Agroforest Syst (2020) 94:811–829
https://doi.org/10.1007/s10457-019-00449-6

Willingness to pay for environmental effects of agroforestry systems: a PLS-model of the contingent evaluation from German taxpayers' perspective

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Received: 14 September 2018 / Accepted: 28 September 2019 / Published online: 29 November 2019

Abstract The standards of society with regard to agricultural land use have risen during the course of time. A method of management is increasingly being demanded that, alongside the production of food, also benefits the environment and society. Alley cropping agroforestry systems can make a contribution to supporting this demand, since they offer many environmental advantages and also enhance the landscape. In Germany, alley cropping systems in agriculture have only been of low-level importance, since the scale of planting has been restricted to just a few test areas. The reasons for the reticence among farmers to implement alley cropping are likely to lie in the economic disadvantages of agroforestry compared to full area field cultivation. With the aid of financial support, incentives could be created that encourage farmers to establish agroforestry systems. However, potential subsidies should be provided that take into account societal preferences, in order to be able to publicly legitimise them. The aim of this article is therefore to analyse and quantify the level of willingness to pay and its determining factors from the perspective of German taxpayers. To achieve this aim, a complex socio-economic research model has been developed on the basis of the contingent evaluation method and concepts for consumer awareness of sustainably produced food products. The primary data collected on the basis of this research framework from 1714 taxpaying individuals living in Germany was evaluated using descriptive statistics, t-tests, and the partial least squares (PLS) method. The descriptive results show that 65.1% of the respondents have an additional willingness to pay. Of the remaining respondents who were not willing to pay, 75.7% regard agroforestry systems as being useful, but are not willing to pay higher amounts of tax to subsidise them. Throughout the entire sample, an average willingness to pay of €36.59 (∼ US$38.79) per year emerges. Furthermore, the majority of respondents regarded the fulfilment of environmental and nature conservation measures as being the responsibility of agriculture, and the subsidisation of these measures as being the responsibility of the government. The PLS model showed that the assessment regarding secondary tasks of agriculture, including the implementation of environmental and nature conservation measures and the provision of renewable raw materials, has a positive influence on taxpayers' willingness to pay for environmental improvement through agroforestry systems. Based on these results, a wide range of implications are derived for policy makers, farmers, and various advocacy groups.

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Keywords Alley cropping · Landscape element · Willingness to pay · Contingent evaluation method · PLS model · Germany

Introduction

During the past few decades, the use of agricultural land in Germany has been mainly characterised by an intensification, with the focus on increasing yields. The decisive factor for this orientation was the perceived main task of agriculture as being the provision of high-quality food in sufficient quantity. The needs of the almost continuously growing population for a wide-ranging offer of food had to be met despite the decline in area available, realised through continuous productivity increases (Rohwer 2010). Growth of the German population has, however, been stagnating since the start of the twentieth first century. Serious food shortages lie far back in the past, and, notwithstanding the persisting decisive role of food production, additional demands regarding agricultural land use have gradually grown. Therefore, the negative external effects associated with land management, such as nutrient inflow into the groundwater, the disappearance of landscape elements, and the decline in biodiversity, are nowadays publicly discussed, resulting in claims for changes in agricultural management methods (Oppermann et al. 2013).

Agroforestry systems planted with the alley cropping cultivation method, consisting of a mixed cropping system combining the strip-shaped cultivation of short rotation coppice wood with field crops on one plot, has the potential to contribute to sustainable land use (Tsonkova et al. 2012). Within such systems, 12–15 m wide tree strips are planted on the agricultural plots. This distance between the strips complies with the working widths of the respective agricultural machinery and, therefore, minimises disadvantages regarding the cultivation of agricultural crops between them. The trees used are fast-growing short rotation woody plants such as poplar, robinia, or willow, which are harvested at recurring time intervals of 3–8 years and can be used as energy sources in the form of wood chips (Nair 1993; Reeg 2010). Alley cropping agroforestry systems offer many ecological advantages and enhance the landscape (Zehlius-Eckert 2010), while simultaneously taking the value creation function of the soil into account (Schmidt 2011). Consequently, they combine the ecological, social, and economic requirements related to agricultural land use forming the focus of public discussions. Ecological benefits of the agroforestry systems compared to full area farming systems can be generated, such as through better utilisation of groundwater, a reduction in nutrient leaching, a decrease in soil erosion, and enhanced biodiversity (Krummenacher et al. 2008). With regard to social aspects, the tree strips counteract the unattractive appearance of cleared landscapes and as a farmland element, improve the aesthetic appearance of the landscape. The economic aspect is on the one hand taken into account through the fact that the tree strips are planted in harmony with agricultural cropping and are therefore only a marginal interference. On the other hand, the trees as sustainable raw material also generate yield while serving as wind protection for intermediate agricultural crops (Gruenewald et al. 2007). However, these benefits are usually not enough to make agroforestry systems equally as profitable as full area farming. Despite the optimal integration of tree strips into the plots, the farmer incurs additional operating costs through agroforestry systems, and on most German sites, wooded plants deliver a lower yield than field crops (Emmann et al. 2013). In addition, the tree strips can lead to declines in field crop yields due to shading, competition for nutrients and water, and the creation of new habitats for plant pests (Gruenewald 2005). Furthermore, tree strips are planted perennially, so the flexibility in agricultural management decisions is limited during the approximately 20-year period of use. This makes it difficult to react to changes in working widths or shifts in price relations between wood chips and the field crops (Schmidt 2011). These economic restrictions are likely to be the major reason why alley cropping agroforestry systems have not been widely implemented in Germany, and are restricted almost exclusively to trial plots (Reeg 2011). With financial support for planting agroforestry systems, incentives can be created for farmers to implement this form of land use (Bärwolff et al. 2013). In Germany, however, no general public subsidies for agroforestry systems exist to date, even though European Union (EU) agricultural policy takes agroforestry farming into account (Drittler and Theuvsen 2017). The initial establishment of agroforestry systems on agricultural plots is recognised by regulation number 1698/2005

on support for rural development from the European Agricultural Fund for Rural Development (EAFRD), as being eligible for funding in principle (EU 2005). This regulation, which has to date not been implemented by the federal states in Germany, could be applied in the future without any appreciable legal hurdles, on the basis of the European legal framework. In order to politically justify any subsidies, socio-economic evaluations are necessary in order to determine the general level of valuing and willingness to pay among the population for environmental benefits associated with agroforestry systems. This way, it is ensured that funds are used in accordance with public preferences (Pommerehne and Römer 1992).

Since no such investigation on agroforestry systems using the alley cropping method in Germany exists up to now, it is the aim of this study to close this research gap by analysing the level of monetary willingness to pay and its determining factors from the perspective of German taxpayers. A monetary compilation of the price paid on the basis of market observations is not possible, since agricultural wood is a collective environmental good with value components independent of usage. For this reason, the subjectively expressed (additional) willingness to pay among German taxpayers needs to be acquired within the scope of a complex socio-economic research model, which is based on the contingent evaluation method and concepts of consumer perception of sustainable food products (Gerpott and Mahmudova 2008). The primary data collected from 1714 taxpaying individuals living in Germany on the basis of this research model was analysed using the partial least squares (PLS) method, and provides multifaceted implications for politicians and various interested organisations. In this regard, materials and methods are described in detail in "Materials and methods" section. In "Results" section, the results are presented. In "Discussion" section, the results are discussed and a conclusion is drawn.

