Land Use Policy 126 (2023) 106467

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Did policy lose sight of the wood for the trees? An UTAUT-based partial least squares estimation of farmers acceptance of innovative sustainable land use systems

Verena Otter [a,*], Maximilian Deutsch [b]

[a] *Business Management & Organisation Group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, the Netherlands*
[b] *Agribusiness Management, Department of Agricultural Economics and Rural Development, University of Goettingen, Platz der Goettinger Sieben 5, 37073 Goettingen, Germany*

ARTICLE INFO

Keywords:
Alley cropping
Sustainable land use
Innovation acceptance
Unified theory of acceptance and use of technology (UTAUT)
Partial least squares estimation
Germany

ABSTRACT

The ongoing EU-wide public debate on sustainability concerns is increasingly reflected in policy programs at both supranational (e.g. the EU green deal), and national levels (e.g. the German climate protection program of 2030). As part of these programs, measures for improving the ecological sustainability of food production play a central role and require the wider implementation of innovative land use systems. Alley cropping agroforestry systems are one example that could, according to recent scientific literature, make an important contribution to resolving the trade-off between economic and ecological sustainability in sparsely forested EU countries such as Germany. However, even today these systems show limited dissemination in agricultural practice, exposing a lack of knowledge about farmers' profit and subsidy expectations and their main behavioral acceptance drivers in the current political situation. This study aims to close this gap in two ways. Firstly, it assesses farmers' expectations of economic benefits from planting alley cropping agroforestry systems, and offsets them against national taxpayers' willingness to pay an annual tax for these systems. Secondly, it quantifies the influence of psycho-social factors that drive farmers to accept alley cropping agroforestry systems as part of their cultivation program. It does this through the empirical application of a case-specific model based on the Unified Theory of Acceptance and Use of Technology. Data on farmers' economic expectations and model constructs were generated during a quantitative survey of 209 farmers in Germany and analyzed using descriptive statistics and partial least squares structural equation modeling technique. The descriptive results demonstrate a general rejection of alley cropping agroforestry systems and a low intention to implement them. Farmers prefer subsidy programs to the sale of wooden components as sources of economic benefit, expecting a yearly support of €512 (~ 606US$) per hectare. Results from the partial least squares analysis show the positive influence of performance expectancy, attitude, and facilitating conditions on the behavioral intention to use an alley cropping agroforestry system, with the latter exerting a positive influence on the final use behavior. Entrepreneurial planning and intuition appear to influence some of the acceptance factors. The results suggest a wide range of implications for policy makers, advocacy groups, and farmers, proposing a focus on creating favorable conditions and positive attitudes among farmers in order to increase agroforestry dissemination.

1. Introduction

The public debate on ecological sustainability and climate change has gained significant EU-wide momentum in recent years. Not only common policy programs such as the Green Deal of the European Commission (European Commission, 2019a), but also national ones, such as the Climate Protection Program 2030 of the German Federal Government (BMU, 2019), acknowledge sustainability concerns raised by society. These concerns often target the food industry. For the agricultural sector in particular, corresponding political measures aim to increase dissemination of innovative sustainable land use systems such as conservation agriculture, Climate-Smart Agriculture, or agroforestry systems (van Noordwijk et al., 2018; Long et al., 2016; Pisante et al., 2015; Neufeldt et al., 2013). Besides their core function of food or

* Corresponding author.
E-mail addresses: verena.otter@wur.nl (V. Otter), maximilian.deutsch@agr.uni-goettingen.de (M. Deutsch).

https://doi.org/10.1016/j.landusepol.2022.106467
Received 29 December 2020; Received in revised form 21 October 2021; Accepted 17 November 2022
Available online 13 January 2023

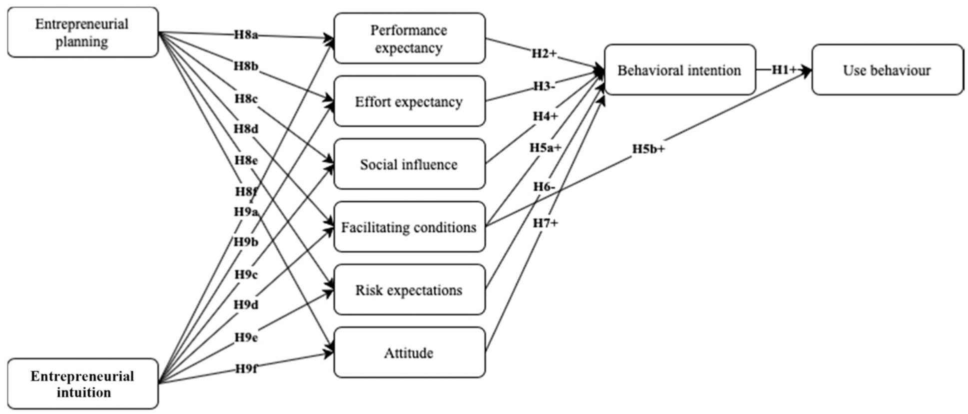

Fig. 1. UTAUT – based research model with hypotheses for determining farmers' acceptance of alley-cropping agroforestry systems.
Source: authors' own graphic adapted from Venkatesh et al. (2003), boxes: hypothetical constructs; arrows: hypothesized causal relationships.

biomass production, such systems offer additional regulating and supporting ecosystem services including nutrient stabilization, CO^2 capturing, soil improvement, and increased biodiversity (Pisante et al., 2015; Neufeldt et al., 2013). Research shows that sustainable land use systems are advantageous for farmers, sustainability, and climate when compared to conventional land use systems (van Noordwijk et al., 2018; Long et al., 2016; Neufeldt et al., 2013). Nevertheless, dissemination of sustainable land use systems still remains limited in practical agriculture (Senyolo et al., 2018; Long et al., 2016; Knowler und Bradshaw, 2007; Pannell, 2003). Alley-cropping agroforestry systems (AFS) are one of these systems proposed and acknowledged with an increase in subsidies as part of the aforementioned programs (BMU, 2019). EU Common Agricultural Policy (CAP) plans for the post 2020 funding period highlight the importance of agroforestry systems, but provide huge flexibility in defining the allocation of funds for measures to the member states as part of their strategic plans (European Commission, 2019b). Yet the question arises of whether European policy lost sight of the wood for the trees, in designing effective measures for increasing the dissemination of innovative land use systems in order to achieve its sustainability goals.

AFS are combined production systems of arable crops and agricultural wood in the shape of tree strips on the same plot (Baerwolff et al., 2011). They are widely recognized in society, politics and by scientists as causing improvements in soil and water quality and decreases in CO2 and pollution levels through sustainably produced biomass (European Commission, 2019a; BMU, 2019; Otter and Langenberg, 2020; Tarlé Pissarra et al., 2021). As for many other sustainable land use systems, AFS remain rarely implemented on farm in the EU, despite their potential to reconcile stakeholders' sustainability interests. AFS constitute only 0.1% of the total territorial area of the European Union, which for most parts is explained by traditional land use systems in southern EU countries such as Spain, Italy or Portugal, the dissemination of innovative AFS is mostly restricted to private and governmental trial fields in other EU countries (FNR, 2020; den Herder et al., 2017; Baerwolff et al., 2011; Herzog, 2011). In Germany, one of the EU countries with sparsely forested regions (den Herder et al., 2017), their scope is still limited to only a few trial plots (FNR, 2020; Baerwolff et al., 2011), although AFS have the potential to resolve the trade-offs between agricultural production, sustainability, and climate protection measures by providing an additional income and risk diversification option for farmers (Langenberg et al., 2018; Kröber et al., 2008). One reason for the scarcity of AFS may be that they require great investment in time, knowledge, and equipment, as well as procedural changes to the farm; another may be uncertainty about the possible economic and ecological returns (Otter and Beer, 2021; Langenberg et al., 2018; Tsonkova et al., 2018; Borremans et al., 2016; Baerwolff et al., 2011; Zehlius-Eckert, 2010; Gruenewald, 2005).

AFS represent a typical case for the dissemination dilemma of innovative sustainable land use systems providing regulating and supporting ecosystem services, but research on farmers' acceptance of AFS is scarce (e.g. Otter and Beer, 2021; Beer et al., 2018; Borremans et al., 2016; Warren et al., 2016; Jonsson et al., 2011). The few existing studies have shown that apart from financial and legal factors, social and behavioral economic factors also play a decisive role in farmers' acceptance. Nevertheless, these studies concentrate on short-rotation coppice or agricultural wood adoption from a more general viewpoint (Beer et al., 2018; Warren et al., 2016). They consider AFS only as an ecological focus area in the Common Agricultural Policy of the European Union (Otter and Beer, 2021) or have a strong qualitative focus on financial and legal barriers (Tsonkova et al., 2018). This leaves open the actual influence of different social and behavioral acceptance factors on farmers' intentions to implement sustainable land use systems and their expectations of benefits. Thus, key aspects that might help explain farmers' low acceptance of sustainable land use systems and their resulting failure to develop effective policy measures remain unexamined.

To close the research gap, this study has two objectives. Firstly, it assesses farmers' expectations of economic benefits from planting alley cropping agroforestry systems, and offsets them against national taxpayers' willingness to pay an annual tax for these systems. Secondly, it quantifies the influence of psycho-social factors that drive farmers to accept alley cropping agroforestry systems as part of their cultivation program. It does this through the empirical application of a case-specific model based on the Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh et al. (2003). To provide a comprehensive view of the influences on farmers' AFS acceptance factors, we expanded the model by including risk expectations and attitude as well as entrepreneurial planning and intentions, as proposed by Dwivedi et al. (2019), Beer (2019), Schlaegel and Koenig (2014) and McGee et al. (2009). Empirical results are based on descriptive statistics and partial least square (PLS) estimation of quantitative survey data collected from 209 farmers in Germany from November 2019 to January 2020. By investigating acceptance factors and proposing targeted measures, the findings contribute to public debate about sustainable farm practices and the further propagation of AFS, and help policy makers, scientists, agricultural advisors, NGOs, and farmers to take elaborate decisions about AFS.

