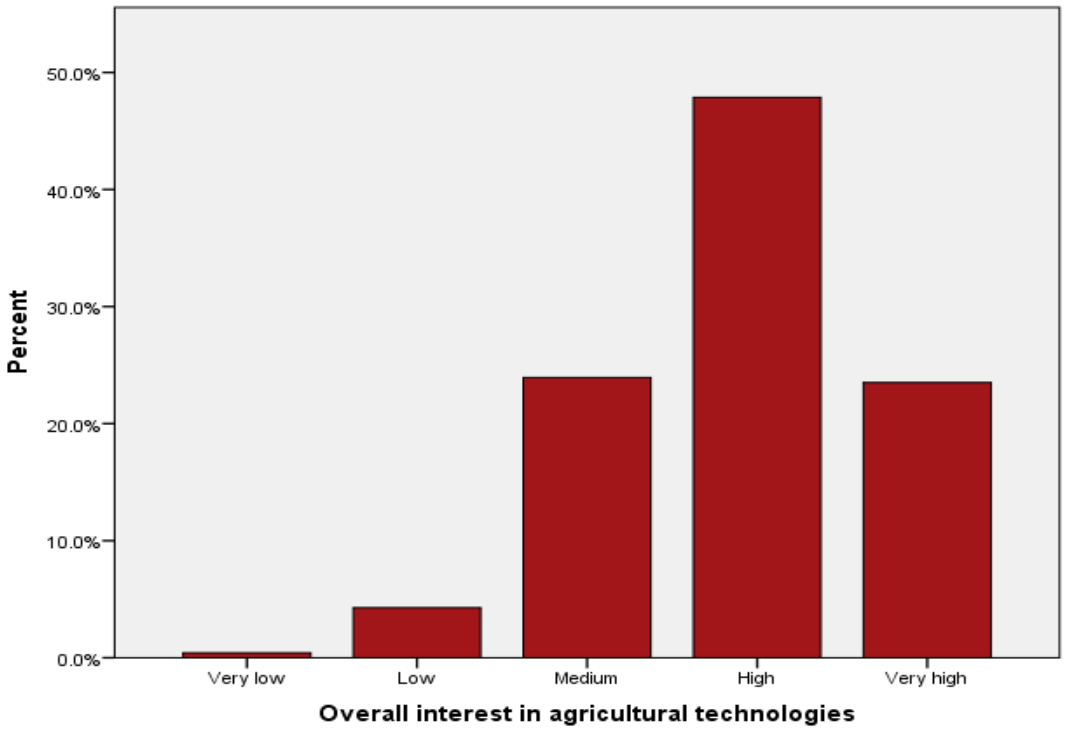

Figure 5. Participants' response on overall interest in agricultural technologies

Knowledge of what AD is also showed a significant relationship with gender, level of education and farm size (Table 3). The association strength with gender is small to medium (Phi=.185). More males (96.9%) had knowledge of what AD is than females (87.3%). Overall, 93.9% indicated 'yes' to knowing what AD is. This response does not exactly suggest that the farmers who said 'yes' know exactly what AD involves but rather that the farmers believe they have an idea of what it is. With respect to education, the strength of association was large (Cramer's V=.324). The percentage of those who said 'yes' increased progressively from GCSE or equivalent (75%) to diploma level (98.2%) and declined slightly but remained high at degree (97.9%) and postgraduate levels (93.1%). Association with farm size was small to medium and the percentage of 'yes' responses increased with farm size. This trend suggested a relationship between overall interest in agricultural technology and knowledge of what AD is, and test results revealed that there was indeed a significant relationship (p=0.027) with a small to medium strength of association (Cramer's V= .248).

The question on interest in AD was asked to only those farmers who said they had knowledge of what AD is. As seen in Table 3, only age shares a significant relationship with interest in AD, which had a small to medium strength (Cramer's V=.237). The distribution of responses showed that farmers older than 70 had the highest percentage of interest (100%) followed by those under 30 with 82.9%.