Materials and methods

Conceptual research framework

In previous scientific literature on the determination of individual preferences for collective environmental goods, both the "contingent evaluation method" and the "choice experiment" are well established (Liebe and Meyerhoff 2005). Unlike methods for evaluating environmental goods with close relationships to private goods, such as the travel to a nature park, those two methods are based on the assumption of hypothetical markets. Therefore, choice experiments focus on weighing up different alternative options for behavioural actions against each other, according to different asset attributes with different gradation levels. Since this study is related to one specific environmental good without any possible variations, the conceptual research framework of this study is based on the contingent evaluation method. This method originates from ideas by Ciriacy-Wantrup (1947), and allows for modelling complex socio-psychological decision processes. The characteristics of the environmental good and/or the resulting perceived (usage-dependent and non-usage-dependent) environmental change, the institution providing the environmental good, socio-demographic characteristics of the taxpayers, and the so-called "payment vehicle", are incorporated in accordance with the contingent evaluation method (Bateman et al. 2002). Since agricultural companies and, thus, privately owned enterprises are the provision institutions in the case of alley cropping agroforestry systems, this environmental good has additional analogies with sustainably produced food. Consequently, such agroforestry systems can also be considered a private, agriculturally produced good with additional collective benefits, which also partially permits arguments relating to concepts of consumer perception towards sustainably produced food products (Liebe and Meyerhoff 2005; Otter et al. 2014). However, the payment vehicle in this study, consistent with the contingent evaluation method, relates exclusively to the additional collective environmental benefit to the public (Liebe and Meyerhoff 2005). In this regard, the payment vehicle can be conceptualised either in the form of a voluntary (i.e., donations) or mandatory payment (i.e., taxes). The advantages and disadvantages of both forms of payment vehicle, and the fact that both state and individual private control can also potentially co-exist in German society for this collective environmental good, justify a more complex design of the payment vehicle (Liebe and Meyerhoff 2005; Ostheimer and Vogt 2010). Consequently, in this study, both voluntary actionism and mandatory

willingness to pay are regarded as separate elements of a willingness to act as presented in Fig. 1. The term "actionism" in the context of this study refers to efforts made to change the awareness of a society or existing conditions by actions.

According to the basic economic principle of utility maximisation, also for agricultural products that can reduce the negative external effects of agriculture, the willingness to act of individuals in the society depends on the value placed on different components of the associated environmental benefit. Thereby, the valuing can be either usage-dependent or non-usage-dependent. In the case of agroforestry systems, usage-dependent valuing would arise through activities in the area affected by the landscape element, such as cycling, hiking, and collecting wild plants. By contrast, non-usage-dependent valuing consists of existence value, option value, and bequest value. Although a clear delimitation of both types of valuing is regarded as being difficult and unnecessary for measuring their entirety, they are considered as conceptually separate from each other in this study (Freeman 2003; Liebe and Meyerhoff 2005). In this regard, usage-dependent valuing of society members is represented by activities that are indicative for a particular closeness to nature, assuming that these influence the willingness to act.

H1 German taxpayers' closeness to nature has an influence on their actionism.

A similar influence must also be assumed for the non-usage-dependent valuing. In this case, it is anticipated that existence value, option value, and bequest value would potentially be reduced through negative external effects associated with agricultural land use. Consequently, a negative attitude towards

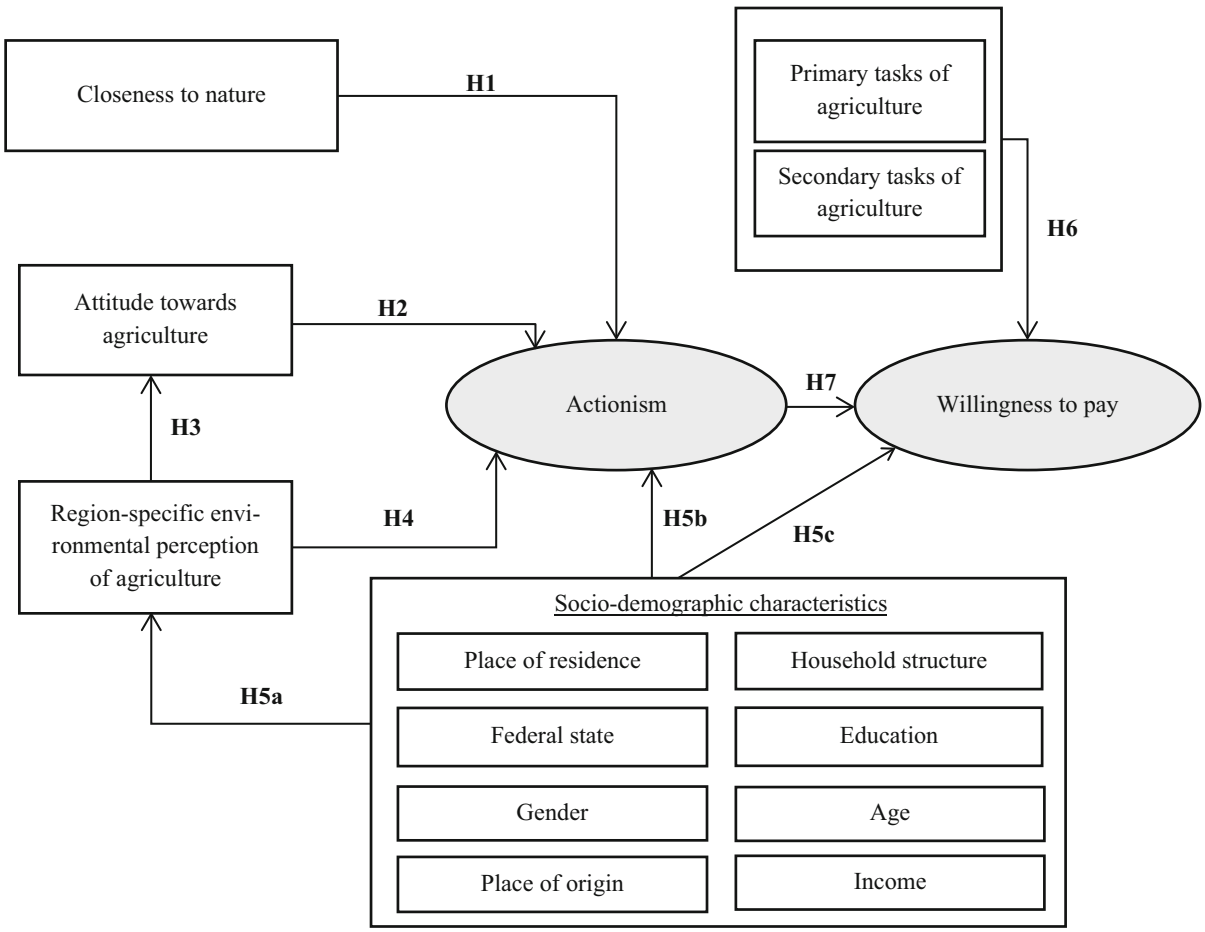

Fig. 1 Research model with hypotheses. *Source*: authors own graphic

the use of existential resources by agriculture would lead to a greater willingness to act (Liebe and Meyerhoff 2005). However, the German landscape architecture and, therefore, also the perception of negative external effects, is subject to strong regional differences (Hunziker 2010). As a consequence, in the present research model, a differentiation is made between the environment-related attitude towards agriculture in Germany as a whole, and the region-specific environmental perception of agriculture. Through the halo effect—a perception bias well known from psychology and often observed in consumer perception—it is expected that the region-specific perception of agriculture will overshine the perception from agriculture in Germany as a whole (Otter et al. 2014; Helmle 2011; Thorndike 1920).