2. Materials and Methods

2.1. Conceptual framework

Due to the high levels and long duration of investment, along with the challenges associated with the new farming practice, implementing an AFS involves far-reaching changes for farms and a complex decision making process based on a variety of factors. In order to capture these factors, this study utilizes an extended version of the exploratory Unified Theory of Acceptance and Use of Technology (UTAUT) model by Venkatesh et al. (2003) (Fig. 1). The UTAUT expands previous research and findings from several other acceptance research models such as Ajzen's (1991) Theory of Planned Behavior (TPB) and Davis's (1989) Technology Acceptance Model (TAM), combining them in a comprehensive approach to explain and predict the acceptance of new technologies. Innovative sustainable land use systems like AFS share several similarities with new technologies. Both require a change of behavior and upfront investments in knowledge and equipment and carry uncertainty about future returns (Chouinard et al., 2008). These features make the UTAUT model well-suited to the agricultural context (e.g. Michels et al., 2019; Wellner et al., 2019; Alemu and Negash, 2015; Trozzo et al., 2014). Compared to the TAM2 model, that was applied in an earlier study by Otter and Beer (2021), UTAUT uses broader definitions of performance and effort expectancy and incorporates the social, technical and knowledge environment. This creates an even more comprehensive model with a higher degree of explanatory power (R^2) that allows for the derivation of more specific recommendations (Dwivedi et al., 2011; Venkatesh et al., 2003). The comprehensiveness is reflected in the UTAUT-model by assuming that the constructs *performance expectancy*, *effort expectancy, social influence,* and *facilitating conditions* have an effect on the *behavioral intention* to implement an innovation. Subsequently, *behavioral intention* and *facilitating conditions* influence the *use behavior* of an innovation (Venkatesh et al., 2003). As previous studies have shown, *attitude*, *facilitating conditions,* and *risk expectations* play an important role in the process of adopting sustainable land use systems, due to their significant behavioral influence (Lemken et al., 2017; Trozzo et al., 2014; Pattanayak et al., 2003). Based on proposed enhancements of the original UTAUT model (Dwivedi et al., 2019; Slade et al., 2015), a direct influence of these constructs on the behavioral intention was added to the framework of this study. Since ex ante tests of the research model have shown no significant effects of the moderators used in the original UTAUT model (age, gender, experience, and voluntariness of use) they were not included in the final research model.

As in the original model, and with the support of existing research (Otter and Beer, 2021; van Dijk et al., 2016), we assume that the *behavioral intention* to implement sustainable land use systems such as AFS influences *use behavior* positively (**H1 +**). The multidimensional, long-term changes they imply for the farm and the farmer can be better realized and maintained with a positive mindset towards implementation (Venkatesh et al., 2003; Sheppard et al., 1988). *Behavioral intention* is influenced by *performance* expectancy, *effort expectancy*, *social influence*, *facilitating conditions*, *risk expect*ations, and *attitude*. *Performance expectancy* describes farmers' expectations of benefits from implementing a sustainable land use system like AFS on their farm. Such benefits can stem from direct effects such as an increased or diversified income (Langenberg et al., 2018; Kröber et al., 2008), or from indirect effects of regulating and supporting ecosystem services, e.g. a reduction of nitrate leeching and soil erosion in combination with a higher utilization of soil water capacity (Zehlius-Eckert, 2010; Gruenewald, 2005). As farmers strive to maximize the benefits for their farm when choosing between land use alternatives, previous studies have identified *performance expectancy* as the strongest determinant of *behavioral intention* (Trujillo--Barrera et al., 2016; Venkatesh et al., 2003; Morris and Venkatesh, 2000). This leads to the hypothesis that *performance expectancy* positively influences the *behavioral intention* to implement AFS (**H2 +**). *Effort expectancy* describes the effort a farmer expects from implementing and maintaining a sustainable land use system, covering financial and time aspects that are usually higher at the start of using a new system and decrease over time (Hardesty and Leff, 2010; Venkatesh and Morris, 2000; Verhaegen and van Huylenbroeck 2001). For example, farmers might not only expect an increase in operating costs for maintaining the tree strips of an AFS, but also a reduction in economies of scale and negative yield effects on the main crop due to light, nutrient, and water competition, especially at the edge between main crop and tree strip (Gruenewald, 2005). As these aspects contradict a farmer's goal of maximizing benefits, and thus act as deterrents to implementation, we can hypothesize that *effort expectancy* negatively influences the *behavioral intention* (**H3-**). The influence of friends, family, and colleagues on the *behavioral intention* is summarized as *social influence*, acting as a normative foundation for behavior based on the goals of social desirability and knowledge transfer (Boerger, 2012; Kuczera, 2006). Venkatesh and Davis (2000) have shown that the effect of *social influence* decreases with greater user experience with a new technology. Since sustainable land use systems with additional regulating and supporting ecosystem services are not widespread, farm colleagues' experience with similar systems can affect the behavioral intention positively; a farmer can benefit from their peers' experience, reducing uncertainties usually associated with the implementation of new crops such as the tree strips as part of an AFS (Otter and Beer, 2021; Trozzo et al., 2014; Foster and Rosenzweig, 1995). Thus, it is hypothesized that *social influence* has a positive effect on the *behavioral intention* to implement an AFS (**H4 +**).

Facilitating conditions describe to what extent an individual perceives the availability of a technical and organizational environment as supportive of a new technology. Such a supportive environment is considered an important prerequisite to implement a new technology (Venkatesh et al., 2012) and includes the equipment for the implementation, maintenance, and harvest of an AFS which is in agricultural practice often very limited in availability (Jonsson et al., 2011). *Facilitating conditions* such as access to special machinery either on the farm or at a suitably equipped contractor are hypothesized to positively influence the *intention* to implement (**H5a+**) an AFS as well as the actual *use behavior* (**H5b+**) an AFS. *Risk expectations* are feelings of anxiety about the potentially negative results of a behavior (Mandrik and Bao, 2005). Previous studies have shown significant, and mostly negative effects of risk expectations on the *behavioral intention* (e.g. Slade et al., 2015; Luo et al., 2010; Schaupp et al., 2010). Implementing an AFS is a long-term investment in a novel farming practice with uncertain and unevenly distributed cash-flows (Langenberg and Theuvsen, 2018), possibly leading to a negative economic result. Most of the literature describes farmers as risk-averse decision-makers (Maart-Noelck and Mußhoff, 2014), and AFS are considered suitable for risk-neutral and risk-averse farmers depending on the cultivation site (Langenberg and Theuvsen, 2018). As the intention to accept a technology decreases with growing *risk expectations* (Slade et al., 2015), it is hypothesized that *risk expectations* has a negative influence on the *behavioral intention* (**H6-**). *Attitude*, meaning an individual's mentality towards performing a behavior, has been widely acknowledged to have an influence on the intention to implement both, new technologies (e.g. Kim et al., 2009; Yang and Yoo, 2004; Bobbitt and Dabholkar, 2001) and new land use systems and methods (e.g. Faridi et al., 2020; Beer et al., 2018; Lemken et al., 2017; Borremans et al., 2016, Warren et al., 2016; Jonsson et al., 2011). *Attitude* symbolizes the intrinsic motivation that complements extrinsic motivations, such as expected performance and effort, and facilitating conditions to influence a farmer's intention to establish a sustainable land use system (e.g. AFS). Whatever the potential benefits comprise, implementation is unlikely to happen against a contrary mentality (Bopp et al., 2019; Dwivedi et al., 2019; Lemken et al., 2017; Borremans et al., 2016; Greiner and Gregg, 2011; Shin, 2009). This suggests the hypothesis that *attitude* positively influences the *behavioral intention* to implement an AFS (**H7 +**).

In addition, we propose that the exploratory constructs *entrepreneurial planning* and *entrepreneurial intuition* have an influence on the previously mentioned acceptance factors. With this conceptual extension we are seeking to achieve a better understanding of whether and how these character traits influence the acceptance process for sustainable land use systems, possibly allowing for more targeted policy recommendations. *Planning* (e.g., setting up a business plan) and *intuition* (formed by experience of doing business) are considered the two sides of entrepreneurial thinking that may shape investment

Table 1
Sample description compared to Germany's agricultural structure *Source*: Author's calculations based on own data, DESTATIS (2019), and German Farmers' Federation (2019).

Variable	Description	Sample: Absolute frequency	Sample: Relative frequency (%)	German agricultural structure: Relative frequency (%)
Gender	Male	176	84,2	90.4
	Female	33	15,8	9.6
Age	Under 25	33	15,8	7.7
	25–34	63	30,1	14
	35–44	33	15,8	16.4
	45–54	34	16,3	28.3
	Older than 55	46	22,0	33.6
Education	Secondary school leaving certificate	3	1,4	n.a.
	Secondary school degree	4	1,9	n.a.
	A level	29	13,9	n.a.
	Vocational degree	5	2,4	n.a.
	Foreman/technician	47	22,5	n.a.
	Technical College	38	18,2	n.a.
	University	83	39,7	n.a.
North	Bremen, Hamburg, Lower Saxony, Schleswig-Holstein	40	19,1	18.4
East	Berlin, Brandenburg, Mecklenburg Western Pomerania, Saxony, Saxony-Anhalt, Thuringia	53	25,4	9.3
West	North Rhine-Westphalia, Saarland, Hesse, Rhineland-Palatinate	60	28,7	24.8
South	Baden-Württemberg, Bavaria	56	26,8	47.5
Farm management	Conventional	167	79,9	88.0
	Organic	42	20,1	12.0
Farm size	Less than 10 ha	6	2,9	2.2
	10–19 ha	7	3,3	4.8
	20–49 ha	21	10,0	12.5
	50–99 ha	36	17,2	19.2
	100–199 ha	50	23,9	20.5
	200–499 ha	43	20,6	16.0
	500–1000 ha	24	11,5	10.1
	More than 1000 ha	22	10,5	14.7

expectations from using a new technology (Dias et al., 2019; Blume and Covin, 2011; Kickul et al., 2009; McGee et al., 2009; La Pira and Gillin, 2006; Allinson et al., 2000). In most cases, sustainable land use systems with additional regulating and supporting ecosystem services constitute a major and uncertain investment of time and money, either through the opportunity costs attached to choosing one land use system over another, or by expenditures for training, machinery, plants, and labor (Lipper et al., 2014; Greiner and Gregg, 2011; Pannell, 2003). A farmer who has made a detailed investment plan may have different expectations of performance, effort, or risk from the implementation of sustainable land use systems such as AFS on their farm, and consequently a different *behavioral intention* than farmers with less detailed planning. Intuitively investing farmers may have, for example, a more positive attitude towards sustainable investments or may be less influenced by social surroundings as they can build on their intuition and existing experiences (Dias et al., 2019; Blume and Covin, 2011; McGee et al., 2009). The implementation of the two exploratory constructs into the acceptance model of this study is a conceptual novelty and based on the hypotheses that *entrepreneurial planning* and *intuition* influence *performance expectancy* (**H8a;H9a**), *effort expectancy* (**H8b;H9b**), *social influence* (**H8c;H9c**), *facilitating conditions* (**H8d;H9d**), *risk expectations* (**H8e;H9e**) and *attitude* (**H8f;H9f**).

