Agroforest Syst (2018) 92:1091–1103
https://doi.org/10.1007/s10457-018-0228-4

Addressing farmer-perceptions and legal constraints to promote agroforestry in Germany

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Received: 24 March 2017 / Accepted: 9 April 2018 / Published online: 13 April 2018

Abstract Agroforestry is receiving increasing attention in Germany because of its capacity to address some of the negative consequences of intensive agriculture. However the actual uptake and maintenance of agroforestry by farmers remains low. The aim of this study was to identify the opportunities and obstacles to agroforestry in Germany and to identify potential measures which could address the obstacles and increase agroforestry adoption. Qualitative interviews with 32 farmers indicated that the legal framework and administrative burden associated with agroforestry in Germany was a major obstacle. The farmers recognised that agroforestry provided environmental benefits, but these do not always increase farm profitability. Agroforestry was identified as a viable alternative to conventional farming systems, especially in less productive areas, not profitable when managed in a conventional way. To enhance the implementation of agroforestry the simplification of the legal framework is crucial. Modern agroforestry should be better recognized by existing policy measures providing payments for environmentally friendly farming. Ultimately, an integrated approach for environmental benefits and production objectives is required, which is based on rewarding farmers for providing ecosystem services (ESs) and a stronger public involvement in sustainable land use practices. Rewarding farmers for ESs could increase the interest in agroforestry in highly productive areas, enhancing sustainable land use in the long term.

Keywords Barriers for agroforestry · Ecosystem services · Legal framework · Market benefits · Policy measures

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Introduction

Agroforestry systems are receiving increasing attention in temperate regions due to their capacity to counteract negative impacts of intensively managed systems. Traditionally, trees in rural areas were used for the production of fruits, fodder and wood for fuel or timber (Eichhorn et al. 2006). Trees were also planted to provide shade and shelter, combat erosion, and improve landscape aesthetics (Eichhorn et al. 2006). The most prominent traditional agroforestry systems still present in central Europe are windbreaks, hedgerow systems, and orchard meadows (*Streuobst*) (Baudry et al. 2000; Herzog 1998; Nerlich et al. 2013). In the context of contemporary agricultural and forestry practices, traditional agroforestry systems have lost their economic significance, however they

remain ecosystems of high nature and cultural value (HNCV; Moreno et al. 2017).

In contrast to many traditional systems, modern, production-orientated agroforestry is compatible with contemporary production technologies, allowing for machinery usage, in order to achieve economically competitive production (Unseld et al. 2011). In this context, agroforestry practices, such as alley cropping systems (ACSs), which consist of linear tree hedgerows and crop alleys that are multiple machine widths wide, come into the picture. In Germany a type of ACS, which consist of multiple rows of fast growing trees (short rotation coppice hedgerows) for biomass feedstock production and conventional crops, has been proposed (Grünewald et al. 2007). These ACSs can diversify agricultural production systems in an economically viable and environmentally friendly manner. For example, tree rows of ACSs improve microclimate conditions, prevent soil erosion, reduce ground- and surface water pollution, promote biodiversity mainly in intensively managed landscapes and improve landscape aesthetics (Böhm et al. 2012, 2014; Grünewald et al. 2007; Reeg et al. 2009; Tsonkova et al. 2012; Unseld et al. 2011). Hence, ACSs provide market goods and non-market benefits, while the non-market benefits may have higher societal value they may not be taken into account by the farmer, because they are not market traded (Tsonkova et al. 2012).

Despite these benefits, so far only a few modern agroforestry systems exist in Germany (Nahm et al. 2014). In addition, the interest in the management of traditional agroforestry has declined and multi-functional land use is lacking in many systems (Unseld et al. 2011). The lack of knowledge that farmers have about agroforestry is an obstacle to the implementation of the system and many farmers in industrialised countries have little or no knowledge about trees (Reeg 2011). Because it is farmers who determine the actual land use in the field, their attitude towards agroforestry and their understanding of the benefits is crucial for the successful establishment and management of these systems.

Farmer's perception towards agroforestry systems has been studied previously using interviews or surveys. A recent study was conducted by García de Jalón et al. (2017) covering different agroforestry systems in 11 European countries to capture the perception of stakeholders and key actors including farmers, landowners, agricultural advisors, researchers and environmentalist towards agroforestry. When given the same list of 45 issues related to production, management, the environment, and socio-economic issues, the stakeholders ranked improved biodiversity and wildlife habitat, animal health, and landscape aesthetics as the main positive aspects of agroforestry (García de Jalón et al. 2017). These stakeholders identified that the most important negative aspects of agroforestry were increased labour, complexity of work, management costs, and administrative burden (García de Jalón et al. 2017).

A previous study conducted by Graves et al. (2009) focused specifically on farmers' perception of silvoarable agroforestry systems (integrating arable crops and trees) which was studied in face-to-face interviews, across 14 sample areas in Europe. Farmers in Mediterranean areas expected that the principal benefit of silvoarable systems would be increased farm profitability (37%), while the negative aspect would be intercrop yield decline (31%) (Graves et al. 2009). Farmers in Northern Europe placed greatest value on environmental benefits, while the most negative aspect was related to general complexity of work and difficulties with mechanisation (Graves et al. 2009). For example, the most frequently mentioned negative aspects by farmers in UK were linked to use of farm machinery, complexity of work, general project feasibility and the effect of trees on crop productivity, while the most frequently mentioned positive aspects were related to farmer image, biodiversity, landscape, farm diversification, soil conservation and timber production (Graves et al. 2017).