H2 German taxpayers' attitude towards agriculture has an influence on their actionism.

H3 German taxpayers' region-specific environmental perception of agriculture has an influence on their attitude towards agriculture.

H4 German taxpayers' region-specific environmental perception of agriculture has an influence on their actionism.

As observed for other agricultural products with an associated sustainable benefit, such as food certified with a sustainability standard, it must be assumed for alley cropping agroforestry systems that different socio-demographic characteristics have a direct or indirect effect on the willingness to pay (von Berlichingen 2006; Otter et al. 2014). Earlier studies on the perception of food products by German consumers have proven the considerable influence of age, gender, degree of education, and household income. Schulze et al. (2008), Kayser and Spiller (2011), and Otter et al. (2014) present evidence that young female consumers with an above-average level of education are significantly more willing to pay. In addition, for the agroforestry systems forming the focus of this study, a region-specific socio-demographic influence on the willingness to pay must be assumed. This influence can be assumed both directly, via a perception bias arising from the loss of the direct relation to agriculture among parts of the population as a result of urbanisation, and indirectly, via the perception of home landscapes characterised by different types of agricultural production systems (Helmle 2011). For animal welfare meat products, the direct effect has already been confirmed in a study by Pirsich (2017), in which, as in this study, the region and the size of the current place of residence have been taken into account as determinants of purchasing behaviour.

H5a German taxpayers' socio-demographic characteristics have an influence on their region-specific environmental perception of agriculture.

H5b German taxpayers' socio-demographic characteristics have an influence on their actionism.

H5c German taxpayers' socio-demographic characteristics have an influence on their willingness to pay.

Besides the general valuing of environmentally friendly measures, in the specific case of agroforestry systems, it must also be considered that this measure is assigned to a specific sector, namely agriculture. Theoretically, the willingness to pay for farmers' subsidies resulting from the overall valuing of a corresponding measure could be reduced if the population does not regard the implementation of this measure as falling within the remit of agriculture. However, as described in the introduction, the remits associated with agriculture have altered in the perception of the German population since the 1990s from primary tasks, and thus the production of food in high quality and large quantities, towards secondary tasks, such as the conservation of resources and landscape protection (Rohwer 2010). The increasing importance of such process quality aspects in consumer behaviour with respect to food products has already been confirmed in earlier studies by, for example, Korn et al. (2014) and Zühlsdorf and Spiller (2012), and are additionally supported by the increasing proportion of the German population with an additional willingness to pay for environmentally friendly products (Statista 2017). Therefore, it also has to be assumed in the present study that this shift in the perception of agricultural remits has an effect on the willingness to pay for the goods produced in this sector. This applies in particular when these goods, as in the present case of alley cropping agroforestry systems, reduce sector-specific negative external effects and thus benefit the environment (Tsonkova et al. 2012).

H6 German taxpayers' perception of the primary and secondary remits of agriculture influences their willingness to pay.

Referring to sociological research on the control of environmental protection, it is assumed that German taxpayers' willingness to act in favour of an environmental benefit, engendered through the production of an agricultural product, can be divided into voluntary actionism and willingness to pay (Ostheimer and Vogt 2010). Since the individual willingness to take voluntary action per se requires a higher intrinsic motivation with regard to environmental protection, it is also assumed that this actionism to the benefit of environmental and resource protection, which is determined by different characteristics and valuing components, leads to the decision regarding the level of willingness to pay in the form of a tax to subsidise the introduction of alley cropping agroforestry systems (Liebe and Meyerhoff 2005).

H7 German taxpayers' actionism influences their willingness to pay.

The hypothesised complex causal connections between the theoretical constructs in this research model imply the application of variance-based structural equation modelling of primary data for statistical analysis (Chin 1998).

Study design

For the empirical application of the research model, primary data was collected from 1714 taxable German inhabitants in February 2017 by means of a structured online questionnaire (average response duration: 10.31 min). The respondents were recruited via the panel provider mo'web using quota sampling. In order to assure representativeness, quota with regard to age, gender, and regional distribution of the place of residence were set at the beginning of the questionnaire. Minors were not included, since they are usually not fully subject to taxation, and thus do not fall within the target group of this study. Furthermore, they are not of full legal capacity, which due to the framework conditions of the panel provider, excluded them from participating in the survey. This initial socio-demographic information is supplemented by questions regarding type of household, education, income, size of the place of residence, and size of the place where they primarily grew up, at the end of the questionnaire (H5a, H5b, H5c). To operationalise the latent variables reflecting the theoretical constructs within the research model (see Fig. 1), the psychographic characteristics "closeness to nature" (H1), "region-specific environmental perception of agriculture" (H3, H4), "perceived tasks of agriculture" (H6), and "general attitude towards agriculture" (H2) were measured in this order, on the basis of 5-point Likert and Likert-like scaled statements. Due to the novelty of both the conceptualisation and the case under research, the phrasing of the statements reflecting the "closeness to nature", the "region-specific environmental perception of agriculture", and the "general attitude towards agriculture" had to be self-developed, which gives the questionnaire design a partially explorative nature. The "perceived tasks of agriculture" were distinguished in primary and secondary tasks, and aligned to task descriptions according to Nolten (2010). In this study, the resulting actions are divided into "voluntary actionism" (voluntary actions) and "willingness to pay" (binding actions). Measuring the willingness to donate as an indicator of willingness to pay for environmental benefits is considered unreliable due to potential free rider behaviour. Also, the consideration of fictitious entry prices is lacking appropriateness for the specific case under investigation, since they require the ability to exclude non-paying persons from positive external effects. Therefore, in this study, the willingness to pay was queried in the form of a tax increase (Pearce and Özdemiroglu 2002). In this context, the respondents were presented with a payment card for selection, ranging from 0 to 150 euros ($\sim$ 0 to 159 US$[1]) of additional annual tax. Through the targeted limitation of the range of payment suggestions on this scale, the problems of starting point bias and excessive numbers were avoided (Mitchell and Carson 1989). The value range was defined between 0 and 150 euros ($\sim$ 0 to 159 US$) since this reflects a realistic range (Rowe et al. 1996). Despite the limited suitability of the willingness to donate as an indicator for the willingness to pay, the amount of money donated to environmental and nature conservation organisations (ratio scale), the membership in such organisations (nominal scale), and the frequency of nature conservation-related voluntary work (Likert-like scale) are appropriate indicators for "voluntary actionism", and were therefore also part of the questionnaire. While

[1] Throughout the whole paper, the exchange rate of €1 = US$1.06, observed on February 15th 2017, has been used for the conversion of the currency.

these variables were placed after the statement regarding the psychographic feature "closeness to nature" in the questionnaire due to their thematic relation, the "willingness to pay" together with the prior information text (and the complementary illustration) was only queried after all psychographic characteristics, in order to avoid a bias in the response behaviour of the interviewees. The information text was aimed to establish a hypothetical market by defining the change to the environment through the good, its provision, and the tax as a payment vehicle (Liebe and Meyerhoff 2005). In order to minimize response bias, a quality assurance statement[2] was implemented and respondents who answered incorrectly excluded from the survey.