2.2. Data collection and analysis

Based on the research model, quantitative primary data was collected from 209 German farmers between November 2019 and January 2020 using a structured online survey. After initial pre-testing, respondents were recruited using a combination of methods: surveying farmers with a tablet version of the questionnaire at a large agricultural fair, on the one hand, and distributing the questionnaire via e-mail and social media to farms all over Germany, on the other. From the raw data, incomplete observations and those showing incongruous answering behavior, including the incorrect reply to the quality control question,[1] were removed to prevent inattentive responses from distorting the results (Biemer and Lyberg, 2003).

To establish an equal level of basic knowledge on the innovation under investigation among participants, the questionnaire began with a short neutral information text about what AFS is. This text was accompanied by a picture of an arable alley cropping AFS. Farm characteristics, such as production segments, farm size, main or side occupation, and workforce, were also queried at the beginning to give participants a smooth start with answering questions. The mid part of the questionnaire included several sets of statements operationalizing in different dimensions the latent variables of the research model which cannot be observed directly (Homburg and Gierung, 1996). These statements were verbalized based on existing literature (Dwivedi et al., 2019; Wellner et al., 2019; Slade et al., 2015; Venkatesh et al., 2012, 2003) as shown in Table A2 of the Appendix. Due to the novel conceptualization, the statements measuring the two entrepreneurial constructs were self-developed, based on existing research (Blume and Covin, 2011; McGee et al., 2009). For all statements, 5-point Likert scales from − 2 for Strongly Disagree to + 2 for Strongly Agree were used. The overall expectations of performance and effort from cultivating AFS as well as farmers' intentions to implement such a system were each measured additionally on a single 10-point scale (1 = very low; 10 = very high). Participants were also asked about the sources of economic benefits they prefer for AFS, with five answer options of which respondents were allowed to chose multiple. The desired level of one-time installation and yearly maintenance subsidy was queried using a free entry field to avoid response bias. The questionnaire ended with questions on the respondents' socio-demographics, including gender, year of birth, federal state of residence, educational level, income, type of company and position on the farm.

[1] This is a quality check. Please select the option "Totally disagree".

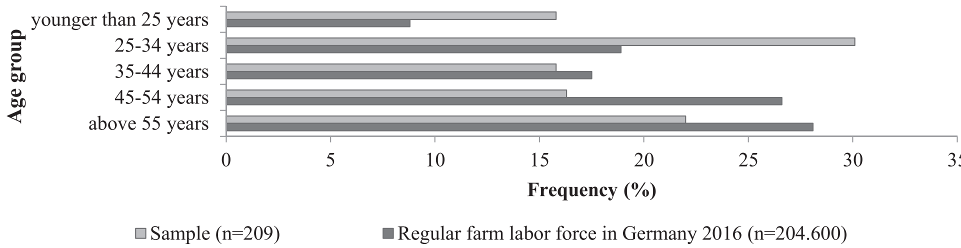

Fig. 2. Distribution of farmers' age in the sample compared to Germany's regular farm labor force
Source: authors' own graphic and calculations based on own data (n = 209) and DESTATIS (2018a).

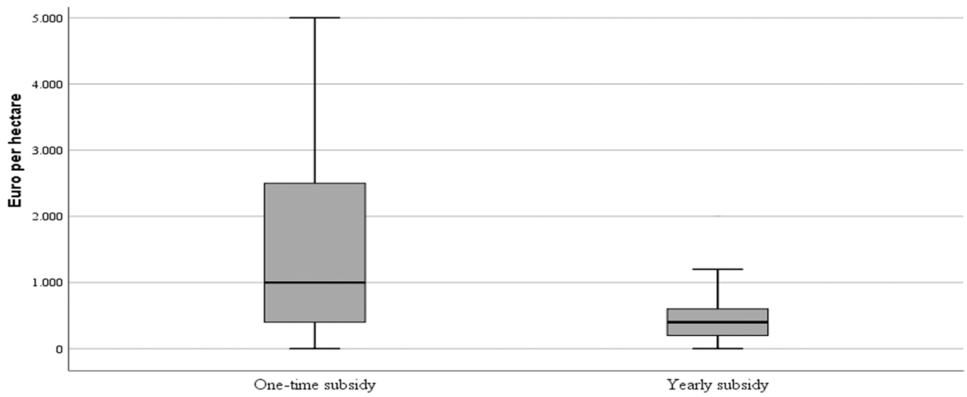

Fig. 3. Farmers' desired level of governmental subsidy schemes - one-time and yearly subsidy in Euro per hectare.
Source: authors' own graphic and calculations based on own data.

In addition to descriptive analyses, causal relationships between the latent variables of the adjusted UTAUT model are estimated using component-based PLS structural equation modelling (SEM) with SmartPLS 3.3.0 software. PLS-SEM is advantageous over covariance-based SEM in this study due to the complexity created by the large number of constructs in the model, the rather small sample size, the non-normal distribution of the variables, and the exploratory nature of our research which focuses on prediction (Chin, 1998; Ringle et al., 2012; Henseler et al., 2016; Hair et al., 2017). The statistical significance and relevance of the path-coefficients in the SEM were estimated using a non-parametric bootstrapping procedure with 5000 randomly drawn subsamples (Efron and Tibshirani, 1986; Davison and Hinkley, 1997; Hair et al., 2017).

3. Results

3.1. Sample description

The descriptive statistics of the sample are shown in Table 1. The sample consists of 209 farmers from all over Germany, of which 84.2 % are male and 15.8 % female, as compared to 90.4 % male and 9.6 % female in the general farmer population (DESTATIS, 2018a). The average age of respondents in this study is 40 years. As Fig. 2 shows, younger farmers are overrepresented in the sample compared to the main population of the regular farm labor force in 2016, which may be due to the use of an online questionnaire (DESTATIS, 2018a).

The regional distribution of the sample, based on the main operating site of the farm, shows an underrepresentation of the southern region (Baden-Württemberg, Bavaria) with 26.8 % of the farms, as compared to 47 % in the general statistics (DESTATIS, 2018b). 19.1 % of the farms are located in the northern region (Bremen, Hamburg, Lower Saxony and Schleswig-Holstein), 25.4 % in the eastern region (Berlin, Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia), and 28.7 % in the western region (North Rhine-Westphalia, Saarland, Hesse, Rhineland-Palatinate). The overrepresentation of farms in Eastern Germany matches a high number of participants practicing farming as their main occupation (90 % of the farmers surveyed, as compared to 48 % in the general statistics). Accordingly, the farm sizes in the sample, which average 381.6 ha, are much larger compared to the overall German average for commercial farms of 66.1 ha (DESTATIS, 2018b). 86.6 % of the respondents practice arable farming, 50.7 % forage production, and 90 % animal husbandry. The latter is well above the national share (68 %) (BMEL, 2018) and divided into 28.7 % pig farming, 53.1 % cattle and cow farming, and 8.2 % poultry farming. Around 28 % of the farmers surveyed operate renewable energy plants with an average output of ca. 580 kilowatts. 70.8 % of the farmers state that they had heard about agroforestry systems before the survey.

3.2. Descriptive statistics

When asked about their general expectations of an AFS, farmers rate the performance on average 4.92 on the 10-point scale, with a median of 5 and a standard deviation of 2.3. As the valuation of the effort on the same scale shows an average of 6.63, a median of 7, and a standard deviation of 1.99, farmers expect much more effort from implementing AFS than performance. This observation matches the rather low mean value of 3.8 for the overall intention to implement an AFS, with a median of 3.0 and a standard deviation of 2.6. According to the 5-point Likert-scaled statements capturing different aspects of performance and effort expectancy (see Table A2 in the Appendix), farmers perceive the set-up of an AFS on their farm to be complicated, and to require permanently increased efforts for the care of the wooden parts of the system compared to their standard crops. Simultaneously, farmers do not expect positive effects on either the quality or the yield of their conventional crops in the inter-tree rows.

Preferred sources of economic benefits for installing and maintaining an AFS, of which multiple options could be chosen by the respondents, are governmental subsidy schemes such as agri-environmental programs

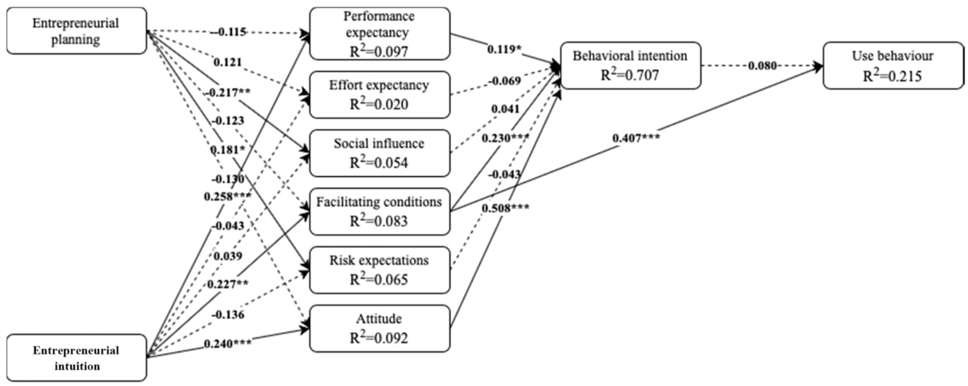

Fig. 4. Determinants of German farmers' acceptance of alley cropping systems (PLS structural model estimation) . Significance level: * =$p \leq 0.05$, * *=$p \leq 0.01$, * ** =$p \leq 0.001$; boxes: latent variables; arrows: path coefficients with significance levels; broken line: not significant.
Source: authors' own graphic and calculations based on own data.

Table A1
Description of the hypotheses **underlying the research model on farmers' acceptance of alley cropping agroforestry systems**.