In Germany, farmers were interviewed in the provinces of Brandenburg and Schleswig–Holstein (Graves et al. 2009). The negative expectations of these farmers were related with work complexity, environment, labour required, mechanisation, risk, status and subsidies, and project feasibility (Graves et al. 2009). The overall positive benefits were related to the environment, conservation, profitability, and patrimony (Graves et al. 2009). Since then a few modern agroforestry systems have been established in Germany and analysing the practical experience of these farmers is essential to improve the uptake of agroforestry. Accordingly, the objectives of this study were (i) to identify the benefits, opportunities and barriers currently perceived by German farmers towards agroforestry and (ii) to identify how a range

of measures could be used to reduce barriers to the use of agroforestry by farmers.

Materials and methods

Interviews with 32 farmers were conducted across Germany in 2015. The interview questions were developed under the European project AGFORWARD (AGroFORestry that Will Advance Rural Development) in order to identify farmer's reasons for adopting agroforestry across Europe (Rois-Díaz et al. 2017). The AGFORWARD project has identified the following four categories of agroforestry across Europe—agroforestry of high natural and cultural value (HNVC), agroforestry for high value tree systems, agroforestry for arable farmers and agroforestry for livestock farmers (Burgess et al. 2015). This study focused on two of these categories, i.e., agroforestry of HNCV and agroforestry for arable farmers. Of the 32 interviews carried out, 16 farming systems could be considered HNCV systems and the other 16 conventional arable systems. The 16 farmers from these two categories were again split into 8 farmers with agroforestry and 8 farmers with conventional agriculture (arable land or grassland). This resulted in the following four categories of eight farmers—with agroforestry in area of HNCV (HNCV-AFS), with conventional agriculture in area of HNCV (HNCV-CA), with modern silvoarable agroforestry (M-AFS), and with conventional agriculture (CA). Due to the low distribution of agroforestry, the contacts of farmers with agroforestry were provided by the European Agroforestry Federation (EURAF) and the BTU Cottbus–Senftenberg. The farmers with CA were selected randomly by searching internet databases.

The complete interview questions can be found in Rois-Díaz et al. (2017), who studied farmers reasoning behind the uptake of agroforestry on a European scale. In order to address the low adoption of agroforestry in Germany, in this paper, we provide an in-depth analysis on a national scale and scrutinise the responses given by the German farmers in accordance with the national legal framework. The interview questions relevant for this study comprised closed format questions regarding main farm characteristics and the following open format questions to record farmers perception: "What do you understand by agroforestry?" and "Please state several positive and several negative aspects of agroforestry, with respect to its production, environment and social aspects". The interviews were conducted face-to-face or by telephone and were recorded with the permission of the farmers. The questionnaire was then filled out by the interviewer. The interviews were transcribed and were subsequently analysed using the qualitative content analysis according to Mayring (2010), by applying the method of content structuring in predefined main categories. The identification of categories was based on market and non-market benefits commonly related with agroforestry systems according to the literature (Jose 2009; Tsonkova et al. 2012). The responses of farmers regarding positive and negative aspects were organized according to the suitable category. Where appropriate quotes was inserted in the text to illustrate farmers' perceptions accompanied by the farmer's number defined by the chronological order of the interview and the type of system managed (e.g., Farmer 1, M-AFS). Accordingly, the negative aspects were interpreted as obstacles to the implementation and management of agroforestry and were complemented with an extensive literature research, to be used as a basis for the development of conceptual measures.

Results

Farmers and their familiarity with agroforestry

The distribution of the 32 farmers interviewed is presented in Fig. 1. The average age of farmers was 47 years with 88% male and 12% female representatives. The farming area ranged between 1 and 2900 ha, with a median of 310 ha for farms in HNCV and a median of 1225 ha for the farms in conventional areas. The farmers with agriculture in areas of HNCV were managing predominantly pastureland, permanent crops and forestland. The farmers in conventional areas were managing predominantly arable crops, but also pastureland, permanent crops, and forestland. The most common tree species in the agroforestry systems included poplar (*Populus* spp.), oak (*Quercus* spp.), maple (*Acer* spp.), alder (*Alnus* spp.), and willow (*Salix* spp.), as well as fruit trees such as cherry (*Prunus* spp.), apple (*Malus* spp.), and pear (*Pyrus* spp.).