Results

Sample description

The sample comprises 1714 inhabitants of Germany subject to taxation, and who are all > 18 years of age, with 851 women (49.6%) and 883 men (50.4%) participating in the survey. This makes the sample representative with regards to gender distribution, since it approximately corresponds to the gender distribution in the German population as a whole (women: 50.7%; men: 49.3%) (Statistisches Bundesamt 2018). The same applies to the age distribution within the sample with regards to the German adult population, although the youngest (18–29) and oldest (60 and above) age groups are slightly underrepresented, while the two middle age groups (30–44; 45–59) are slightly overrepresented, as shown in Table 1. The average age within the sample is about 49.5 years (standard deviation: 14.4) and the median is about 51 years. The regional distribution of the sample is also comparable to that of the German population overall, divided according to German federal states. Only the states of Hamburg, Saxony, Berlin, and Schleswig–Holstein are slightly overrepresented in the sample, while the opposite is true for Baden-Württemberg, Bavaria, and North Rhine-Westphalia (see Table 1). The distribution with regards to the highest professional/educational qualification shows some small differences between the population sample and the whole German population. While a secondary school leaving certificate and vocational degree were less common, secondary school degree and study were more frequent in the sample compared to the overall German population (see Table 1). In Table 1, it is also visible that there are only slight deviations in relation to the general population for both the size of the municipality in which the respondents primarily grew up, and the size of the municipality in which they are currently living. In both cases, the share of inhabitants is slightly higher for communities and large towns, while it is slightly lower for small and medium-sized towns in the sample compared to the overall situation in Germany. In addition, a comparison of the numbers for size of place of origin and size of the place in which they live shows that both within the sample and within Germany as a whole, there is a trend towards urbanisation and/or living in larger towns. The household structure of the sample compared to the German population only shows an underrepresentation of childless single occupancy households, and a slight overrepresentation of households containing partners and a child/children. The income distribution of the sample is also very similar to that of the overall German population, with the low and high incomes a little less represented, while the middle incomes are slightly overrepresented.

Descriptive statistics

The additional willingness to pay through tax payments/tax increases for subsidising agroforestry systems amounts to an average level of €36.59 (∼ US$38.79) annually. The standard deviation is €40.96 (∼ US$43.42) and the median €20.00 (∼ US$21.20). The fact that the median lies considerably below the average value can be explained by the fact that 598 (34.9%) of the respondents, i.e., over a third, are not willing to pay more and are accordingly not willing to accept a tax to fund agroforestry. However, of those who are not willing to pay, 75.7% have a positive attitude towards the statement: "I regard agroforestry systems as being useful, but I am not willing to pay more for them". In terms of the 5-point Likert scale, the average value was 4.11, and the standard deviation was 0.974. There was a very similar response to the statement: "I cannot afford any more payments". This was agreed by 68.9% of the

[2] Phrasing of the quality assurance statement: "This is a quality assurance. Please strictly reply with "completely true"!".

Table 1 Sample description compared to the overall German population. *Source*: authors own calculations with data from Statistisches Bundesamt (2018)

Variable	Description	Frequency (%) sample	Frequency (%) in Germany
Gender	Women	49.6	50.9
	Men	50.4	49.1
Age	18–29	11.3	13.7
	30–44	24.8	20.2
	45–59	35.8	31.4
	60 and older	28.1	34.7
Federal state	Bremen	0.8	0.8
	Saarland	1.3	1.2
	Mecklenburg-West Pomerania	2.5	2.0
	Thüringen	2.7	2.6
	Brandenburg	3.2	3.0
	Hamburg	3.2	2.2
	Saxony-Anhalt	3.3	2.7
	Rhineland-Palatinate	4.1	4.9
	Hessen	5.8	6.5
	Saxony	6.8	5.9
	Berlin	6.8	5.3
	Schleswig–Holstein	7.2	5.6
	Lower Saxony	9.1	9.6
	Baden-Württemberg	10.4	12.3
	Bavaria	13.4	14.7
	North Rhine-Westphalia	19.4	20.7
Education	Secondary school leaving certificate	7.6	13.9
	Secondary school degree	16.4	10.1
	A-level	13.7	13.7
	Vocational degree	28.6	34.4
	Foreman/technician/college	9.2	7.1
	Diploma/bachelor/master	22.9	16.9
	Doctorate	1.3	1.2
	Other	0.3	2.7
Place of origin	Community < 500 inhabitants	5.7	4.1
	Community 500–4999	21.3	20.3
	Small town 5000–19,999	20.5	23.9
	Medium town 20,000–99,999	20.2	24.1
	Large town 100,000 and more	32.3	27.6
Place of residence	Community < 500 inhabitants	3.7	0.8
	Community 500–4999	16.0	13.7
	Small town 5000–19,999	21.1	26.5
	Medium town 20,000–99,999	21.8	27.4
	Large town 100,000 and more	37.4	31.6
Household structure	Single occupancy	30.0	41.1
	Single occupancy with child/children	5.1	3.8
	Partner household	39.5	38.9
	Partner household with child/children	25.4	16.2

Table 1 continued

Variable	Description	Frequency (%) sample	Frequency (%) in Germany
Income	< 1000 €/month	12.4	13.1
	1000–1999 €/month	27.2	31.7
	2000–2999 €/month	26.7	23.1
	3000–3999 €/month	18.5	13.4
	4000–4999 €/month	9.0	8.5
	5000 €/month and more	6.2	10.2

The categorisation of educational levels follows the German system (secondary school leaving certificate, so called "Hauptschulabschluss", represents the lowest school-leaving qualification (9 or 10 years of schooling); secondary school degree, so called "Realschulabschluss", represents the medium school-leaving qualification (10 years of schooling); A-level, so called "Abitur", represents the highest school-leaving qualification (12 or 13 years of schooling)

respondents without an additional willingness to pay, while the average value was 4.04 and the standard deviation was 1.146. The statements "protection of and improvement in the environment are not necessary" and "the conservation of natural resource is not necessary" were responded to negatively by 74.4% (average value: 1.91; standard deviation: 0.988) and, respectively 76.1% (average value: 1.88; standard deviation: 0.986) of those who are not willing to pay.

The results of the mean value comparisons for the willingness to pay between different sociodemographic groups within the sample show that respondents who are male, older than 45, or with higher qualifications, have a greater willingness to pay. As presented in Table 2, the t-tests for independent samples show that the differences are significant in all three cases on different levels, after the Levene test for variance equality had previously shown that the variances are not equal.