Hypothesis	Description
H1 + #	The behavioral intention to implement an AFS positively influences use behavior.
H2 + *	The performance expectancy positively influences the behavioral intention.
H3- #	The effort expectancy negatively influences the behavioral intention.
H4 + #	Social influence positively influences the behavioral intention.
H5a+ *	Facilitating conditions positively influence the behavioral intention.
H5b+ *	Facilitating conditions positively influence the use behavior.
H6- #	Risk expectations negatively influence the behavioral intention.
H7 + *	Attitude positively influences the behavioral intention.
H8a #	Entrepreneurial planning has an influence on performance expectancy.
H8b #	Entrepreneurial planning has an influence on effort expectancy.
H8c *	Entrepreneurial planning has an influence on social influence.
H8d #	Entrepreneurial planning has an influence on facilitating conditions.
H8e *	Entrepreneurial planning has an influence on risk expectations.
H8f #	Entrepreneurial planning has an influence on attitude.
H9a *	Entrepreneurial intuition has an influence on performance expectancy.
H9b #	Entrepreneurial intuition has an influence on effort expectancy.
H9c #	Entrepreneurial intuition has an influence on social influence.
H9d *	Entrepreneurial intuition has an influence on facilitating conditions.
H9e #	Entrepreneurial intuition has an influence on risk expectations.
H9f *	Entrepreneurial intuition has an influence on attitude.

Source: Authors' own illustration. (* indicates hypothesis accepted, # indicates hypotheses rejected)

(73% of respondents) or greening as part of the EU direct payments (63 % of respondents). The sale or on farm use of wood chips was mentioned by 54 % and 45 % of the respondents respectively. The production of quality timber from the tree strips after an extended period of growth is the least popular option, selected by 33 % of the respondents. The desired level of governmental subsidy schemes for a one-time installation subsidy amounts to an average of €2718 (~ 3217US$[2]) per hectare with a high standard deviation of €4993 (~ 5910US$), based on answers ranging from €0 up to €35000 (~ 41431US$) per hectare (Fig. 3). The desired level of an additional yearly subsidy for maintaining the AFS amounts to an average of €512 (~ 606US$) per hectare and year, with a standard deviation of €779 (~ 922US$).

3.3. PLS analysis

Before presenting and discussing the estimated results for testing the hypotheses of the research model, the following quality criteria are assessed (see overview in Appendix Table A1). The Cronbach's Alpha Values (ranging from 0.601 to 0.904) are all, except for the "EI" (Entrepreneurial intuition) construct (CRA = 0.524), above the threshold of 0.6 (Hair et al., 2017). With composite reliability values above 0.7 (ranging from 0.759 to 0.933) and with all average variance extracted (AVE) values exceeding the threshold of 0.5 (ranging from 0.515 to 0.811) (Hulland, 1999), the model is considered reliable (Hair et al., 2017). Since all indicators load higher on their respective construct (latent variable) than on others and none of the observed AVE values are higher than the squared correlations (Fornell-Larcker criterion), these two discriminant validity criteria are also fulfilled (see Table A2/A3 in the Appendix) (Fornell-Larcker, 1981; Hair et al., 2017). According to Henseler et al. (2015), the Fornell-Larckner criterion should be supported by the Heterotrait-Monotrait-ratio (HTMT) to sufficiently fulfill discriminant validity. HTMT describes the relation between the correlation of indicators measuring different constructs and the correlation of indicators measuring their own construct (Hair et al., 2017). All indicator cross-loadings in our research model have a significantly higher loading on their own construct than on others and no indicators had to be removed. The HTMT does not exceed the threshold of 0.9 and the 97.5% confidence interval does not contain the value 1, thus, discriminant validity is confirmed for the estimations presented (Hair et al., 2017). The test for collinearity, using the variance inflation factor (VIF) that shows the level to which collinearity increases the standard error, passed with all VIF values for the constructs below the threshold of 5 (Hair et al., 2017).

Fig. 4 shows the results of the structural model with determination coefficients R^2, standardized path coefficients, and corresponding significance levels. The R^2 value, acting as a criterion for the forecasting performance of the model, shows the amount of variance of an endogenous variable explained by the exogenous variables, and should be at least 25% ($R^2 \geq 0.25$) (Huber, 2012; Hair et al., 2017). The R^2 for the central construct *behavioral intention* clearly exceeds the threshold ($R^2 = 0.707$), while the R^2 for the *use behavior* ($R^2 = 0.215$) is still acceptable for an explorative study on the acceptance of an innovative land use system. The variances explained by the exogenous variables *entrepreneurial intuition* and *entrepreneurial planning* in the model are, however, rather low as R^2 values of the constructs *performance expectancy*, *effort expectancy*, *social influence*, *facilitating conditions*, *risk expectations* and *attitude* do not exceed 10 % (Huber, 2012). This suggests that more uninvestigated constructs other than those *entrepreneurial* constructs may explain the constructs of the UTAUT model. The Q^2 values of the Stone-Geisser criterion of cross-validated redundancy are all above zero, suggesting the assumption of predictive validity for the structural model (Huber, 2012).

Path-coefficients show the positive or negative effects of one construct on another. To show a clear influence, they should be above a

[2] Exchange factor EUR to USD 1–1.183 (7.9.2020) with 0% interbank rate. Source: www.oanda.com

Table A2
Reliability of the research model on farmers' acceptance of alley cropping agroforestry systems.

Item	Question/statement	AV	SD	FL
Factor "Entrepreneurial planning'' *(AVE=0.570; CRA=0.750; CR=0.840; VIF=1.090)*				
EP1	I thoroughly evaluate the pros and cons of an investment.	1,28	0672	0821
EP2	I reflect for a long time about the financial impact of an investment in advance.	1.10	0.835	0.851
EP3	Before I make an investment, I try to collect as much information as possible.	1.46	0.611	0.693
EP4	I leave nothing to chance regarding investments.	0.82	0.939	0.634
Factor "Entrepreneurial intuition'' *(AVE=0.515; CRA=0.524; CR=0.759; VIF=1.090)*				
EI1	I often make investment decisions according to my instincts.	-0.78	1.003	0.815
EI2	I have often had good spontaneous ideas about how to develop my farm.	0.39	0.847	0.662
EI3	I see formal planning more as a hurdle than a support.	-0.40	1.085	0.665
Factor "Performance expectancy'' *(AVE=0.742; CRA=0.824; CR=0.896; VIF=2.180)*				
PE1	The use of an AFS increases the sustainability of my farm.	0.38	1.184	0.790
PE2	… improves the quality of the crops between tree rows.	-0.38	1.109	0.902
PE3	… increases the yield of the crops between tree rows.	-0.49	1.059	0.888
Factor "Effort expectancy'' *(AVE=0.580; CRA=0.638; CR=0.804; VIF=1.500)*				
EE1	It would be very complicated for me to set up an AFS on my farm.	0.64	1.007	0.855
EE2	Caring for the wooden parts of an AFS takes more effort than for conventional land.	0.66	1.074	0.725
EE3	The use of an AFS increases my efforts in planning cultivation	0.39	1.093	0.695
Factor "Social Influence'' *(AVE=0.557; CRA=0.601; CR=0.782; VIF=1.387)*				
SI1	Due to increasing social pressures, changes in the ways of arable farming are becoming unavoidable.	0.75	0.991	0.565
SI2	People who have an influence on my decision think that I should implement an AFS on my farm.	-1.02	1.016	0.867
SI3	My farming colleagues are promoting the use of AFS.	-1.18	0.802	0.773
Factor "Facilitating conditions'' *(AVE=0.551; CRA=0.630; CR=0.785; VIF=1.736)*				
FC1	The use of an AFS fits my farm structure well.	-0.41	1.183	0.890
FC2	I am experienced in growing short rotation shrubs.	-0.98	1.192	0.556
FC3	Our farm has the necessary equipment to implement and maintain an AFS.	-1.16	1.146	0.686
Factor "Risk expectations'' *(AVE=0.517; CRA=0.771; CR=0.841; VIF=1.704)*				
RE1	I consider the implementation of an AFS on my farm to be a risk.	0.44	1.006	0.791
RE2	Dependence on subsidies for the implementation of an AFS is a risk.	0.63	1.113	0.623
RE3	The marketing of the wood products from an AFS is a risk.	0.36	1.268	0.717
RE4	An AFS is a risk for my neighboring crops.	0.03	1.171	0.649
RE5	Investment in the implementation of an AFS is a risk.	0.56	0.992	0.797
Factor "Attitude" *(AVE=0.777; CRA=0.904; CR=0.933; VIF=3.088)*				
AT1	It is a good idea to implement an AFS on my farm.	-0.32	1.147	0.920
AT2	I am positive about the implementation of an AFS.	0.11	1.225	0.902
AT3	An AFS is advantageous for my farm compared to other sustainable land use systems.	-0.34	1.077	0.804
AT4	It would make me feel satisfied to implement an AFS on my farm.	-0.13	1.229	0.896

Table A2 *(continued)*

Item	Question/statement	AV	SD	FL
Factor "Behavioral intention" *(AVE=0.811; CRA=0.884; CR=0.928; VIF=1.766)*				
BI1	I plan to implement or further use an AFS on my farm in the coming years.	-0.81	1.217	0.900
BI2	I think that from the 2030 s onward an AFS will be an inherent part of my planting program.	-0.59	1.219	0.893
BI3	Please rate your intention to implement an AFS on your farm.	3.80	2.590	0.909
Factor "Use behavior" *(AVE=1; CRA=1; CR=1.766)*				
BU1	Have you implemented an AFS on your farm?	1.12	0.455	1.000

Scale from 2 = totally agree to − 2 = totally disagree; BI3 = Rating scale (from 1 = very low. to 10 = very high); BU1 = statement (1 = No. 2 = Yes but abandoned. 3 = Yes); AVE = Average Variance Extracted; CRA = Cronbach's Alpha; CR = Composite Reliability; VIF = Inner Variance Inflation Factor; AV = Average value; SD = Standard deviation; FL = Factor loading
Source: Authors' calculation based on own data

reference value of 0.1 (Lohmoller, 1988) or 0.2 (Chin, 1998). To show statistically significant results, p-values should be below 0.05 (significant), 0.01 (very significant) or 0.001 (highly significant). The path coefficients evidence statistically significant and positive influences of *performance expectancy* (0.119 *; H2 +), *facilitating conditions* (0.230 ***; H5a+) and *attitude* (0.508 ***; H7 +) on the *behavioral intention* to implement an AFS and of *facilitating conditions* (0.407 ***; H5b+) on the *use behavior*. *Entrepreneurial planning* has a statistically significant negative influence on *social influence* (−0.217 **; H8c) and a statistically significant positive influence on *risk expectations* (0.181 *; H8e). *Entrepreneurial intuition* exerts a statistically significant positive influence on *performance expectancy* (0.258 ***; H9a), *facilitating conditions* (0.227 **; H9d) and *attitude* (0.240 ***; H9f). Overall, four out of eight hypotheses from the core model and five out of twelve hypotheses for the entrepreneurial extension are supported. The remaining hypotheses (H1 +, H3-, H4 +, H6-, H8a, H8b, H8d, H8f, H9b, H9c, H9e) are rejected due to missing statistical significance, although directions were hypothesized correctly (see Table A1 in the Appendix).