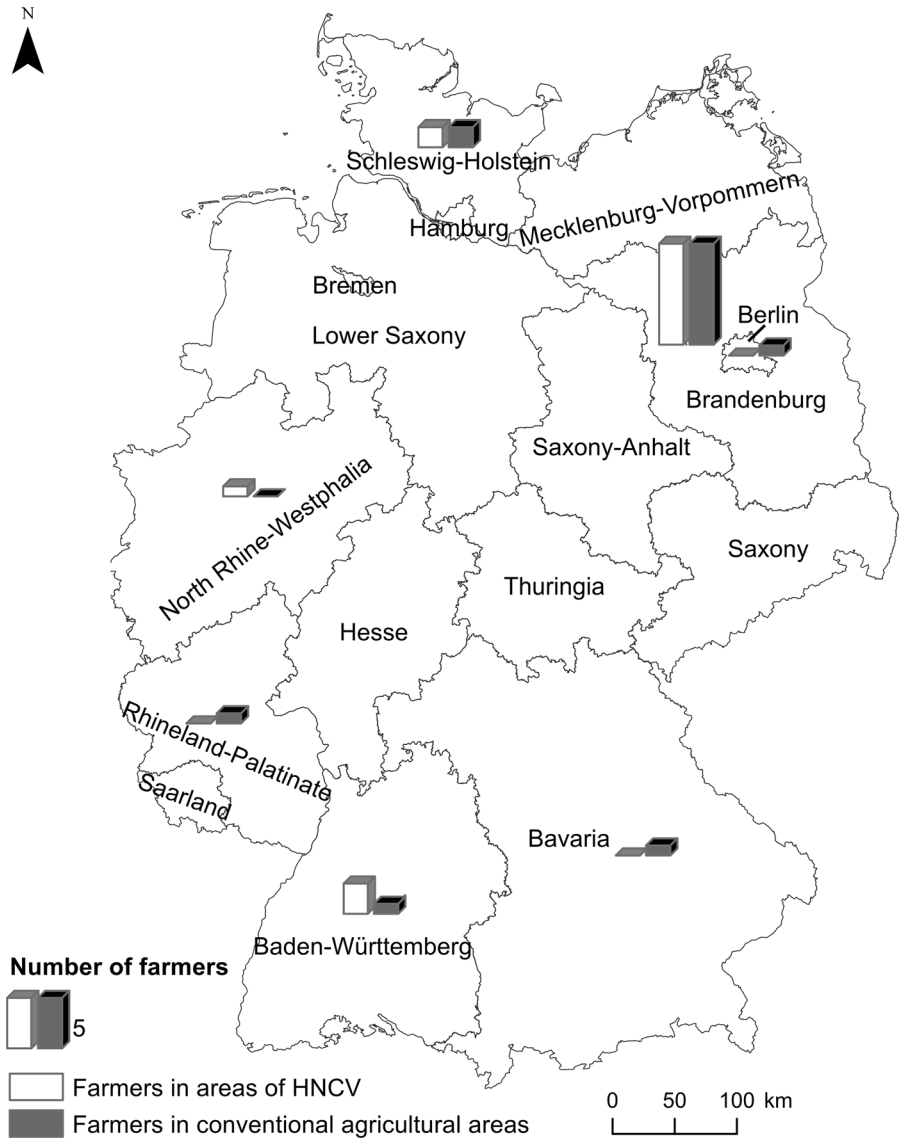

Fig. 1 Map of Germany with distribution of interviewed farmers in area of high natural and cultural value (HNCV) and conventional agricultural area by Federal State. Adapted from Tsonkova et al. (2016)

According to the majority of farmers interviewed, agroforestry was a combination of agriculture and forestry, while animals were mentioned by less than 20% of the farmers (Fig. 2). In total, 75% of the farmers in HNCV areas were not aware of the term agroforestry (62.5% of farmers with HNCV-AFS and 12.5% with HNCV-CA). In contrast, most of the farmers with modern agroforestry could give a definition of agroforestry, but the diversity of agroforestry system was not widely known. Moreover, 75% of the farmers with CA associated the term with growing plantations of short rotation coppice (SRC), which are commonly used for the production of biomass feedstock and did not differentiate between these monoculture plantations and agroforestry. In agroforestry, a key principle is the ecological and economic interaction between a woody perennial component and an understorey crop and/or pasture which is consumed by livestock.

Market benefits provided by agroforestry according to farmers

The perception of market benefits, regarding economic and socio-economic aspects according to the farmers interviewed is presented in Fig. 3. In general,

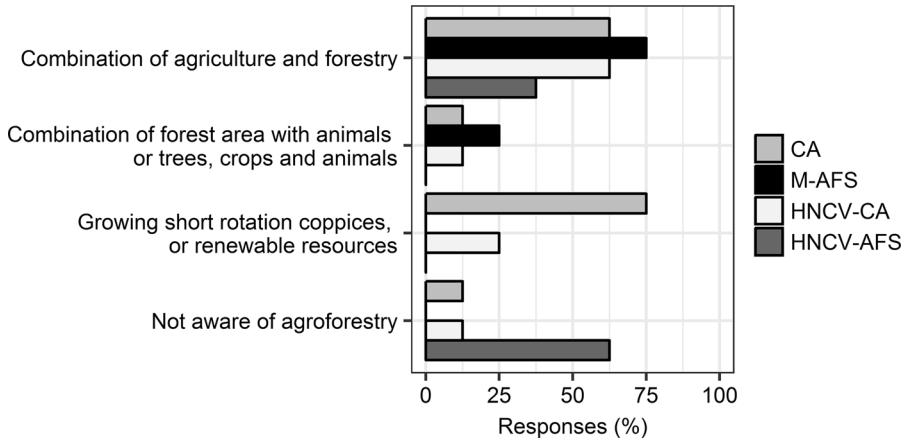

Fig. 2 Responses (in %) of farmers (n = 32) regarding the meaning of agroforestry. Percentages sum to over 100% because some farmers gave more than one response. Farmers: conventional agriculture (CA), modern agroforestry (M-AFS), conventional agriculture in area of high nature and cultural value (HNCV-CA), agroforestry in area of high nature and cultural value (HNCV-AFS). Adapted from Tsonkova et al. (2016)