Regarding potential supportive measures as part of agricultural policy, 82.1% of respondents agreed that it is in principle the task of politicians to subsidise environmental and nature conservation measures (average value: 4.27; standard deviation: 0.903). A comparable importance was ascribed by respondents to agriculture, with regard to the fulfilment of both primary and secondary tasks. The securing of natural habitats, environmental and nature conservation, and the production of food are regarded by a particularly large number of respondents as being an important task of the German agricultural sector, as is shown in Table 3 (average values and standard deviations are shown in Table 4).

Table 2 Gender, age and education differences with regard to willingness to pay. *Source*: authors own calculations

Gender		Male	Female	t-value
Willingness to pay		€38.93	€34.21	2.393*
Age		Over 45	Up to age 45	t-value
Willingness to pay		€38.73	€32.78	2.939**
Education	Higher qualification[a]		No higher qualification[b]	t-value
Willingness to pay	€44.97		€32.38	5.794***

Significance level: $p < 0.001$ (extremely significant***), $p < 0.01$ (highly significant**), $p < 0.05$ (significant*)

[a]Doctorate, study, foreman

[b]Secondary school leaving certificate, secondary school degree, A-level, vocational degree

PLS analysis

For further analysis of the data described above, the PLS method was used with the aid of the SmartPLS 3 software. Due to its specific statistical appropriateness for estimating complex causal dependencies between latent variables within explorative models (Chin 1998; Hair et al. 2017; Henseler et al. 2016), the PLS method is considered advantageous over other regression models (e.g., logit regression) for analysing the willingness to pay model for agroforestry systems developed in the previous sections. The quality of the measurement model will be tested using reliability and validity criteria. The reliability of the respective

Table 3 Relative frequency distribution of the assessment regarding the importance of fulfilling primary and secondary tasks by the German agricultural sector. *Source*: authors own calculations

	Unimportant (%)	Rather unimportant (%)	Somewhat important (%)	Rather important (%)	Very important (%)
Production of food[a] (n = 1714)	0.6	1.3	15.0	39.8	43.3
Provision of renewable raw materials[b] (n = 1714)	0.8	2.7	19.0	38.2	39.3
Securing of food for the global population[a] (n = 1714)	1.5	3.7	19.0	34.1	41.7
Securing of natural habitats[b] (n = 1714)	0.9	1.5	12.6	41.2	43.8
Landscape maintenance[b] (n = 1714)	0.8	2.6	14.4	42.6	39.6
Environmental and nature conservation measures[b] (n = 1714)	0.9	2.1	12.2	36.1	48.7
Maintenance of the population in rural areas[b] (n = 1714)	1.1	4.0	20.9	39.7	34.3
Securing jobs in rural areas[b] (n = 1714)	1.1	2.5	20.3	38.3	37.8
Preserving of rural tradition[b] (n = 1714)	2.2	5.7	24.0	38.5	29.6

[a]Primary tasks

[b]Secondary tasks

indicators used in the model is checked with the aid of the loading of all indicators onto the corresponding constructs. Since the construct loadings are without exception above the threshold value of 0.6 (Table 4), the requirements for indicator reliability are met. Furthermore, it is checked whether with the average variance extracted (AVE) and the construct reliability, the convergence criteria are satisfied. Table 4 shows that all AVE values exceed the threshold value of 0.5, and the minimum requirements with regard to construct reliability of 0.7 have been achieved throughout. Therefore, the model can be regarded as being reliable (Hair et al. 1998, 2011). With the Fornell–Larcker criterion and the cross-loadings, two quality measures are used to examine the discriminant validity. In order to fulfil the Fornell–Larcker criterion, the AVE values of the constructs must be greater than all squared correlations of the affected variables with the other constructs. On the basis of the cross-loadings, it is evaluated whether all indicators used to operationalise the constructs have higher loadings for the related construct than for the remaining constructs of the model (Fornell and Larcker 1981; Hair et al. 2012). In the present model, both quality criteria are fulfilled (Table 5), so that the discriminant validity can be assumed as being given. Alongside the quality criteria described above, it is also controlled for predictive validity using the Stone-Geisser criterion Q^2 of the cross-validated communality for the constructs. In the willingness to pay model for agroforestry systems under consideration, the commonality according to Stone-Geisser's Q^2 is significantly higher than the threshold value of 0 for all constructs (Hair et al. 2011; Huber 2012). The model can therefore be regarded not only as being reliable, but also as valid.

Below, the R^2 values and path coefficients are considered with the related significance level in order to evaluate the willingness to pay model for agroforestry systems in Germany. In Fig. 2, the coefficients of determination are shown for the "attitude towards agriculture" ($R^2 = 0.106$) and "region-specific environmental perception of agriculture" ($R^2 = 0.005$) constructs, as well as the "voluntary actionism" ($R^2 = 0.445$) and "willingness to pay" ($R^2 = 0.162$) constructs. A high coefficient of determination means that the respective construct is explained well by the determining constructs. According to Huber (2012), the basic rule applies that the declared variance share of a construct by the determining constructs of the model should be at least 25% ($R^2 \geq 0.250$). Figure 2 clarifies that the explained variance of voluntary actionism ($R^2 = 0.445$) clearly

Table 4 Reliability of the willingness to pay model for agroforestry systems. *Source*: authors own calculations; constructs created from individual statements

Indicator	Question/statement	AV[1]	SD[2]	CL[3]	CR[4]	AVE[5]
Construct "Actionism"					0.886	0.565
SpH	How often have you financially supported an environmental or nature conservation organisation in the last 12 months?	1.84	1.095	0.774		
AB1	How often do you engage in preserving nature and animal and plant species or attempt to take climate protection measures?…. I buy organic products	3.17	1.011	0.802		
AB2	…I help plant and care for biotopes	1.67	1.012	0.664		
AB3	…I buy regional products	3.74	0.914	0.669		
AB4	…I buy Fairtrade-certified products	3.04	1.052	0.779		
AB5	…I give targeted financial support to environmental/nature/climate conservation measures	2.06	1.109	0.808		
Construct "Willingness to pay"					1.000	1.000
ZbH	What amount of tax would you be willing to pay as a maximum per year to support agroforestry systems?	36.59	40.964	1.000		
Construct "Primary tasks of agriculture"					0.859	0.754
Ap1	In your view, how important is the fulfilment of the following tasks by the German agricultural industry? …Production of food	4.24	0.795	0.948		
Ap2	… Securing food provision for the global population	4.11	0.938	0.781		
Construct "Secondary tasks of agriculture"					0.910	0.629
As1	…Provision of renewable raw materials	4.12	0.865	0.785		
As2	…Securing of natural habitats	4.25	0.802	0.864		
As3	…Landscape maintenance	4.18	0.829	0.830		
As4	…Environmental and nature conservation measures	4.29	0.831	0.862		
As5	…Maintenance of the settlement of rural areas	4.02	0.901	0.712		
As6	…Securing jobs in rural areas	4.09	0.879	0.687		
Construct "Bond with nature"					0.912	0.511
Nv1	How frequently do you undertake the following leisure activities in nature? …Walking	3.77	1.047	0.630		
Nv2	…Hiking	2.75	1.235	0.680		
Nv3	…Nature observation	2.79	1.212	0.798		
Nv4	…Animal observation	2.58	1.180	0.781		
Nv5	…Determining animals and plants	2.08	1.113	0.780		
Nv6	…Gardening	2.97	1.421	0.641		
Nv7	How often do you come into contact with other activities? …I gather fruit or mushrooms	2.27	1.224	0.700		
Nv8	…I enjoy relaxing time in nature	3.65	1.013	0.705		
Nv9	…I smell/collect herbs and flowers	2.54	1.262	0.755		
Nv10	…I create decorations from natural materials	2.03	1.152	0.653		
Construct "Attitude towards agriculture"					0.848	0.583
EL1	We'd like to know your opinion about the following statements regarding the German agricultural industry. … The agricultural industry uses too much fertiliser and pest control agents	4.01	0.888	0.765		
EL2	…The agricultural industry produces too much food	2.99	1.061	0.735		
EL3	…The maintenance of intensive agriculture makes no sense	3.03	1.079	0.712		
EL4	…Agriculture in its present form is an increasing danger to natural resources such as water bodies and soil	3.58	1.006	0.836		