4. Discussion

The descriptive results of the survey show a discrepancy between the expected effort (mean value = 6.63) for implementing and maintaining an AFS and the corresponding expected performance (mean value = 4.92). This discrepancy implies that farmers estimate the effort an AFS involves as higher than the performance they can get from it and might entail their overall low intention to implement an AFS on farm (mean value = 3.8). The rather negative overall perception of AFS is in line with previous research on agricultural wood and agroforestry systems, which found a low interest of farmers in AFS due to negative perceptions of profitability and compatibility (Beer et al., 2018; Borremans et al., 2016; Warren et al., 2016).

The majority of participants prefer subsidy schemes such as greening or agri-environmental programs as sources of economic benefits over profit generation from marketing wooden components. Presumably, this preference for governmental programs is connected to unknown and volatile sales channels for tree components, e.g. in the form of wood chips (Beer and Theuvsen, 2019). The one-time (€2718 (~ 3217US) per hectare) and yearly (€512 (~ 606US$) per hectare) amounts of subsidies desired by the surveyed farmers is higher than the real cost of implementing (€1935 (~ 2282US$) per hectare) and maintaining (€108 (~ 127US$) per hectare) an AFS (Langenberg et al., 2018). This gap might give evidence of a risk premium that farmers expect for the uncertainties associated with making a long-term investment decision in favor of sustainable farming systems such as AFS. If AFS were implemented on 25 % of the total arable farmland in Germany (Lamersdorf et al., 2018), this annual subsidy would sum up to a total amount of 877 million Euro (~ 1.038 billion US$). According to Otter and Langenberg (2020), who

Table A3
Fornell-Larcker criterion for examining the discriminant validity of the research model on farmers' acceptance of alley cropping agroforestry systems.

	AT	BI	EE	EI	EP	FC	PE	RE	SI	BU
AT	**0.881**									
BI	0.81	**0.901**								
EE	-0.434	-0.423	**0.762**							
EI	0.278	0.286	-0.078	**0.717**						
EP	-0.199	-0.172	0.134	-0.288	**0.755**					
FC	0.638	0.659	-0.316	0.263	-0.188	**0.742**				
PE	0.697	0.626	-0.251	0.291	-0.189	0.419	**0.861**			
RE	-0.497	-0.489	0.52	-0.188	0.22	-0.393	-0.475	**0.719**		
SI	0.497	0.46	-0.202	0.101	-0.229	0.377	0.455	-0.251	**0.746**	
BU	0.223	0.348	-0.18	0.219	-0.041	0.46	0.145	-0.246	0.002	

Source: Authors' calculation based on own data (highlighted: square roots of AVE values; not highlighted: construct correlations)

Table A4
HTMT criterion for examining the discriminant validity of the research model on farmers' acceptance of alley cropping agroforestry systems.

	AT	BI	EE	EI	EP	FC	PE	RE	SI	BU
AT										
BI	0.898									
EE	0.552	0.555								
EI	0.401	0.414	0.187							
EP	0.234	0.201	0.183	0.506						
FC	0.676	0.737	0.382	0.44	0.262					
PE	0.805	0.736	0.337	0.445	0.217	0.449				
RE	0.555	0.548	0.718	0.267	0.265	0.451	0.557			
SI	0.654	0.6	0.309	0.202	0.33	0.47	0.642	0.366		
BU	0.227	0.368	0.222	0.307	0.056	0.591	0.161	0.282	0.045	

Source: Authors' calculation based on own data

show that for supporting a wider AFS implementation, a German taxpayer has an average yearly willingness to pay of 36 € (~ 42.62 US$) for supporting a wider AFS implementation,. When subtracting the sum of 1.6 billion Euro (~ 1.894 billion US$) calculated for 44.6 million German taxpayers (DESTATIS, 2020) from the subsidy amount needed for the scenario of a 25 % AFS implementation rate on German arable farmland, the result shows a substantial surplus of potentially available subsidies.

In accordance with previous research (Beer et al., 2018; Lemken et al., 2017; Borremans et al., 2016) this study gives evidence that farmers' acceptance of innovative new production systems such as AFS is based not solely on economic attractiveness, but also on psycho-social acceptance factors. This finding obtained from the PLS analysis helps explain the discrepancy between desired subsidies and real costs, and offers deeper insight into the influence of these AFS acceptance factors. While exogenous variables explain 70.7% of the *behavioral intention* variance and 21.5 % of *use behavior* variance, *behavioral intention* shows only a low and non-significant influence on *use behavior* (0.080), contradicting previous research (Michels et al., 2019; Beer, 2019; Ajzen, 2011; Venkatesh et al., 2003). This result may indicate an intention-behavior gap between the ex-ante statements and the final action of the farmer – similar to the discrepancy between consumers' stated preferences for sustainable foods and their actual consumption – that is caused by not prioritizing sustainability during later stages of the decision-making process about adopting certain land use systems. This could explain the limited dissemination of sustainable land use systems in German practical agriculture (ElHaffar et al., 2020; Sheeran and Webb, 2016; Carrington et al., 2014; Renner et al., 2007). *Performance expectancy* has a statistically significant, albeit low, positive influence on *behavioral intention* (0.119 *), which is generally in line with findings from other studies on acceptance behavior (e.g. Dwivedi et al., 2019; Otter and Beer, 2021; Dwivedi et al., 2011; Venkatesh et al., 2003). On the one hand this influence may imply importance of expected economic and ecological benefits for the decision-making process, as a farmer aims to maximize these benefits and compare them to other land use systems before making a decision (Otter and Beer, 2021; Cary and Wilkinson, 1997). On the other hand the path coefficient of *performance expectancy* is relatively low and *effort expectancy* as an antithesis to *performance expectancy* does not show any significant influence on the *behavioral intention.* Confirming the findings of Otter and Beer (2021) and Trozzo et al. (2014) the decision-making process for sustainable land use systems is likely being driven more by intrinsic motivation than by expectations of performance and effort. The positive influence of *facilitating conditions* on both *behavioral intention* (0.230***) and *use behavior* (0.407***) confirms existing literature in finding advantageous facilitating conditions an important driver of innovation acceptance (Venkatesh et al., 2012). Having the necessary technical equipment and personal knowledge could make farmers more confident about handling the challenges and prerequisites associated with both implementation and maintenance of AFS (Langenberg et al., 2018; Granoszewski et al., 2011; Skodawessely and Pretzsch, 2009). Vice versa, disadvantageous facilitating conditions can discourage from implementing AFS, as they typically create uncertainty and greater learning requirements for adopting new technologies (Jonsson et al., 2011).

The statistical insignificance of the *social influence* effect on *behavioral intention* contrasts previous studies that find social relationships to have strong influence on decisions (Trozzo et al., 2014), either as support by family (Raedeke et al., 2003; Salamon et al., 1997) or by community (Atwell et al., 2009). The above average farm sizes and younger age of farmers in the present sample may contribute to that deviation, as future-oriented farmers with larger farms are prone to have a strong self-perception and rely less on input from others, thus diminishing the social influence of family, friends, and institutions on their decisions (Yamano et al., 2015; Vesala et al., 2007; Knierim and Siebert, 2004). The statistical insignificance of *risk expectations* confirms some of the existing studies (Otter and Beer, 2021) but contradicts others (Trozzo et al., 2014; Pattanayak et al., 2003), while being in line with research showing that at some cultivation sites AFS is even preferrable for risk-averse farmers when comparing its risk profile to the one of the usual annual cropping system (Langenberg et al., 2018).

Attitude shows the strongest statistically significant influence of all constructs on the *behavioral intention* (0.508***). This is generally in line with earlier findings on the importance of attitude in the decision-making process of accepting technologies (Kim et al., 2009; Yang and Yoo, 2004) and agricultural innovations (Faridi et al., 2020; Beer et al., 2018; Borremans et al., 2016; Warren et al., 2016; Jonsson et al., 2011). The strong influence of *attitude* confirms our earlier interpretation that intrinsic motivation is the main driver in the decision-making process for accepting sustainable land use systems, rather than *performance* and *effort expectancy* (Greiner and Gregg, 2011; Bopp et al., 2019). Farmers' decision to implement an AFS on farm is strongly influenced by the motivation to act sustainably. A stronger communicative focus on regulating and supporting ecosystems services such as water conservation and improvements in biodiversity, rather than on economic cost and benefits, might further increase AFS dissemination (Greiner and Gregg, 2011; Bopp et al., 2019).

Statistically significant effects on the acceptance factors were found to come from either *entrepreneurial planning* or *entrepreneurial intuition*, but not both at the same time. However, as the variances of the acceptance constructs explained by entrepreneurial constructs are not exceeding a value of 9.7 % (*Performance expectancy*), there are likely more, still unconsidered constructs influencing AFS acceptance. *Entrepreneurial planning* shows a significantly negative (−0.217***) effect on *social influence* and a significant positive (0.181*) influence on *risk expectations*. The former effect may be explained by farmers' being less dependent on orientation towards their social surrounding when a clear strategic plan is in place. The latter effect shows that a well-elaborated business plan helps to reduce the risk perceived with regards to AFS investment, since a detailed evaluation of potential risks and benefits reduces the uncertainties that form a part of risk expectations (Slade et al., 2015). The significant influences of *entrepreneurial intuition* on *performance expectancy* (0.258***), *facilitating conditions* (0.227**), and *attitude* (0.240***) are likely grounded in farmers' previous experiences forming a generally positive outlook on AFS performance and surrounding conditions (Kickul et al., 2009; Allinson et al., 2000) and a generally positive attitude towards respective investment opportunities (La Pira and Gillin, 2006). This finding implies that farmers with an entrepreneurial mindset or previous experience with investments that provide regulating and supporting ecosystem services, e.g. organic farming, are more likely to invest in sustainable land use systems such as AFS, and thus could be a target for measures to establish a larger group of early adopters (Borremans et al., 2016; Kickul et al., 2009; Pannell et al., 2006).