Similarly, the question on willingness to invest in AD if it improved soil properties was asked to only those farmers with knowledge of what AD is. 29.4% responded 'yes' while 22.5% and 48.2% respectively responded 'no' and 'neither yes or no'. Chi square test results showed a significant relationship between willingness to invest in AD if it improved soil properties and

farm ownership, with a small to medium strength of association (Cramer's V=.187). Farm mangers had the highest 'yes' response (50%), tenant farmers the highest 'no' response (32%) and those in the 'other' category of ownership the highest 'neither yes or no' response (52.9%).

Table 3. Observed p values for Chi square tests between independent and dependent variables pertaining to agricultural technology and AD

Independent / Dependent	Gender	Age	Farm type	Level of education	Farm ownership	Farm size
Overall interest in agricultural technologies	.0001*	.227	.285	.028*	.944	.003*
Knowledge of what AD is	.013*	.132	.113	.002*	.191	.001*
Interest in AD	.993	.036*	.107	.091	.095	.739
Willingness to invest in AD if it improved soil properties	.723	.162	.324	.851	.019*	.379

*significant relationship

3.4 Factors Influencing Technology Use by UK Farmers

Farmers were asked to select the factor(s) they considered before engaging in the use of a particular agricultural technology. The options provided and the percentage responses are shown in Table 4. The most common factor considered was affordability, followed by knowledge of its benefit, while the least common was what other people say of the technology.

Within gender (Figure 6), a slightly higher percentage of female farmers considered affordability of a technology than male farmers. The same was observed for other factors with exclusion of simplicity of the technology and efficiency of the technology where male farmers had a higher response percentage.

Table 4. Response summary to factors considered in the use of agricultural technology

Factors	Number of response	% of total response
Affordability of the technology	214	91.8%
Knowledge of its benefits	187	80.3%
What other people say of the technology	47	20.2%
Simplicity of the technology	97	41.5%
Efficiency of the technology	179	76.8%
Availability of government support	101	43.3%

The distribution of response across age groups is illustrated in Figure 7 where participants older than 70 had the highest percentage response on affordability (100%), followed by 'less than 30' and '61-70', both with 95.8%. Knowledge of its benefits' was the main consideration of those aged '51-60', and least considered by older than 70. 'What other people say of the technology' was the common choice for farmers under 30, while 'simplicity of the

technology' increased progressively in percentage response from the lowest to highest age group. Farmers older than 70 again had the highest percentage response for both 'efficiency of the technology' and 'availability of government support'.

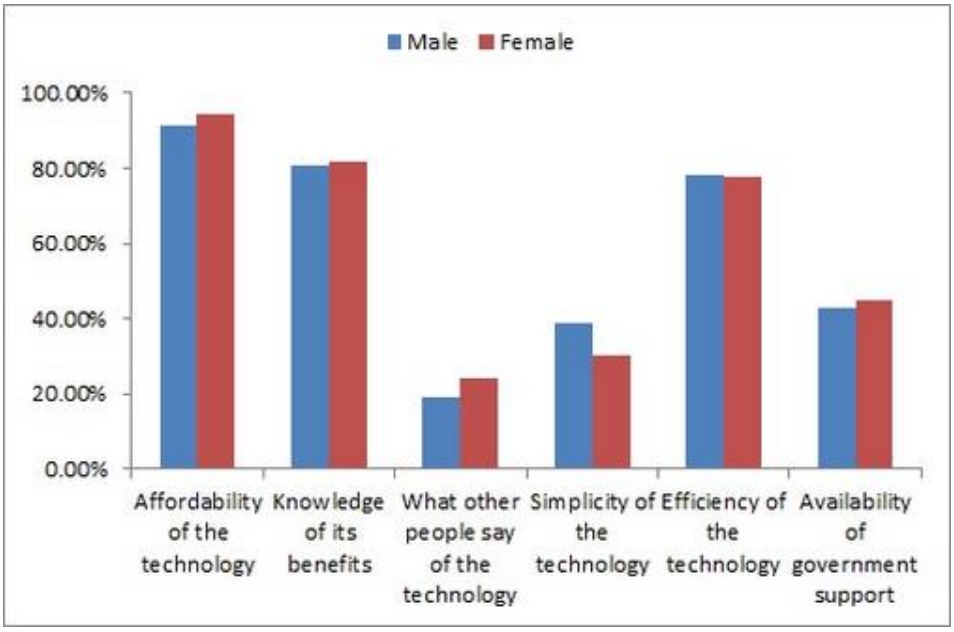

Figure 6. Percentage response distribution for factors considered in the use of agricultural technologies across gender