Table 4 continued

Indicator	Question/statement	AV[1]	SD[2]	CL[3]	CR[4]	AVE[5]
Construct	*"Region-specific environmental perception of agriculture"*				0.940	0.692
UL1	Do you think that the following impact of agriculture on the environment is also of significance in your region?… Inflow of substances into water bodies (fertilisers, etc.)	3.33	1.143	0.815		
UL2	…Air pollution	3.42	1.114	0.773		
UL3	…Soil and wind erosion	2.89	1.112	0.825		
UL4	…Changes to the soil/disappearance of humus	2.96	1.124	0.864		
UL5	…Changes to the landscape (empty landscapes)	3.18	1.149	0.848		
UL6	…Extinction of animal and plant species	3.23	1.172	0.843		
UL7	…Destruction of habitats	3.39	1.140	0.853		
Construct	*"Gender"*				1.000	1.000
Wei	Female	0.50	0.500	1.000		
Construct	*"Age"*				1.000	1.000
Alt	Year of birth (recoded—over 45)	0.64	0.480	1.000		
Construct	*"Education"*				1.000	1.000
Bil	Highest qualification (Doctorate, study, foreman)	0.33	0.472	1.000		
Construct	*"Income"*				1.000	1.000
EK	Monthly net household income (over €3000)	0.34	0.473	1.000		
Construct	*"Household structure"*				1.000	1.000
HS	Type of household (partner household with child/children)	0.25	0.436	1.000		
Construct	*"Federal state"*				1.000	1.000
BL	In which federal state do you live (Saxony)	0.07	0.252	1.000		
Construct	*"Size of place of origin"*				1.000	1.000
AU	Where did you grow up? (community from 500 to less than 5000 residents)	0.21	0.410	1.000		
Construct	*"Size of place of residence"*				1.000	1.000
WO	Where do you live? (community from 500 to less than 5000 residents)	0.16	0.367	1.000		

[1]*AV* average value, [2]*SD* standard deviation, [3]*CL* construct loading, [4]*CR* construct reliability, [5]*AVE* average variance extracted

SpH, AB1–5, Nv1–10 = statements (scale from 1 = never, to 5 = very often); ZbH = rating scale (from 0 = €0, to 15 = €150); Ap1–2, As1–6 = statements (scale from 1 = unimportant, to 5 = very important); EL1-4 = statements (scale from 1 = not at all true, to 5 = completely true); UL1–7 = statements (scale from 1 = very low importance, to 5 = very high importance); Wei, Alt, Bil, EK, HS, BL, AU, WO = dummy variable (0 = no; 1 = yes)

exceeds the threshold value, and is therefore well explained. The explained variance of the willingness to pay is about 16.2% ($R^2 = 0.162$), and thus below the desired value. However, when evaluating the explained variance, the aim of the study should be taken into account. Within the scope of the present explorative pilot study regarding the willingness to pay for agroforestry systems, a variance explaining about 16.2% of the willingness to pay for a land usage system that is still largely unknown is considered acceptable, and is only restrictive to the quality of the overall model to a limited degree (Huber 2012). The relatively low R^2 value merely states that other values that have not been investigated in the model exist, which exert an influence on the willingness to pay. The results of the cross-validated redundancy for the constructs also show that the Q^2 values according to Stone–Geisser are all above the threshold value of 0. Therefore, the predictive validity can also be assumed for the structure model (Huber 2012).

The path coefficients show, in case they are significant, high causal influences within the willingness to pay model (Fig. 2). The closeness to nature (0.537***; H1), the attitude towards agriculture (0.144***; H2), and the region-specific environmental perception of agriculture (0.133***; H4) exert a clear positive influence on the voluntary actionism. The voluntary actionism (0.272***; H7) in turn positively

Table 5 Latent variable correlations and discriminant validity. *Source*: authors own calculations

	Willingness to act	Age	Primary tasks of agriculture	Size of place of origin	Education	Federal state	Income	Attitude towards agriculture	Gender	Household structure	Bond with nature	Region-specific environmental perception	Secondary tasks of agriculture	Size of place of residence	Willingness to pay
Willingness to act	**0.752**														
Age	− 0.030	**1.000**													
Primary tasks of agriculture	0.126	0.210	**0.869**												
Size of place of origin	0.002	− 0.013	0.027	**1.000**											
Education	0.196	0.045	0.021	− 0.024	**1.000**										
Federal state	− 0.052	0.049	0.049	0.006	0.044	**1.000**									
Income	0.202	− 0.030	0.004	− 0.030	0.258	− 0.041	**1.000**								
Attitude towards agriculture	0.267	0.053	0.029	− 0.034	0.091	− 0.015	0.074	**0.764**							
Gender	− 0.014	− 0.136	0.002	0.005	− 0.130	− 0.028	− 0.076	− 0.032	**1.000**						
Household structure	0.137	− 0.172	− 0.003	0.017	− 0.008	− 0.020	0.258	− 0.017	0.079	**1.000**					
Bond with nature	0.605	0.119	0.208	0.028	0.131	− 0.011	0.119	0.185	0.096	0.128	**0.715**				
Region-specific environmental perception	0.334	0.021	0.180	0.006	− 0.005	− 0.027	0.011	0.326	0.012	0.011	0.306	**0.832**			
Secondary tasks of agriculture	0.279	0.250	0.675	0.028	0.022	0.047	− 0.011	0.224	0.082	− 0.026	0.360	0.325	**0.793**		
Size of place of residence	0.029	0.004	0.060	0.421	− 0.030	− 0.017	0.041	− 0.025	0.033	0.073	0.098	− 0.044	0.046	**1.000**	
Willingness to pay	0.345	0.070	0.105	0.007	0.145	− 0.060	0.178	0.185	− 0.058	0.025	0.247	0.147	0.215	0.051	**1.000**

influences the willingness to pay, just as the secondary tasks of agriculture (0.168***; H6) directly influence the willingness to pay. In addition, the region-specific environmental perception of agriculture (0.326***; H3) has a recognisable positive influence on the attitude towards agriculture. Of the socio-demographic characteristics, only the (relatively small) size of the place of residence (-0.061*; H5a) has an influence on the region-specific perception of agriculture and its negative externalities, remarkably a negative one. By contrast, the federal state (− 0.038*; H5b), education (0.091***; H5b), gender (− 0.062**; H5b), age (− 0.105***; H5b), and income (0.087***; H5b) influence the voluntary actionism in different directions. Direct influences of socio-demographic characteristics on the willingness to pay come from the federal state (− 0.052*; H5c), education (0.056*; H5c), gender (− 0.047*; H5c), and income (0.112***; H5c).