The research has some limitations from the representativeness of the sample, the exploratory nature of the study, and from utilizing a self-completion offline and online questionnaire for data collection. The representativeness is limited due to the respondents in the sample being younger and operating larger farms than in Germany's overall agricultural structure. On the other hand, this deviation may emphasize the relevance of the topic for larger farms, which may have greater financial leeway to meet capital requirements for investments, and younger farmers who still face a longer work life ahead of them and are, thus, likely more open for making a long-term investment into AFS (Fabbrizzi et al., 2016). We mitigated the risk of self-selection bias (Jacobs et al., 2009) by also recruiting respondents in person during tablet-based data collection. The self-assessment of respondents might have biased the results due to answers given with central tendency (Bortz and Döring, 1995) and according to social desirability and norms (Boerger, 2012), although these biases were mitigated by using proper survey techniques.

5. Conclusions

This study targets farmers' profit and subsidy expectations and their main behavioral acceptance factors regarding innovative land use systems such as AFS in the current political situation. Results provide a basis for developing effective policy measures towards an increase in dissemination of these systems in practical agriculture. The descriptive results show that farmers are reluctant to implement AFS on their farm, and estimate the effort to be greater than the benefits. They prefer governmental subsidies over generating profits from marketing the wooden components of the AFS, with a desired initial implementation subsidy of €2718 (~ 3217US$) per hectare and annual maintenance subsidy of €512 (~ 616US$) per hectare and year. The large standard deviations of desired subsidies show the high degree of uncertainty farmers feel about implementing a sustainable land use system with limited knowledge about economic and ecological benefits. Still, the German taxpayers' willingness to pay would be sufficient to fulfill farmers' subsidy expectations (Otter and Langenberg, 2020). According to the results of the PLS analysis *performance expectancy*, *facilitating conditions* and *attitude* influence the *behavioral intention* to implement a sustainable land use system such as AFS positively. That farmers' *attitude* exerts the strongest influence suggests that they are rather intrinsically motivated to implement these land use systems than by cost-benefit considerations. Considering both PLS and descriptive results, a stronger focus on enhancing farmers' intrinsic motivation is needed to promote sustainable land use systems, accompanied by measures to reduce farmers' uncertainty, which may also reduce the amount of desired subsidies. With *facilitating conditions* having a significant influence on both *behavioral intention* and *use behavior*, the results show the need for support in terms of machinery and knowledge transfer to assist farmers who are willing to trial sustainable land use systems on their farm. The entrepreneurial components of the research model show that *entrepreneurial planning* and *entrepreneurial intuition* influence some of the factors relevant to the *behavioral intention* to use AFS, albeit to a relatively small extent. Consequently, farmers with considerate strategic planning or entrepreneurial mindset and experience in investments providing regulating and supporting ecosystem services could be a worthy target group for pioneering supportive measures. While existing policy programs give a basic level of guidance, more refined measures to foster dissemination of sustainable land use systems are needed.

The results imply several recommendations for politicians, advocacy groups, and farmers in order to speed up agroforestry dissemination. Firstly, taking into consideration Otter and Langenberg (2020) results regarding taxpayers' willingness to pay for AFS, politicians should focus on implementing a tax-backed low-threshold subsidy program for implementing and maintaining AFS as part of the CAP post 2020 and national strategy plans. Such a program would help to overcome the uncertainties farmers face in terms of profitability, capital commitment, and sales channels; help to meet expected risk premiums; and help to establish a group of early adopters (Pannell et al., 2006).

Secondly, politicians, advocacy groups, and farmers should focus on improving the attitudes of farmers towards sustainable land use systems as well as towards surrounding conditions, by supporting their intrinsic motivation with the necessary equipment and knowledge (Langenberg et al., 2018; Granoszewski et al., 2011; Jonsson et al., 2011). Facilitating conditions could be improved by empowering and subsidizing new and existing collaborative structures in farming, such as machinery cooperatives; as sources of equipment and knowledge for implementing and maintaining an AFS. Similar to existing structures in e.g. sugar beet or organic farming, those collaborations would reduce the need to purchase, and thus the machinery or training cost for each individual farm. These cooperatives could also act as learning and education centers for farmers, supporting them in establishing an AFS on their farm and and operating it efficiently (Strauss et al., 1991). Attitudes could be influenced by promoting the basics and benefits of sustainable land use systems in vocational schools, universities, and during field demonstrations to establish a higher level of understanding among farmers and foster the intrinsic motivation to implement such systems on their farm (Bopp et al., 2019; Tsonkova et al., 2012; Greiner and Gregg, 2011).

Thirdly, a comprehensive economic framework for AFS should be developed and communicated by scientists and advocacy groups, including a risk analysis, a cash flow analysis, and an analysis of effects on neighboring crops. This would substantiate the entrepreneurial planning of farmers, and a better attitude and performance expectancy towards AFS. Overall, a joint initiative from multiple stakeholders such as policy makers, advocacy groups and farmers that covers financial, educational, and scientific aspects would be needed to target acceptance factors and increase the dissemination of AFS as a sustainable and innovative land use system.

Besides the proposed comprehensive economic framework, future research should conduct such acceptance studies for other EU countries in order to obtain an integrated view of the subject, and to endorse AFS in future CAP reforms of the European Union as well as respective national strategy plans of the member states. Further research should focus on the relationship between knowledge about sustainable land use systems and the level of governmental subsidies farmers expect for their implementation (e.g. by using a choice-experiment). Findings of those studies could be of help to estimate the required subsidy levels more precisely, and shed light on specific knowledge needs of farmers.

Funding

This research has been conducted as part of the project SIGNAL 2, which was funded by the German Federal Ministry of Education and Research (BMBF) in the framework of the funding measure "Soil as a Sustainable Resource for the Bioeconomy - BonaRes" (grant number 031B0511).

Appendix

see Table A1-A4.