Across all factors provided horticultural farms had highest percentage response, significantly higher on the 'simplicity of the technology' as shown in (Figure 8). With education (Figure 9), farmers with a postgraduate degree considered 'affordability' and 'efficiency of a technology' more than other levels of education. 'Knowledge of its benefits' was jointly the highest response from farmers with A level or equivalent and degree.

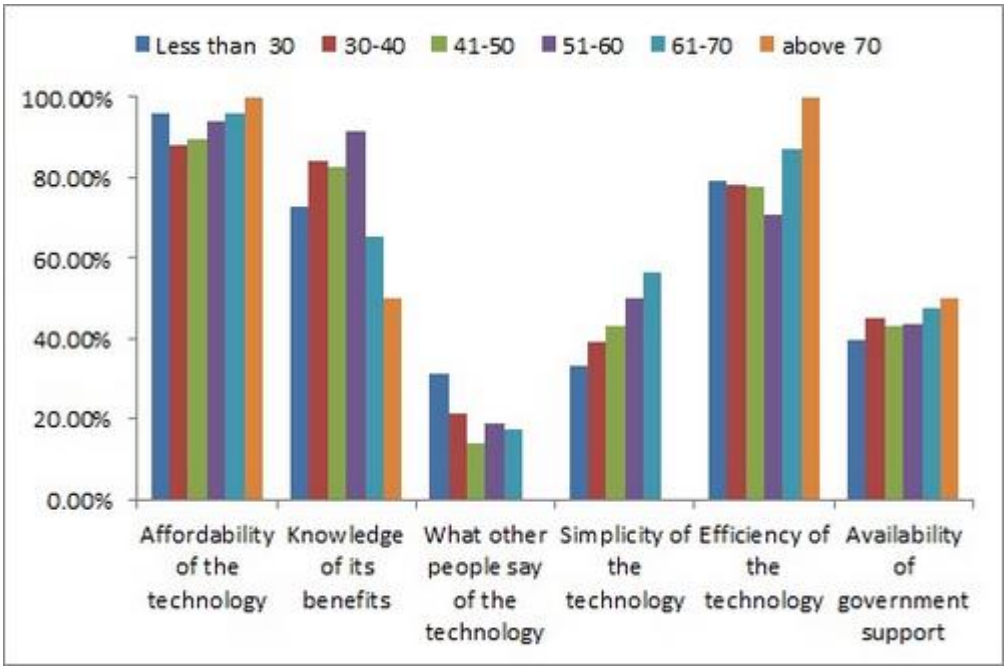

Figure 7. Percentage response distribution for factors considered in the use of agricultural technologies across age