Discussion

The descriptive results show that the majority of respondents (65.1%) are willing to pay for agroforestry systems. In addition, 75.7% of those who are not willing to pay (34.9%) regard agroforestry systems as being useful, but are not willing to pay more money for them. These results reflect a very high approval level of 94.9% with regard to agroforestry mixed cultures, and a supportive attitude of the German population towards land usage alternatives becomes very evident. This is also made clear with regard to the evaluation of task fulfilment. Securing natural habitats is classified as important by most respondents (85.0%), followed by environmental and nature conservation measures (84.8%). The production of food comes only third, and is regarded by 83.1% of respondents as being an important task of agriculture. Furthermore, 82.1% endorse subsidies for environmental and nature conservation measures as part of the agricultural policy. The societal contribution by agriculture therefore goes far beyond the production of food, as already demonstrated by Kantelhardt and Heissenhuber (2005).

Earlier studies on sustainable food revealed that in Germany young females with above average education are significantly more willing to buy (e.g., Otter et al. 2014), however this observation does not appear to equally hold true for agroforestry systems. The comparisons of mean values in this case show that men are more willing to pay than women, respondents over 45 years of age are more willing to pay than those under 45, and that a higher qualification is associated with a higher willingness to pay. The results of the PLS analysis also confirm the direct influence of gender and education on the willingness to pay. The gender-specific difference could be attributed to the fact that women feel more responsibility and have a greater knowledge of purchasing food than men, and are therefore more willing to pay for food but not for agroforestry systems (Stieß and Hayn 2005). By contrast, age is not directly significant regarding willingness to pay, but has an indirect effect on willingness to pay via path dependence. Other socio-demographic features such as household structure and size of the place of origin show no significant influences. The region-specific perception of agriculture and its environmental impacts are the only factors to be significantly influenced by the size of the place of residence, showing that German inhabitants living in smaller municipalities perceive fewer negative externalities associated with agriculture. As a consequence, hypotheses 5a, 5b, and 5c can only be partially accepted.

The PLS analysis provides further evidence of the high influence of a closeness to nature on the voluntary actionism, leading to the acceptance of hypothesis 1. A high usage-dependent valuing of nature corresponds to a high willingness to act. Therefore, this study also confirms statements by Nisbet et al. (2009) and Perkins (2010) regarding the positive influence of proximity to nature on behaviour towards the environment.

The results further show that non-usage-dependent valuing also influences the willingness to act. Consequently, a critical attitude towards agriculture in Germany as a whole (directly) and a negative region-specific environmental perception of agriculture (indirectly) leads to a greater voluntary actionism. Our results therefore confirm hypotheses 2 and 4, as well as the assumptions that goods with a high existence, option, and bequest value potentially attempt to reduce the associated negative external effects formulated above (Liebe and Meyerhoff 2005). Furthermore, the influence of the region-specific environmental perception of agriculture on the attitude towards agriculture (hypothesis 4) provides evidence

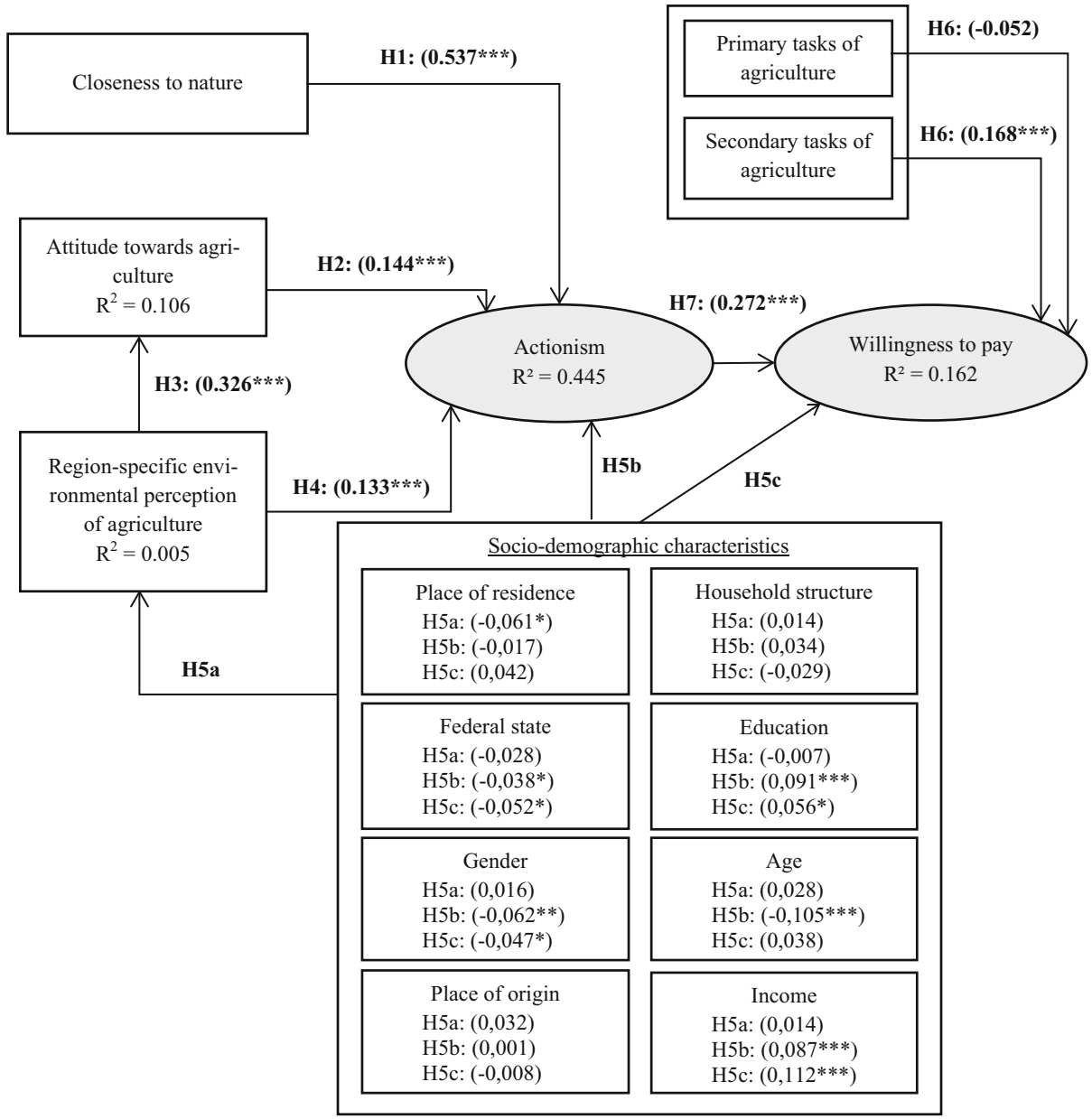

Fig. 2 Determinants of the willingness to pay for agroforestry systems. Numbers in parentheses represent path coefficients; significance level: $p < 0.001$ (extremely significant***), $p < 0.01$ (highly significant**), $p < 0.05$ (significant*). *Source*: authors own graphic and calculations.

of the halo effect (e.g., Thorndike 1920). The public perception of agriculture in Germany as a whole is not solely created by national measures and processes, but regional agricultural structures and performances.