References

Ajzen, I., 1991. The theory of planned behavior. Organ Behav. Hum. Decis. Process. 50 (2), 179–211.
Ajzen, I., 2011. The theory of planned behaviour: Reactions and reflections. Psychol. Health 26 (9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995.
Alemu D., Negash S. (2015) Mobile information system for small-scale rural farmers. 2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR), 79–83, doi: 10.1109/TIAR.2015.7358535.
Allinson, C.W., Chell, E., Hayes, J., 2000. Intuition and entrepreneurial behaviour. Eur. J. Work Organ Psychol. 9 (1), 31–43. https://doi.org/10.1080/135943200398049.
Atwell, R.C., Schulte, L.A., Westphal, L.M., 2009. Linking resilience theory and diffusion of innovations theory to understand the potential for perennials in the US Corn Belt. Ecol. Soc. 14 (1), 30–47.
Baerwolff M. , Vetter A. , Boehm C. , Hoffmann J. , Schmidt C. (2011) Projekt AgroForstEnergie? Was bringen Streifen-Kup? energie pflanzen 2:9–11.
Beer L. (2019) Agrarholz aus ökonomischer Perspektive. Dissertation. Cuvillier Göttingen, Germany.
Beer, L., Theuvsen, L., 2019. Conventional German farmers' attitudes towards agricultural wood and their willingness to plant an alley cropping system as an ecological focus area: a cluster analysis. Biomass Bioenergy 125, 63–69. https://doi.org/10.1016/j.biombioe.2019.04.008.
Beer L., Schaper C., Theuvsen L. (2018) Agrarholzanbau in der deutschen Landwirtschaft: Ergebnisse einer empirischen Erhebung. Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. 54:19–30.
Biemer P.P., Lyberg L.E. (2003) Introduction to survey quality. John Wiley & Sons, Hoboken, NJ.
Blume, B.D., Covin, J.G., 2011. Attributions to intuition in the venture founding process: do entrepreneurs actually use intuition or just say that they do? J. Bus. Ventur 26 (1), 137–151. https://doi.org/10.1016/j.jbusvent.2009.04.002.
BMU(Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety) (2019) Klimaschutzprogramm 2030 zur Umsetzung des Klimaschutzplans 2050. https://www.bmu.de/download/klimaschutzprogramm-2030-zur-umsetzung-des-klimaschutzplans-2050/.
Bobbitt, L.M., Dabholkar, P.A., 2001. Integrating attitudinal theories to understand and predict use of technology-based self-service. Int. J. Serv. Ind. Manag. 12 (5), 423–450. https://doi.org/10.1108/EUM0000000006092.
Boerger T. (2012) Social desirability and environmental evaluation. Peter Lang AG, Frankfurt am Main.
Bopp, C., Engler, A., Poortvliet, P.M., Jara-Rojas, R., 2019. The role of farmers' intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. J. Environ. Manag. 244, 320–327. https://doi.org/10.1016/j.jenvman.2019.04.107.
Borremans, L., Reubens, B., van Gils, B., Baeyens, D., Vandevelde, C., Wauters, E., 2016. A sociopsychological analysis of agroforestry adoption in Flanders: understanding the discrepancy between conceptual opportunities and actual implementation. Agroecol. Sustain. Food Syst. 40 (9), 1008–1036. https://doi.org/10.1080/21683565.2016.1204643.
Bortz J., Döring N. (1995) Research methods and evaluation. Springer Berlin, Germany.
Carrington, M.J., Neville, B.A., Whitwell, G.J., 2014. Lost in translation: exploring the ethical consumer intention–behavior gap. J. Bus. Res. 67 (1), 2759–2767. https://doi.org/10.1016/j.jbusres.2012.09.022.
Cary, J.W., Wilkinson, R.L., 1997. Perceived profitability and farmer's conservation behavior. J. Agric. Econ. 48, 13–21. https://doi.org/10.1111/j.1477-9552.1997.tb01127.x.
Chin, W.W., 1998. The partial least squares approach to structural equation modeling. Mod. Met. Bus. Res. 295 (2), 295–336.
Chouinard, H.H., Paterson, T., Wandschneider, P.R., Ohler, A.M., 2008. Will farmers trade profits for stewardship? Heterogeneous motivations for farm practice selection. Land Econ. 84 (1), 66–82. https://doi.org/10.3368/le.84.1.66.
Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13 (3), 319–339.
Davison A.C., Hinkley D.V. (1997) Bootstrap methods and their application. Cambridge university press Cambridge, United Kingdom.
DESTATIS (Statistisches Bundesamt) (2018b): Rechtsformen und Erwerbscharakter. Agrarstrukturerhebung. Fachserie 3 Reihe 2.1.5.
DESTATIS (Statistisches Bundesamt) (2018a): Arbeitskräfte und Berufsbildung der Betriebsleiter/ Geschäftsführer. Agrarstrukturerhebung. Fachserie 3 Reihe 2.1.8.
DESTATIS (Statistisches Bundesamt) (2019): Landwirtschaftliche Betriebe. Betriebsgrößenstruktur landwirtschaftlicher Betriebe nach Bundesländern.
DESTATIS (Statistisches Bundesamt) (2020): Saison- und kalenderbereinigte Anzahl der Erwerbstätigen mit Wohnsitz in Deutschland (Inländerkonzept) von Juli 2019 bis Juli 2020.
Dias, C.S., Rodrigues, R.G., Ferreira, J.J., 2019. What's new in the research on agricultural entrepreneurship? J. Rural Stud. 65, 99–115.
Dwivedi, Y.K., Rana, N.P., Jeyaraj, A., Clement, M., Williams, M.D., 2019. Re-examining the unified theory of acceptance and use of technology (UTAUT): towards a revised theoretical model. Inf. Syst. Front 21, 719–734. https://doi.org/10.1007/s10796-017-9774-y.
Dwivedi Y.K., Rana N.P., Chen H., Williams M.D. (2011) A Meta-analysis of the Unified Theory of Acceptance and Use of Technology (UTAUT). IFIP Advances in Information and Communication Technology 366. Springer Berlin Heidelberg. doi: 10.1007/978–3-642–24148-2_10.
Efron, B., Tibshirani, R., 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Stat. Sci. 1 (1), 54–75.
ElHaffar, G., Durif, F., Dubé, L., 2020. Towards closing the attitude-intention-behavior gap in green consumption: a narrative review of the literature and an overview of future research directions. J. Clean. Prod. 275, 122556 https://doi.org/10.1016/j.jclepro.2020.122556.
European Commission (2019b) The environmental objectives of the future CAP. https://ec.europa.eu/info/news/environmental-care-and-climate-change-objectives-future-cap-2019-jan-25_en.
European Commission (2019a) A European Green Deal. https://ec.europa.eu/info/strategy/priorities-2019–2024/european-green-deal.
Fabbrizzi, S., Maggino, F., Marinelli, N., Menghini, S., Ricci, C., 2016. Sustainability and well-being: the perception of younger generations and their expectations. Agric. Agric. Sci. Proc. 8, 592–601. https://doi.org/10.1016/j.aaspro.2016.02.081.
Faridi, A.A., Kavoosi-Kalashami, M., El Bilali, 2020. Attitude components affecting adoption of soil and water conservation measures by paddy farmers in Rasht County, Northern Iran. Land Use Policy 99, 104885. https://doi.org/10.1016/j.landusepol.2020.104885.
FNR (Fachagentur für nachwachsende Rohstoffe) (2020) Anbau und Verwendung nachwachsender Rohstoffe in Deutschland. FNR Gülzow, Germany.
Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Mark. Res. 18 (1), 39–50.
Foster, A.D., Rosenzweig, M.R., 1995. Learning by doing and learning from others: Human capital and technical change in agriculture. J. Polit. Econ. 103 (6), 1176–1209.
German Farmers Federation (Deutscher Bauernverband) (2019): Situationsbericht 2019/20. Trends und Fakten zur Landwirtschaft. DBV, Berlin.
Granoszewski K., Spiller A., Reise C., Musshoff O. (2011) Die Diffusion regenerativer Energien in der deutschen Landwirtschaft – Investitionsverhalten in einem politisch induzierten Markt. 10. International Conference Marketing Trends, Paris.
Greiner, R., Gregg, D., 2011. Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: empirical evidence from northern Australia. Land Use Policy 28 (1), 257–265. https://doi.org/10.1016/j.landusepol.2010.06.006.
Gruenewald H. (2005) Anbau schnellwachsender Gehölze für die energetische Verwertung in einem Alley-Cropping-System auf Kippsubstraten des Lausitzer Braunkohlereviers. Dissertation. Brandenburgische Technische Universität Cottbus-Senftenberg, Germany.
Hair J.F., Hult G.T., Ringle C.M., Sarstedt M. (2017) A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Sage Los Angeles.
Hardesty, S., Leff, P., 2010. Determining marketing costs and returns in alternative marketing chanels. Renew. Agric. Food Syst. 25 (1), 24–34.
Henseler, J., Ringle, C.M., Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. J. Acad. Mark. Sci. 43, 115–135. https://doi.org/10.1007/s11747-014-0403-8.
Henseler, J., Hubona, G., Ray, P.A., 2016. Using PLS path modeling in new technology research: updated guidelines. Ind. Manag. Data Syst. 116, 2–20. https://doi.org/10.1108/IMDS-09-2015-0382.
den Herder M., Moreno G., Mosquera-Losada R.M., Palma J.H.N., Sidiropoulou A., Santiago Freijanes J.J., Crous-Duran J., Paulo J.A., Tomé M., Pantera A., Papanastasis V.P., Mantzanas K., Pachana P., Papadopoulos A., Plieninger T.,