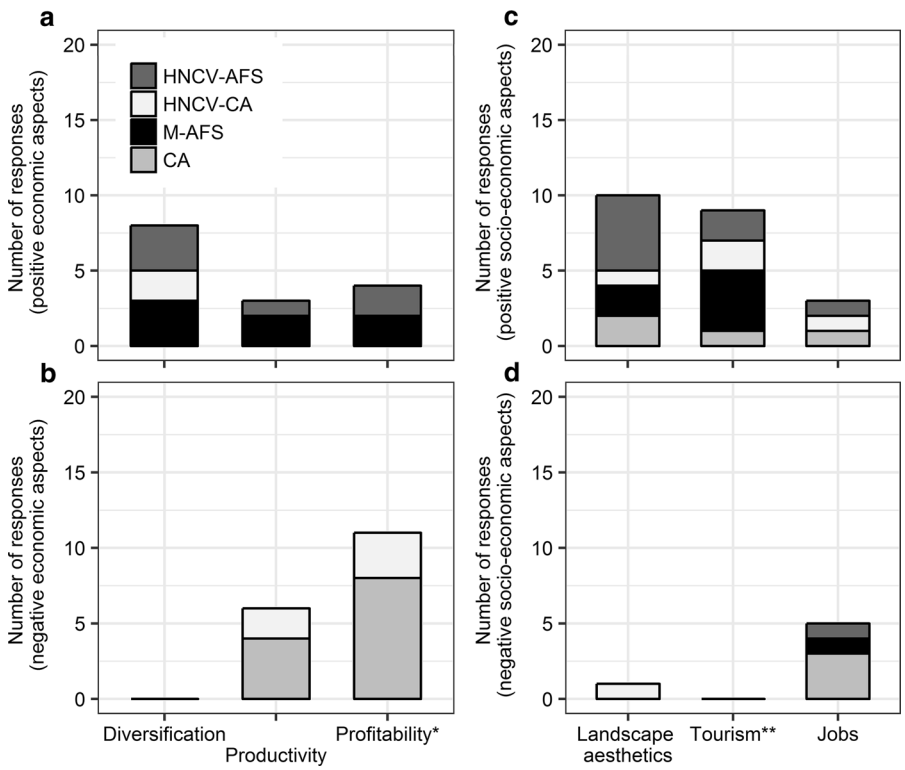

Fig. 3 Responses of farmers (n = 32) regarding perceived **a** positive economic aspects, **b** negative economic aspects, **c** positive socio-economic aspects, and **d** negative socio-economic aspects. Farmers: agroforestry in area of high nature and cultural value (HNCV-AFS), conventional agriculture in area of high nature and cultural value (HNCV-CA), modern agroforestry (M-AFS), conventional agriculture (CA). *Two farmers with HNCV-CA stated that the soil quality was too good for agroforestry and one farmer that marketing of agroforestry products was probably hard, one farmer with CA stated that agroforestry would be an option if it was more profitable than CA, **including publicity

the positive aspects predominated among farmers with agroforestry, while the negative aspects among farmers with CA. Regarding economic benefits, the positive aspects for farmers with agroforestry were product diversification, improvement in productivity, and profitability (mainly due to the increased value of land), while productivity and profitability were assessed negatively by farmers with CA (Fig. 3a, b). Product diversification through agroforestry was mentioned by 8 out of 32 farmers as a positive economic aspect. The perception that agroforestry may result in reduced productivity, predominated among the responses of farmers with CA. The main reason was shading by trees, which was expected to reduce crop yields and cause difficulties during harvest as a consequence of "differences in ripeness caused by shade" (Farmer 4, CA). By contrast, three farmers suggested that the productivity in mixed cropping may increase or has increased, as a result of the improved microclimate after trees were planted. For example, during a very dry year "the potatoes near the trees looked better, because they were protected by shade" (Farmer 1, M-AFS). Nevertheless, farmers with CA, were willing to plant agroforestry on marginal land, which was otherwise not profitable, e.g., "Agroforestry can be seen as an alternative when conventional agriculture is not profitable, for example in a field with soil of low quality" (Farmer 7, CA). The low profitability of agroforestry was assessed as the most negative economic aspect for farmers with CA, mentioned by seven out of eight farmers, e.g., "the biggest problem, is related with marketing; there is no financial profit" (Farmer 5, CA). Moreover, there was little appreciation of how agroforestry could affect the long term sustainability of the land although one farmer recognised "the increased value of the agricultural land due to soil conservation" (Farmer 8, HNCV-AFS).

Regarding socio-economic benefits, landscape aesthetics and tourism were mentioned as positive aspects, while negative aspects were related with a lack of employment opportunities created through agroforestry, mostly mentioned by farmers with CA (Fig. 3c, d). Landscape aesthetics was mentioned by 10 farmers, while tourism including interaction with the public and educational programs was mentioned by 9. The recreational value of the landscape is increased "especially when there is a large city close by" (Farmer 4, HNCV-AFS), but not universally as tourism was not seen as an option "relevant for this region" (Farmer 8, CA). Publicity was mentioned by farmers with modern agroforestry, indicating their willingness to participate in innovative projects to raise awareness about sustainable land use practices. Two farmers mentioned the positive role of agroforestry in creating more stable employment (also in winter) or in creating employment in the case where the farmer was allowed to manage a traditional hedgerow system currently under protection "If we were allowed to manage the hedgerow, also jobs would be created, at least in winter" (Farmer 8, HNCV-AFS). The creation of employment opportunities with agroforestry was generally not seen as a possibility by the farmers especially these with CA. For the farmers with agroforestry the system was related with additional efforts for the farmer himself, e.g., "There is of course a high bureaucratic burden, but that does not create new jobs, it just increased our work load" (Farmer 2, M-AFS). According to the farmers with traditional systems the difficulties were related to system management. In contrast, for farmers with modern agroforestry, the highest effort was related with the bureaucratic burden related to establishing agroforestry "it takes a bit longer to farm the parcel, but this is not a big problem for me. There were problems with the land owners" (Farmer 8, M-AFS).