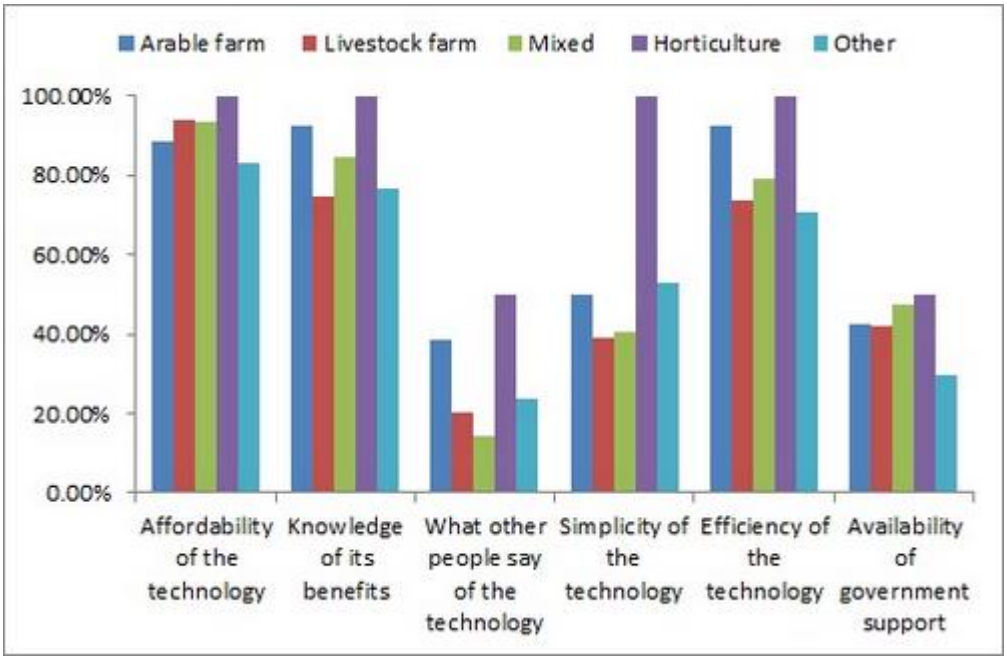

Figure 8. Percentage response distribution for factors considered in the use of agricultural technologies across farm type

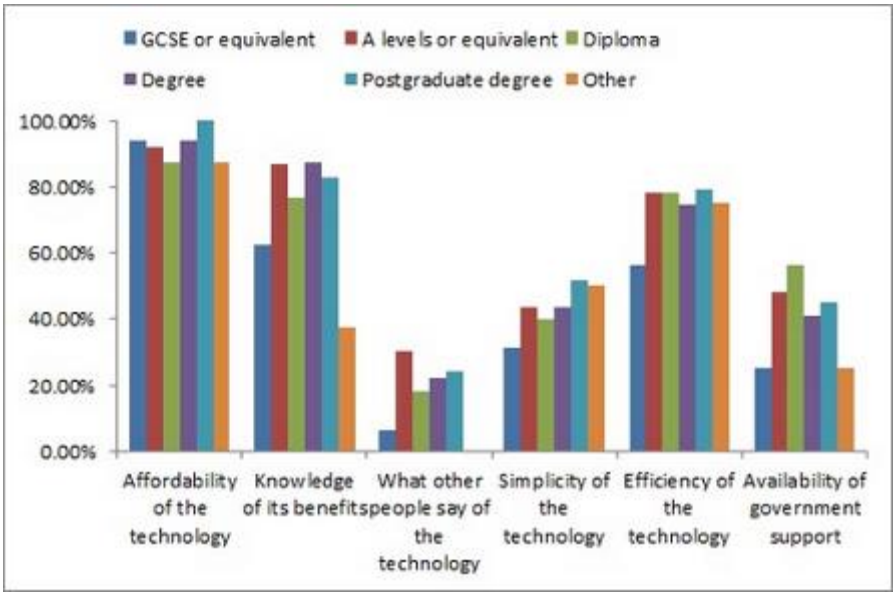

Figure 9. Percentage response distribution for factors considered in the use of agricultural technologies across levels of education

'What other people say of the technology' was mostly considered by farmers with A level or equivalent, while 'availability of government support' was mostly consider by farmers with diploma. The distribution of response across farm size is shown in Figure 10. Farm size between 30-60ha had highest response under 'affordability of the technology' and 'availability of government support', while 'knowledge of its benefits' had the highest response from farms between 61-90ha. The smallest farm size showed the highest response for 'what other people say of the technology' and 'simplicity of the technology'. Farm size above 90ha mostly considered 'efficiency of the technology' more than other farm sizes, and the response on this increased progressively with farm size as seen in (Figure 10).