Burgess P.J. (2017) Current extent and stratification of agroforestry in the European Union. In: Agric Ecosyst Environ 241: 121–132. doi: 10.1016/j.agee.2017.03.005.
Herzog, F., 2011. Umweltleistungen von Bäumen in der offenen Agrarlandschaft. Ökologie Landbau 4, 54–56.
Homburg, C., Gierung, A., 1996. Conceptualization and operationalization of complex constructs. A guideline for marketing research. J. Res. Manag. 18 (1), 5–24. https://doi.org/10.2307/41918481.
Huber F. (2012) Leitfaden SmartPLS. Universität Mainz.
Hulland, J., 1999. Use of partial least squares (PLS) in strategic management research: a review of four recent studies. Strateg. Manag. J. 20 (2), 195–204.
Jacobs, B., Hartog, J., Vijverberg, W., 2009. Self-selection bias in estimated wage premiums for earnings risk. Empir. Econ. 37 (2), 271–286. https://doi.org/10.1007/s00181-008-0231-0.
Jonsson A.C., Ostwald M., Asplund T., Wibeck V. (2011) Barriers to and drivers of the adoption of energy crops by Swedish farmers: an empirical study. World Renewable Energy Congress 2011, Sweden. doi:10.3384/ecp110572509.
Kickul, J., Gundry, L.K., Barbosa, S.D., Whitcanack, L., 2009. Intuition versus analysis? Testing differential models of cognitive style on entrepreneurial self–efficacy and the new venture creation process. Entrep. Theory Pract. 33 (2), 439–453. https://doi.org/10.1111/j.1540-6520.2009.00298.x.
Kim, G., Shin, B., Lee, H.G., 2009. Understanding dynamics between initial trust and usage intentions of mobile banking. Info Syst. J. 19 (3), 283–311. https://doi.org/10.1111/j.1365-2575.2007.00269.x.
Knierim A., Siebert R. (2004) Towards multi-functional agriculture–What motivates German farmers to realise biodiversity conservation. Proceedings of the 6th European IFSA Symposium, Vila Real Portugal:283–292.
Knowler, D., Bradshaw, B., 2007. Farmers' adoption of conservation agriculture: a review and synthesis of recent research. Food Policy 32 (1), 25–48. https://doi.org/10.1016/j.foodpol.2006.01.003.
Kröber M., Hank K., Heinrich J., Wagner P. (2008) Ermittlung der Wirtschaftlichkeit des Energieholzanbaus in Kurzumtriebsplantagen – Risikoanalyse mit Hilfe der Monte-Carlo-Simulation. GEWISOLA-Jahrestagung: Risiken in der Agrar- und Ernährungswirtschaft und ihre Bewältigung, Bonn.
Kuczera C. (2006): Der Einfluss des sozialen Umfelds auf betriebliche Entscheidungen von Landwirten. Kommunikation und Beratung. Sozialwissenschaftliche Schriften zur Landnutzung und ländliche Entwicklung 71. Margraf, Weikersheim: 79–82.
La Pira, F., Gillin, M., 2006. Non-local intuition and the performance of serial entrepreneurs. Int. J. Entr. Small Bus. 3 (1), 17–35.
Lamersdorf, N., Schmidt, M., Brüggemann, C., 2018. Mehrwert agroforstsystem. Energ. Pflanz. 22 (4), 58–60.
Langenberg, J., Theuvsen, L., 2018. Agroforstwirtschaft in Deutschland: alley-cropping-systeme aus ökonomischer Perspektive. J. für Kult. 70 (4), 113–123.
Langenberg, J., Feldmann, M., Theuvsen, L., 2018. Alley cropping agroforestry systems: Using Monte-Carlo simulation for a risk analysis in comparison with arable farming systems. Ger. J. Agric. Econ. 67 (2), 95–112.
Lemken, D., Spiller, A., von Meyer-Hoefer, M., 2017. The case of legume-cereal crop mixtures in modern agriculture and the transtheoretical model of gradual adoption. Ecol. Econ. 137, 20–28. https://doi.org/10.1016/j.ecolecon.2017.02.021.
Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D.P., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P.T., Sessa, R., Shula, R., Tibu, A., Torquebiau, E., 2014. Climate-smart agriculture agriculture for food security. Nat. Clim. Change 4, 1068–1072. https://doi.org/10.1038/nclimate2437.
Lohmoller, J.B., 1988. The PLS program system: latent variables path analysis with partial least squares estimation. Multivar. Behav. Res. 23 (1), 125–127. https://doi.org/10.1207/s15327906mbr2301_7.
Long, T.B., Blok, V., Coninx, I., 2016. Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. J. Clean. Prod. 112, 9–21. https://doi.org/10.1016/j.jclepro.2015.06.044.
Luo, X., Li, H., Zhang, J., Shim, J.P., 2010. Examining multi-dimensional trust and multi-faceted risk in initial acceptance of emerging technologies: sn empirical study of mobile banking services. Decis. Support Syst. 49 (2), 222–234. https://doi.org/10.1016/j.dss.2010.02.008.
Maart-Noelck, S.C., Musshoff, O., 2014. Measuring the risk attitude of decision-makers: are there differences between groups of methods and persons? Aust. J. Agric. Resour. Econ. 58 (3), 336–352. https://doi.org/10.1111/j.1467-8489.2012.00620.x.
Mandrik, C.A., Bao, Y., 2005. Exploring the concept and measurement of general risk aversion. ACR North Am. Adv. 32, 531–539.
McGee, J.E., Peterson, M., Mueller, S.L., Sequeira, J.M., 2009. Entrepreneurial self–efficacy: refining the measure. Entrep. Theory Pract. 33 (4), 965–988. https://doi.org/10.1111/j.1540-6520.2009.00304.x.
Michels M., Bonke V., Mußhoff O. (2019) Understanding the adoption of crop protection smartphone apps – An application of the Unified Theory of Acceptance and Use of Technology. Discussion paper 1905. Georg-August-University Göttingen, Germany.
Morris, M.G., Venkatesh, V., 2000. Age differences in technology adoption decisions: Implications for a changing work force. Pers. Psychol. 53 (2), 375–403.
Neufeldt, H., Jahn, M., Campbell, B.M., et al., 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. Agric. Food Secur 2, 12. https://doi.org/10.1186/2048-7010-2-12.
Otter, V., Beer, L., 2021. Alley cropping systems as ecological focus areas: a PLS-analysis of German farmers' acceptance behaviour. J. Clean. Prod. 280 (2), 123702 https://doi.org/10.1016/j.jclepro.2020.123702.
Otter, V., Langenberg, J., 2020. Willingness to pay for environmental effects of agroforestry systems: a PLS-model of the contingent evaluation from German taxpayers' perspective. Agroforest Syst. 94, 811–829. https://doi.org/10.1007/s10457-019-00449-6.
Pannell J., David, 2003. Uncertainty and Adoption of Sustainable Farming Systems. In: Babcock, B.A., Fraser, R.W., Lekakis, J.N. (Eds.), Risk Management and the Environment: Agriculture in Perspective. Springer, pp. 67–81.
Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation practices by rural landholders. Aust. J. Exp. Agric. 46 (11), 1407–1424. https://doi.org/10.1071/EA05037.
Pattanayak, S.K., Mercer, D.E., Sills, E., Yang, J., 2003. Taking stock of agroforestry adoption studies. Agrofor. Syst. 57, 173–186. https://doi.org/10.1023/A:1024809108210.
Pisante M., Stagnari F., Acutis M., Bindi M., Brilli L., Di Stefano V., Carozzi M. (2015) Conservation Agriculture and Climate Change. In: Farooq M, Siddique K (Eds.): Conservation Agriculture. Springer, Cham: 579–620.
Raedeke, A.H., Green, J.J., Hodge, S.S., Valdivia, C., 2003. Farmers, the practice of farming and the future of agroforestry: an application of Bourdieu's concepts of field and habitus. Rural Sociol. 68 (1), 64–86. https://doi.org/10.1111/j.1549-0831.2003.tb00129.x.
Renner, B., Spivak, Y., Kwon, S., Schwarzer, R., 2007. Does age make a difference? Predicting physical activity of South Koreans. Psychol. Aging 22 (3), 482–493. https://doi.org/10.1037/0882-7974.22.3.482.
Ringle, C.M., Sarstedt, M., Straub, D., 2012. A critical look at the use of PLS-SEM. MIS Q. Q36 (1), 3–11. https://doi.org/10.2307/41410402.
Salamon, S., Farnsworth, R.L., Bullock, D.G., Yusuf, R., 1997. Family factors affecting adoption of sustainable farming systems. J. Soil Water Conserv. 52 (2), 265–271.
Schaupp, L.C., Carter, L., McBride, M.E., 2010. E-file adoption: a study of US taxpayers' intentions. Comput. Hum. Behav. 26 (4), 636–644. https://doi.org/10.1016/j.chb.2009.12.017.
Schlaegel, C., Koenig, M., 2014. Determinants of entrepreneurial intent: a meta–analytic test and integration of competing models. Entrep. Theory Pract. 38 (2), 291–332. https://doi.org/10.1111/etap.12087.
Senyolo, M.P., Long, T.B., Blok, V., Omta, O., 2018. How the characteristics of innovations impact their adoption: an exploration of climate-smart agricultural innovations in South Africa. J. Clean. Prod. 172, 3825–3840. https://doi.org/10.1016/j.jclepro.2017.06.019.
Sheeran, P., Webb, T.L., 2016. The intention–behavior gap. Soc. Pers. Psychol. Compass 10, 503–518. https://doi.org/10.1111/spc3.12265.
Sheppard, B.H., Hartwick, J., Warshaw, P.R., 1988. The theory of reasoned action: a meta-analysis of past research with recommendations for modifications and future research. J. Consum. Res. 15 (3), 325–343.
Shin, D.H., 2009. Towards an understanding of the consumer acceptance of mobile wallet. Comput. Hum. Behav. 25 (6), 1343–1354. https://doi.org/10.1016/j.chb.2009.06.001.
Skodawessely C., Pretzsch J. (2009) Akzeptanz des Energieholzanbaus bei Landwirten. Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. doi:10.1002/9783527627462.ch19.
Slade, E.L., Dwivedi, Y.K., Piercy, N.C., Williams, M.D., 2015. Modeling consumers' adoption intentions of remote mobile payments in the United Kingdom: extending UTAUT with innovativeness. Risk Trust. Psychol. Mark. 32, 860–873. https://doi.org/10.1002/mar.20823.
Strauss, J., Barbosa, M., Teixeira, S., Thomas, D., Junior, R.G., 1991. Role of education and extension in the adoption of technology: a study of upland rice and soybean farmers in Central-West Brazil. Agric. Econ. 5 (4), 341–359. https://doi.org/10.1016/0169-5150(91)90027-I.
Tarlé Pissarra, T.C., Sanches Fernandes, L.F., Leal Pacheco, F.A., 2021. Production of clean water in agriculture headwater catchments: a model based on the payment for environmental services. Sci. Total Environ. 785. https://doi.org/10.1016/j.scitotenv.2021.147331.
Trozzo, K.E., Munsell, J.F., Chamberlain, J.L., 2014. Landowner interest in multifunctional agroforestry Riparian buffers. Agroforest Syst. 88, 619–629. https://doi.org/10.1007/s10457-014-9678-5.
Trujillo-Barrera, A., Pennings, J.M., Hofenk, D., 2016. Understanding producers' motives for adopting sustainable practices: the role of expected rewards, risk perception and risk tolerance. Eur. Rev. Agric. Econ. 43 (3), 359–382. https://doi.org/10.1093/erae/jbv038.
Tsonkova, P., Böhm, C., Quinkenstein, A., Freese, D., 2012. Ecological benefits provided by alley cropping systems for production of woody biomass in the temperate region: a review. Agroforest Syst. 85, 133–152. https://doi.org/10.1007/s10457-012-9494-8.
Tsonkova, P., Mirck, J., Böhm, C., Fütz, B., 2018. Addressing farmer-perceptions and legal constraints to promote agroforestry in Germany. Agroforest Syst. 92 (4), 1091–1103. https://doi.org/10.1007/s10457-018-0228-4.
van Dijk, W.F., Lokhorst, A.M., Berendse, F., de Snoo, G.R., 2016. Factors underlying farmers' intentions to perform unsubsidised agri-environmental measures. Land Use Policy 59, 207–216. https://doi.org/10.1016/j.landusepol.2016.09.003.
van Noordwijk, M., Duguma, L.A., Dewi, S., Leimona, B., Catacutan, D.C., Lusiana, B., Öborn, I., Hairiah, K., Minang, P.A., 2018. SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry? Curr. Opin. Environ. Sustain. 34, 33–42. https://doi.org/10.1016/j.cosust.2018.09.003.
Venkatesh, V., Davis, F.D., 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. Manag. Sci. 46 (2), 186–204.
Venkatesh, V., Morris, M.G., 2000. Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. MIS Q. 24 (1), 115–139.

Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User acceptance of information technology: toward a unified view. MIS Q. 27 (3), 425–478.
Venkatesh, V., Thong, J.Y., Xu, X., 2012. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Q. 36 (1), 157–178. https://doi.org/10.2307/41410412.
Verhaegen, I., Van Huylenbroeck, G., 2001. Costs and benefits for farmers participating in innovative marketing channels for quality food products. J. Rural Stud. 17 (4), 443–456.
Vesala, K.M., Peura, J., McElwee, G., 2007. The split entrepreneurial identity of the farmer. J. Small Bus. Enterp. Dev. 14 (1), 48–63. https://doi.org/10.1108/14626000710727881.
Warren, C.R., Burton, R., Buchanan, O., Birnie, R.V., 2016. Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice. J. Rural Stud. 45, 175–183. https://doi.org/10.1016/j.jrurstud.2016.03.017.
Wellner, K., Theuvsen, L., Heise, H., 2019. Die Teilnahmebereitschaft deutscher Sauenhalter an der Initiative Tierwohl: Wodurch wird sie beeinflusst? Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. GEWISOLA 59 (Jahrestagung, Germany).
Yamano, T., Rajendran, S., Malabayabas, M.L., 2015. Farmers' self-perception toward agricultural technology adoption: evidence on adoption of submergence-tolerant rice in Eastern India. J. Soc. Econ. Dev. 17, 260–274. https://doi.org/10.1007/s40847-015-0008-1.
Yang, H.D., Yoo, Y., 2004. It's all about attitude: revisiting the technology acceptance model. Decis. Support Syst. 38 (1), 19–31. https://doi.org/10.1016/S0167-9236(03)00062-9.
Zehlius-Eckert, W. (2010) Agroforstwirtschaft in der europäischen Forschung – mit einem Schwerpunkt auf der ökologischen Nachhaltigkeit. Agrarholz 2010. Technische Universität München, Germany.