Non-market benefits provided by agroforestry according to farmers

Among non-market benefits creating habitat for biodiversity, environmental sustainability, and soil erosion reduction were the most important ecological benefits for farmers with agroforestry, while reduced water supply was the most negative aspect for farmers with CA (Fig. 4). The most important positive effect for farmers with agroforestry was improving biodiversity, while for farmers with CA it was erosion reduction. Biodiversity concerns were expressed, including losing the created habitat after harvesting of trees "if a bird settles, but then the tree is cut, where is the benefit?" (Farmer 2, CA). On the other hand, after planting modern agroforestry one farmer commented that "plants that are on the red list returned which were gone from the area" (Farmer 6, M-AFS). In addition, wild animals could damage the trees and the trees had to be protected. Environmental sustainability aspects including benefits like carbon

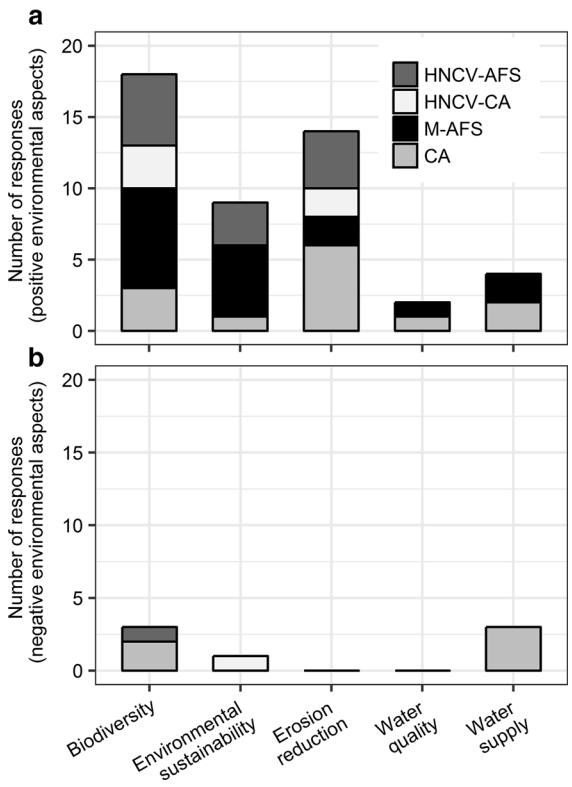

Fig. 4 Responses of farmers (n = 32) regarding perceived **a** positive environmental aspects and **b** negative environmental aspects. Farmers: agroforestry in area of high nature and cultural value (HNCV-AFS), conventional agriculture in area of high nature and cultural value (HNCV-CA), modern agroforestry (M-AFS), conventional agriculture (CA)

sequestration and increased soil health, improved nutrient cycling and microclimate were mentioned by nine farmers (mostly with modern agroforestry). A negative aspect was the expectation that after "growing trees the soil is acidified and the roots remain in the soil, which makes it harder to later grow conventional crops" (Farmer 7, HNCV-CA). The protective effect of trees on soil by reducing wind speed was well known among farmers, not only regarding traditional windbreak systems, but also for modern agroforestry and was mentioned by 14 farmers. The benefits of agroforestry to water quality were recognized by two farmers. Three farmers expected improved water supply to the crop, especially in dry areas as a result of shading and improved microclimate. In contrast, a concern for reduced water availability for the crops, as a result of the competition between the crop and tree component was expressed by three farmers.

Discussion

Obstacles

The profitability estimations for agroforestry by the German farmers interviewed in this study, which were closely linked with the current legal framework, were assessed as very low. Furthermore, despite farmers awareness that agroforestry provided non-market benefits, these benefits were not of interest because they were not rewarded and earning financial benefits was deemed essential, e.g., "The environmental aspects exist, but the system does not create profit" (Farmer 3, CA). One of the results of the study was that the current legal framework in Germany and the administrative burden is a major barrier to the uptake and maintenance of agroforestry, together with the low financial rewards for the ecological benefits provided.