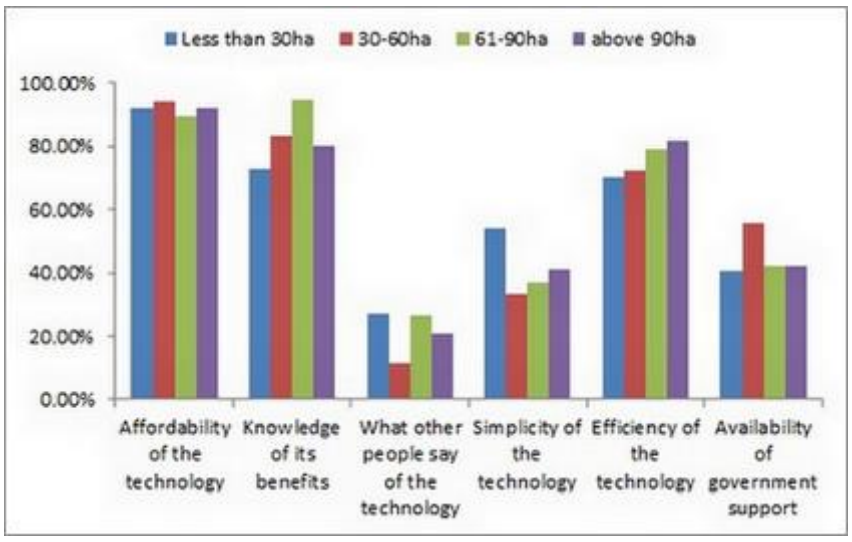

Figure 10. Percentage response distribution for factors considered in the use of agricultural technologies across farm sizes

4. Discussion

4.1 Implication of Findings for AD Adoption in the UK

Interest in agricultural technologies and the level of knowledge of what AD is suggests a high level of awareness of AD technology in the UK, however, existing literature indicates otherwise and this has been identified as one of the limitations to AD development in the UK (Zglobisz *et al.* 2010; Duruiheoma *et al.* 2014). This can also be an indicator that what the participating farmers actually know about AD might just be a general overview of what it involves. The number of those interested in AD on the other hand, suggests that what some of the participants knew of the technology was enough for them to be interested in it even though it remains under developed in the UK. Factors considered in the use of agricultural technologies sheds some light on the state of AD development in the UK and interest of farmers in the technology.

Affordability of a given technology was first in the list of factors considered by farmers in this study. Cost associated with AD plants has been identified as one of the generic limitations to its development (Zglobisz *et al.* 2010; Bywater 2011). Similarly, Sharma *et al.* (2011) broadly stated that the constraints with technological adoption are usually socio-economic in nature in their study of the determinants of technology adoption among UK cereal farmers. The second most popular factor considered by the farmers was knowledge of its benefits. AD technology has several benefits which include renewable energy generation, organic waste reduction, income source, and fertilizer option in the form of digestate. Whether farmers are aware of these benefits is unknown since no question pertaining to this was asked, but results suggest not. The response on willingness to invest in AD if it improved soil properties supports the call for raising awareness of the benefits of AD (Duruiheoma *et al.* 2014) since only 29.4% of the sample indicated ‘yes’ to this factor. The third most considered factor, efficiency of the technology, also supports the importance of educating UK farmers on AD.

Of the three factors considered least important by farmers, availability of government support comes first. The importance of government support in the development of any technology cannot be overemphasised. Support can take the form of incentives, financing options, standardization, and the use of appropriate legislation to promote technology adoption (Purdy 2011). Although there are incentives for renewable energy generation from AD in the UK such as the feed-in-tariff (FiT) and renewable heat incentive (RHI), they have come under criticism in view of their suitability for larger-scale generation (REA 2013), thereby discouraging the development of smaller plants. Response to simplicity of technology as a factor, suggest that some farmers will prefer portable and easy to operate technology, making small AD plants more relevant for AD development in the UK. The factor least considered in the use of agricultural technology is what other people say of the technology. Even though this has the lowest percentage, it suggests of that networking between technology users, in this case AD plant owners, and non-users might be beneficial increasing adoption.