The perception of the primary and secondary tasks of agriculture has a disparate effect on the willingness to pay. While the importance of primary tasks (food production and food security), which can also be realised by classic land usage systems, exert no significant influence according to the PLS results, it has been shown that the assignment of importance regarding the fulfilment of secondary tasks by agriculture (provision of renewable raw material, securing of natural habitats, implementation of environmental

and nature conservation measures, etc.) leads to a higher willingness to pay for agroforestry systems. This result gives evidence that the ongoing shift in remits associated with agriculture and the increasing demand for environmentally friendly agricultural production methods by the German society lead to a higher willingness to pay also for collective environmental goods with value components independent of usage such as agroforestry systems (Rohwer 2010). Hypothesis 6 can therefore only be accepted in relation to the secondary tasks of agriculture.

The influence of the voluntary actionism on the willingness to pay clarifies that an actionism that is characterised by frequent purchasing of organic and regional products, and targeted support for environmental and nature conservation measures, leads to a higher willingness to pay for agroforestry systems. Consequently, hypothesis 7 can be accepted. This result, too, comes against the background of studies that are already known in a supportive manner (e.g., Laroche et al. 2001). Such studies have shown that for consumers with a higher willingness to pay for environmentally friendly products, environmentally friendly behaviour is also of relevance and importance.

The contingent evaluation method has already proven its worth multiple times in order to determine individual preferences for collective environmental goods (Liebe and Meyerhoff 2005), and has also led to plausible and consistent results in the present study. Within the scope of the evaluation of non-tradable goods, deviations can however occur between the actual and stated willingness to pay, since the respondents had limited knowledge of agroforestry systems prior to the survey. Furthermore, the question format can distort the results. Respondents tend to be more willing to pay when asked about a minimal compensation payment for negative effects on environmental quality stemming from the non-use of tree strips, compared to a question concerning the maximum willingness to pay for the comparable environmental improvement through agroforestry systems (Diamond and Hausman 1994). However, the contingent evaluation method offers an appropriate approach in order to give socio-economic consideration to specific innovative (environmental) goods, such as agroforestry systems, on the basis of hypothetical scenarios (Pommerehne and Römer 1992).

Conclusions

This study aims to record the willingness to pay among the German taxpaying population for agroforestry land use, and to identify and quantify the determining factors of the willingness to pay in order to provide specific implications. The descriptive results emphasise that an average willingness to pay of €36.59 (∼ US$38.79) annually exists among German taxpayers. Overall, 65.1% of the population sample expressed a willingness to pay for agroforestry systems. Of the remaining respondents who were not willing to pay, 75.7% regard agroforestry systems as being useful, but are not willing to pay higher amounts of money for them. In addition, 82.1% agree that it is fundamentally the task of politicians to subsidise environmental and nature conservation measures. The fact that agroforestry implementation falls within the remit of agriculture is demonstrated by respondents classifying the fulfilment of sustainability targets linked to agroforestry systems as being important. Furthermore, 85% of respondents regard the securing of natural habitats, and 84.8% regard environmental and nature conservation measures, as being important aspects of agriculture, while 82.2% and respectively 77.7% confer a high degree of importance on landscape maintenance as well as the provision of renewable raw materials. In addition, the results of the PLS analysis show that the increasing societal assignment of importance to the fulfillment of sustainability tasks by the agricultural sector has a highly significant positive influence on the willingness to pay for the planting of agroforestry systems. These results imply the clear recommendation to politicians to subsidise the planting of agroforestry systems using the alley cropping cultivation method in the future. Even though previous studies have observed a higher profitability of such agroforestry systems in Germany, when compared to the annual farming system, they may also be associated with higher risks resulting from high capital commitment and uncertain sales channels. A stronger prioritising within the framework of the ecological focus areas or an alternative financial support might compensate for these risks (Langenberg et al. 2018). The introduction of a tax to subsidise agroforestry systems also provides protection against a possible gap, revealed by Claudy et al. (2013), between the stated and actual willingness to pay, due to its obligatory nature.

The results of the PLS analysis further show that the region-specific environmental perception of agriculture has an highly significant influence on the general attitude towards agriculture. Accordingly, the respondents who confer a high level of importance on the negative external effects of agriculture in their region have a more critical regard for agriculture in the whole of Germany than those who do not. The region-specific environmental perception and the attitude towards agriculture further influence the voluntary actionism and also the willingness to pay. A critical view of current agriculture therefore leads to an increasing willingness to support environmental and nature conservation measures on the one hand (voluntary actionism), and an increasing willingness to support subsidies for agroforestry systems (willingness to pay) on the other hand. Consequently, the results imply that the planting of agroforestry systems using the alley cropping cultivation method could be an appropriate cultivation practice for farmers to contribute to sustainable land use (Tsonkova et al. 2012), and simultaneously deal with the increasing societal criticism on the negative externalities of the agricultural sector in Germany (Spiller et al. 2015). Complying with societal demands could thereby help to enhance their reputation and strengthen their "license to operate". To leverage this effect and improve legitimacy of additional tax payments for agroforestry systems, especially among socio-demographic groups in Germany which are associated with a lower willingness to pay, specific corporate social responsibility (CSR)-campaigns by farmers and agricultural associations are recommended (Heyder and Theuvsen 2008). The positive connection between the voluntary actionism and the willingness to pay shows that the willingness to support environmental or nature conservation organisations also leads to the willingness to financially support sustainable land usage concepts. For the farmers and their advocacy groups, it is therefore advisable to work together with the organisations and to jointly develop concepts for future land use, which meet the demands of both farmers and the society.

Limitations of this research may stem from its explorative nature, as well as the fact that the communities in large towns are underrepresented, and small and medium-sized towns are overrepresented in the population sample. A similar phenomenon applies to the age groups, with the population sample comprising slightly more respondents in the middle-aged groups, while the youngest and oldest age groups are underrepresented respectively compared to the overall German population. Furthermore, the issue of socially desirable responding can only be minimized by proper survey techniques, not fully avoided. Even though this study created an anonymous interview situation and made use of a non- suggestive questionnaire design, the measurement of the willingness to pay might be more frequently affected by an upward than a downward bias depending on the social norm individually perceived by the respondents (Börger 2012).

In future studies, a further analysis should be conducted as to the scale on which supportive measures for agroforestry should be designed, so that agroforestry systems can be implemented by farmers while at the same time avoiding erroneous allocations of tax funds.

Funding Funding was provided by German Federal Ministry for Education and Research (BMBF).

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