The establishment of alley cropping in Germany is currently not possible as a holistic system, because there is no land use code for agroforestry, allowing its registration as a system at the farm level, according to the requirements of the Integrated Administration and Control System (IACS; Böhm et al. 2017a, b). This results in the fact that "agroforestry is not considered as an entire system. For subsidies I would have to enrol each tree row and crop separately" (Farmer 6, CA). In addition, the minimum parcel area in IACS is 0.3 ha, hence each component (tree hedgerow or crop alley) should occupy at least 0.3 ha, which excludes establishing agroforestry on small parcels and prevents the development of small-scale mosaics. Moreover, lease agreements are often issued for short time periods which are insufficient for the tenant to benefit from the tree growth. Some land parcels are very small and some farmland can have hundreds of landowners and contacting them for permission to plant trees on their land can be very time consuming. Furthermore, no financial support for first establishment of agroforestry exists in Germany. This could have been provided through the European measure 222 of the *Rural Development Programme* (RDP) in the period 2007–2013, linked to Article 44 of the Regulation (EU) No. 1698/2005, continued by measure 8.2 described by Article 23 in Regulation (EU) No. 1305/2013 in the period 2014–2020, neither of which has been activated in Germany. According to the farmers, who were interviewed, it was also considered

important that "the system is in the subsidy program for a long period" (Farmer 1, CA).

The current German legal framework allows that SRC which consist of selected species (*Salix*, *Populus*, *Robinia*, *Betula*, *Alnus*, *Fraxinus*, *Quercus*) excluding hybrids, with a maximum rotation of 20 years, are planted on agricultural land (BMEL 2015). Hence, planting high value trees with longer rotation periods is excluded. A farmer with modern agroforestry could not apply for subsidies because of planting "the wrong tree (hybrid poplar) that was not on the list" (Farmer 4, M-AFS). In addition, farmers are neither allowed to manage nor to harvest existing hedgerow structures in the landscape, because they are under environmental protection, but at the same time they can be ineligible for subsidies, due to their width "the hedgerow was 3 m wider than allowed" (Farmer 7, HNCV-AFS). Hedgerows, which in Northern Germany are also called "Knicks" were very common in the past, but during recent decades their occurrence has also reduced. The management of traditional hedgerow systems is currently decoupled from the agricultural management. Existing hedgerows had no significant importance to farmers and many farmers would have even removed them, had they not been under protection (Tsonkova et al. 2016). Lastly, newly established systems are characterized by uncertain harvesting rights, since trees may be placed under protection of national regulations, such as the Tree Protection Regulation (*Baumschutzverordnung*) and farmers are not allowed to harvest them (Böhm et al. 2017b). As a consequence, conflicting goals between nature conservation and productivity impede the establishment and management of agroforestry.

In light of these findings the measures listed below address both farmer-perceptions and legal constraints in the attempt to promote agroforestry in Germany.

Improvement of the legal framework for agroforestry

In order to facilitate the establishment of agroforestry and reduce the bureaucratic burden currently imposed on farmers, the legal framework in Germany should be adapted. Ideally the implementation of a land use code for agroforestry in the IACS is necessary. However, this is currently not foreseen by the German Ministry of Agriculture, as according to EU requirements permanent crops and agricultural crops have to be separately registered (Böhm et al. 2017a). In Germany, agroforestry systems are not recognized by national laws and regulations which are based on agricultural EU funding programs. One reason for this is the lack of a clearly presented definition of agroforestry in EU regulations leading to reluctance to include this land use in the national legislation. This was revealed during meetings conducted since 2014 between relevant ministry officials and members of the Innovation Group AUFWERTEN (Agroforestry for Environmental Services, Energy Production and Added Value) which works on promoting the establishment of agroforestry in Germany. After assessing the relevant legal framework, the relevant officials have interpreted the present EU regulations as indicating that agroforestry systems (including trees and shrubs) are not fully eligible for agricultural support in Germany.

The main reasons were related to the following. In Article 23 of Regulation (EU) No. 1305/2013 agroforestry systems were defined as "land use systems in which trees are grown in combination with agriculture on the same land". However, an explicit reference that trees/shrubs are part of the agricultural land that ensures their eligibility for agricultural subsidies is missing. Moreover, agroforestry is currently perceived as a *forestry area* in Germany because Article 23 is linked to Article 21 of the same regulation, which covers forest trees. Trees eligible for subsidies in agroforestry systems are either trees that provide repeated yields such as fruit trees or trees registered as landscape features, which cannot be used by the farmers. To facilitate the adoption of agroforestry in Germany firstly the Common Agricultural Policy (CAP) definition for agroforestry needs to be clarified. This is a crucial measure to increase the uptake of agroforestry throughout Europe and a definition of agroforestry has been recently proposed by Mosquera-Losada et al. (2017). It is essential that agroforestry systems established on agricultural land are clearly defined as an agricultural land use system, meaning that the area of the entire agroforestry system (crop/pasture and trees/shrubs) is a part of the agricultural area eligible for subsidies.

Furthermore, the maximum density of "100 trees per hectare" stipulated by Article 9 of Regulation (EU) No. 640/2014 severely limits the diversity of possible agroforestry systems and excludes modern agroforestry and ACSs in particular when the tree

hedgerows consist of fast growing trees in high density (Böhm et al. 2017b). Mosquera-Losada et al. (2017) recommend that in addition to measures 222 and 8.2 agroforestry practices on arable land and permanent grassland should be *fully eligible* for subsidies if they were developed with a "management plan" including a minimum tree density (that should be selected by member states), an initial tree density, and the pursuit of a final maximum tree density that should not exceed "100 mature trees per hectare" (if no established local practices are declared). While the specification of "100 mature trees per hectare" is applicable to a number of agroforestry practices, regarding the ACS currently of interest in Germany, where high numbers of trees/shrubs are grown on a small proportion of the agroforestry area, keeping the number of trees under 100 remains a challenge.