4.2 Implication of Findings on Sustainable Agriculture in the UK

Results of this study suggest a general 'awareness' of the concept of *sustainable agriculture* amongst UK farmers, however interpretations of this concept may vary significantly in practice. Cobb *et al.* (1999) called for a wider interpretation of farming systems and property rights, both of which were considered to be limitations to sustainable agriculture in the UK. Even though the concept of sustainable agriculture is quite complex and requires an interdisciplinary approach to its understanding and interpretation (Harris *et al.* 2008), a key message of sustainable agriculture is that; it requires farmers to consider the long-run effect of their practices and how this may interact with the dynamics of agricultural systems (Ogaji 2005). One of the main practices viewed as sustainable in modern agriculture is organic farming, and some believe both are synonymous (Rigby and Caceres 2001). This type of farming requires less to zero inorganic input for crop and animal production, soil nutrient replenishment, pest control and other aspects of agricultural production (Lampkin 2002).

The results on organic farming practice did not conform to expectations based on the level of awareness of sustainable agriculture. The relationship existing between organic farming practice and age, farm type and farm size makes the basis for the arguments made here. With age, the low level of organic farming practice especially within the group younger than 30 and between 30-40 raises concern on the sustainability of the UK's agriculture. Gorp and Goot (2012) identified the importance of the younger generation in promoting and having a positive attitude towards sustainable agriculture. Even though these results are not positive for the future of UK's agriculture, the relationship between age and organic farming is expected, since an earlier study showed that the probability of adopting organic practice increases by 0.03 per cent for every year increase in age (Tiffin and Balcombe 2011).

In terms of farm type, horticultural producers showed the highest percentage of organic farm practice compared to other types. The results conform to the findings of Tiffin and Balcombe (2011) as they also observed that organic farming was more common with horticultural farmers. They further suggested that the main determinants in adopting organic farming based on their model approach were beliefs of the farmer, their gender and source of information. Although the source of information participant farmers have on organic farming was not asked, there was no significant relationship with gender. Perhaps the belief of farmers was the main influencing factor from the study population in the practice of organic farming. The prevalence of horticultural farmers in farms less than 30ha and arable farmers on farms larger than 90ha, account for the relationship observed between organic farm practice and farm size. The concerning part of this relationship is that, since the vast majority of farms surveyed were large (70.2% were 61ha or more), the long-term negative impact of inorganic or conventional farming systems in the UK is inevitable.

Communication between farmers, policy makers and conservationists is vital for the sustainability of agricultural production (Schoon and Grotenhuis 2000; Ingram 2008; Glenna *et al.* 2011). The main reason for this is to continually update farmers on the new skills needed to meet the demands of sustainable agriculture (Ingram 2008). Communication therefore, offers opportunity for improved sustainable agricultural practices in the UK. For

example, since farmers between ages '61-70' practice organic farming more, they can communicate the benefits to younger farmers though focus group meetings and other similar farming forums.

5. Conclusion

This paper identifies the various factors that affect the use of agricultural technology by UK farmers and organic farming, and how this affects AD adoption and sustainable agriculture in the UK. Overall there is a high level of educational attainment among the farmers surveyed and a high level of interest in agricultural technologies. Interest in agricultural technologies was higher among male farmers, and increased with both level of education and farm size. Large farm sizes dominated the survey, and there was a significant presence of female farmers and young farmers. Farm ownership was more common than other forms of involvement, and livestock farms were more common than any other type.

Sustainable agriculture is a popular concept for most of the farmers, but sustainable agricultural practices, such as organic farming, were not as common. This leaves the question of what aspect of sustainable agriculture UK farmers are active in. There is clearly not much concern on the impact inorganic inputs from their agricultural practice has on the environment, not just because of the low number of those who practice organic farming but also, the number of those willing to invest in AD if it improved soil properties. Affordability, knowledge of the benefits, and efficiency of a technology were the top three factors considered by farmers. These are therefore recommended as key areas in which to focus the promotion of AD technology in the UK, however factors such as 'availability of government support' should not be ignored.

The work reported here serves as a useful guide in promoting the adoption of AD in the UK as well as other sustainable agricultural technologies. It also identifies areas for future research, particularly on sustainable agricultural practices in the UK and how these embraces sustainable development goals, the perception of farmers on soils as a vital component of the environment and how policies and legislation can promote sustainable agriculture and soil conservation in the UK.

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