Reflecting the local practice in Germany and considering the eligibility of modern ACSs and traditional agroforestry, an extended approach was suggested by the Innovation Group AUFWERTEN that (i) converts the maximum number of trees to *a maximum proportion of trees* allowed on arable land and (ii) determines the exact *features of an eligible agroforestry field* to ensure the controllability of agroforestry systems (Böhm 2017). For the *control* of agroforestry parcels by administrative bodies, a stepwise approach was suggested that (i) identifies how trees are arranged (scattered, in groups or in lines), (ii) accounts for the proportion of land covered by agricultural crops versus tree species, stipulating that the agricultural component has to be clearly dominant in order to keep the status as agricultural land, and (iii) identifies a maximum distance between trees (scattered, in groups or in lines) to ensure a maximum provision of non-market benefits (Böhm 2017; Böhm et al. 2017b). This approach could be also useful when developing a "management plan" for agroforestry as it takes into account the spatial arrangement of trees for increased provision of ecosystem services (ESs).

Accordingly, when accounting for the woody component in agroforestry, giving member states *the possibility to select* between applying the "maximum number of mature trees" (Mosquera-Losada et al. 2017) or the "maximum proportion of trees" (Böhm 2017; Böhm et al. 2017b) would ensure the highest degree of flexibility in implementing a broad variety of agroforestry systems throughout Europe, while considering the local conditions and maintaining a high level of ES provision. To increase the attractiveness of agroforestry with high value trees in Germany, it is required to permit the planting of these trees on agricultural land, and to allow the farmer to harvest the tree component.

Improvement of the integration of agroforestry in the agricultural policy

The extent and success of policy measures related to promoting agroforestry in Europe was recently described in detail by Mosquera-Losada et al. (2016). Important source of subsidies for farmers are provided by the CAP, which consists of two pillars. The first pillar includes direct payments to farmers and market measures, while the second pillar concerns rural development policy.

First pillar of the CAP: Direct payments to farmers

Due to detailed regulations and the high administrative burden only a few structural elements existing in nature can actually be recognized as landscape features which are eligible for subsidies as *Ecological Focus Areas* (EFAs; Dahl 2016; Mosquera-Losada et al. 2017). In Germany, except for the province of Schleswig–Holstein, the actual coverage of structural elements recognized as such was low (DBV 2016). Hedgerows that exceed the allowed width are not eligible for subsidies, but farmers are neither allowed to manage nor to harvest them, because they stand under environmental protection. As a consequence, farmers associate these structures with a reduction of CAP funds instead of valuing them for the ESs they deliver (Mosquera-Losada et al. 2016). Allowing farmers to manage existing hedgerows in Germany may increase their socio-economic and ecological importance by creating more employment and improving the provision of ESs.

Farmers would generally apply measures related to productivity, rather than those that take land out of production. This was confirmed by the high registration of EFA linked to productive activity, i.e., nitrogen-fixing crops and catch crops amounting to 73.1% of the total declared EFAs in Europe (EC 2016). Modern agroforestry such as alley cropping with tree rows consisting of fast growing trees, which are harvested on a 3–10 year rotational basis are an

example of a high productivity system. The system ranks high among EFAs as modeled by Tzilivakis et al. (2015), since trees are integrated in the production process, hence the area can be used for production and at the same time it offers benefits for biodiversity and ESs. Provided the definition of agroforestry is clarified (see above), farmers in Germany would be able to register a modern agroforestry system as a EFAs which could increase the likelihood of more farmers adopting agroforestry and in turn promote the use of more *permanent measures*, which is expected to increase the impact of EFAs (van Vooren et al. 2016).

Second pillar of the CAP: Rural Development Policy

The interviews indicated that farmers were aware that modern agroforestry provides environmental benefits; however, these systems should be better integrated into the *RDP* of the CAP and the measures should be enacted in Germany. Measures which compensate farmers for income foregone or additional costs in connection with agroforestry can currently be used in Germany to maintain traditional systems, such as hedgerows and orchard meadows (Meyer et al. 2015). The establishment and maintenance of modern agroforestry systems should be supported as well. In order to ensure the provision of benefits by these systems, farmer's concerns regarding habitat provision and competition for water need to be addressed and practical guidelines should be made available to farmers. For example, strategies to reduce the conflict between nature protection and productivity include partly harvesting tree rows and planting a variety of different tree species (Morhart et al. 2014; Unseld et al. 2011). Farmers were aware of the benefits of agroforestry related to protecting soil, but only few mentioned the positive effects regarding water quality. Modern agroforestry could gain in importance as a strategy to improve water quality in Germany, particularly in regions where there are problems with compliance with the *Water Framework Directive*. The average nitrogen balance surplus in Germany is around 20 kg N ha^{-1} higher than the target set by the German Government's sustainability strategy with agricultural use being the largest source of nitrogen (Balzer and Schulz 2015).

In addition to addressing the legal hurdles, there is also a need to promote the benefits of agroforestry. The enactment of an RDP measure by itself is likely to be insufficient. For example measure 222 which supports the establishment of agroforestry on arable land was adopted in the Umbria and Veneto regions in Italy but its application was limited, mainly due to the lack of promotion (training and extension activities) at the institutional level (Pisanelli et al. 2012). An overview of the first year of the CAP 2014–2020 in Europe, showed a continuation of this trend; 22 regions and 8 countries activated measure 8.2, but only 5 have effectively implemented it (Mosquera-Losada et al. 2016). Hence, a better *promotion of agroforestry* in the agricultural policy is essential, as well as increasing the knowledge base and the number of *centres of excellence advising farmers* (Mosquera-Losada et al. 2017; Reeg 2011).

Rewarding farmers for the provision of ecosystem services

The interviews indicated that farmers were aware of non-market benefits that can lead to direct financial benefits, e.g., improved biodiversity that enhances yield stability and the use of trees to reduce soil erosion. However, although soil erosion has direct consequences to the farmer in terms of loss of soil depth and productivity, soil degradation affects wider society on a global level. For example, Graves et al. (2015) estimated that in terms of ESs only 20% of the estimated annual costs of soil degradation in England and Wales were associated with loss of provisioning services linked with agricultural production. In Germany studies, calculating the costs of soil degradation and water contamination by agriculture are still missing which impedes their adequate consideration in decision making processes. Paying farmers for the provision of ESs would increase the attractiveness of agroforestry to farmers with fertile land, hence preserving it in the long run, while managing it in a sustainable way.

According to Batáry et al. (2015), the CAP aims to support the delivery of public goods from agriculture but not to support actions that directly increase farm income. Hence, hedgerows and traditional agroforestry can receive support from RDPs because of their cultural value, but these options place little emphasis on increasing their productive value (Smith et al. 2012). However, multifunctional land use systems like agroforestry can provide goods and

non-market benefits at the same time (Tsonkova et al. 2012). Moreover, according to recent study results, the value of non-market ESs provided by temperate agroforestry surpassed the value of market ESs (Alam et al. 2014; Porter et al. 2009). Hence, employing an *integrated approach towards increasing productivity through enhanced provision of ESs* is necessary.

Within the national regulations in Germany, modern agroforestry could also be included as an *environmental compensation measure* (*Ausgleichs- und Ersatzmaßnahmen*). Examples of traditional agroforestry components (such as hedgerows and orchard meadows), found in the provinces of Bavaria, Baden-Württemberg and Thuringia, could be used to enhance the integration of agroforestry as a compensation measure throughout the country (Zehlius-Eckert 2017).

Public involvement in sustainable land use practices

The profitability of agroforestry for farmers can be also raised by a stronger *public involvement*. The role of society as consumer of products derived from agriculture could be strengthened by using innovative programs for funding of sustainable agricultural practices. For example, the community foundation "Spreewald Cultural Landscape" aims to stimulate public involvement in maintaining the grassland and trees in traditional landscapes. Moreover, agroforestry products could be *marketed* regionally or *certified* under more widely accepted sustainability standards. Farmers thus may benefit from higher prices for certified products, which generate an economic incentive to adopt sustainable practices (Millard 2011). In the European market eco-labels already exist for products derived from traditional agroforestry, while the system itself may not be recognized by the population as agroforestry. For example, in Germany an orchard meadows juice "Meine Streuobstwiese" is certified under the EU eco-label. *Streuobst* is an example of a successful integration between nature protection and agriculture, as numerous environmental organisations have allied themselves with farmers and developed alternative marketing systems for *Streuobst* products (Herzog 2000). Modern agroforestry can also be used for animal friendly production, e.g., free-range farming and offers the possibility for marketing these agroforestry products. For example, geese products under an *agroforestry label* are being tested in Germany (Sänn and Pauly 2017). Should the agroforestry products be marketed under an agroforestry label, the awareness of the population about the benefits of this land use practice could be substantially raised.

To *raise awareness*, the presence of agroforestry could be more strongly implemented through educational programs by using different platforms. Tools accessible to the general public such as explanatory videos and a mobile phone application for agroforestry "Agroforst-App" are being made available in Germany through http://agroforst-info.de/. Furthermore, the establishment of demonstration sites for educational programs and interactions with farmers that manage agroforestry can play a very important role (Briggs 2012). Such farms can set an example for others creating a "snowball effect" increasing the awareness among farmers regarding the variety of agroforestry systems and widely promoting their establishment.

Conclusion

This study attempted to identify the opportunities and constraints to agroforestry according to farmers in Germany, in order to develop measures to increase the uptake of agroforestry. A major barrier to the implementation of agroforestry practices in Germany is that its profitability is perceived to be low, its legal status is unclear, and there are only low financial rewards for the ESs that they provide. In order to improve the market benefits of agroforestry, a simplification of the legal framework is required, including a clear definition of agroforestry applicable to both traditional and modern systems. Under the current framework, agroforestry was identified as a viable alternative to conventional farming systems by farmers, at least in less productive areas. Furthermore, the role of modern agroforestry to improve biodiversity, soil, and water quality should be better recognized by existing policy measures providing payments for environmentally friendly farming. Rewarding farmers for the provision of non-market benefits would increase the attractiveness of agroforestry also for farmers in highly productive areas, enhancing the sustainability of land use in the long term. In addition, stronger consumer participation could increase the profitability of

agroforestry systems for farmers and awareness of agroforestry benefits should be raised among the consumers.

Acknowledgements The AGFORWARD Project (Grant Agreement No. 613520) is co-funded by the European Commission, within the 7th Framework Programme of RTD. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission. The AUFWERTEN Project (Reference No. 033L129AN) is funded by the Federal Ministry of Education and Research (BMBF). We thank all farmers who dedicated part of their valuable time to the interviews.

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