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Installing Flower Strips to Promote Pollinators in Simplified Agricultural Landscapes: Comprehensive Viability Assessment in Sunflower Fields

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Abstract: The installation of flower strips in simplified agricultural landscapes has been promoted as a tool to improve pollination services. While the effectiveness of flower strips in increasing pollinator visitation and yield is well-established, the social and economic feasibility of this measure remains unclear. Here, we evaluated the economic efficiency and social feasibility of installing flower strips to promote pollination under different scenarios of subsidy. A 2-year experiment was implemented by comparing sunflower fields with and without installed flower strips in central Spain, along with local farmer opinions obtained via a focus group. Flower strips significantly increased wild bee visitation to sunflower heads in the second year after implementation, with seed set being 11% higher on average in fields that had flower strips. Cost–benefit analysis revealed that investment in flower strips would be recovered by 4–5 years after installation, depending on the subsidy used. In the most favorable subsidy scenario, farmers could increase their annual benefits by 8.7% (29 €/ha) after recovering the initial investment. However, most local farmers did not perceive a significant increase in yield associated with the flower strip installation. The use of flower strips was negatively identified by farmers as a source of invasive weeds in adjacent fields, along with a lack of technical advice and economic incentives. Farmers fully agreed that direct economic subsidies were required for flower strips to be accepted as feasible approaches in the long-term.

Keywords: flower strips; pollination; sunflower; social viability; cost–benefit analysis

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1. Introduction

Conserving pollinators and pollination services is essential for maintaining ecosystem function, and for ensuring sustainable food production in agroecosystems [1,2]. Pollinators contribute to the productivity of more than 75% of important crop species [3,4]. The market contribution of animal-mediated pollination is estimated to be USD 235–577 billion per year [5,6]. However, there is increasing concern among conservationists, environmental managers, and decision-makers regarding the reported declines in the abundance and diversity of various pollinator taxa [7], and the large number of species currently considered threatened on IUCN Red Lists [8].

Habitat fragmentation, climate change, and agricultural intensification are the main factors driving pollinator decline [9,10]. In intensive agricultural landscapes, remnant patches of natural and semi-natural habitat are critical to provide food and nesting resources for pollinators, and to ensure the effective pollination of pollinator-dependent crops [11]. Where these patches of natural and semi-natural habitat are absent, pollination might be hindered. In such instances, farmers usually depend on the temporal installation of beehives, or the implementation of management measures to promote wild pollinators [12,13].

To enhance and maintain pollination services in intensive agricultural landscapes, the European Union (EU) has adopted a biodiversity strategy that includes specific measures to promote green infrastructure in Member States [14]. The installation of flower strips along the borders of agricultural fields represents one such measure, intended to provide floral resources to attract enough insect pollinators to fulfil the pollination demands in pollinator-dependent crops [11].

Sunflower (*Helianthus annuus*) is one of the most important sources of oil for human consumption in Europe. This crop covers almost 4.2 million ha, with an estimated annual production of ca. 9.2 million tons [15]. Sunflower crops are highly dependent on pollinators for seed production, with honeybees (*Apis mellifera*) being the most important sunflower pollinators; however, several studies have shown that sunflower yields are enhanced by wild bees [16–18]. Sunflower landscapes in Spain are managed intensively and are usually characterized by the absence of natural and semi-natural habitats, limiting the potential habitat for pollinators. Consequently, installing flower strips has been proposed to increase floral resources and nesting habitats for pollinators, and to enhance pollination in sunflower fields [19].

While several studies have tested the effectiveness of flower strips in increasing pollinators and pollination service, few have evaluated the social and economic feasibility of this measure (but see [11,20]). Evaluating the cost effectiveness of agri-environmental measures could provide useful evidence-based information to encourage farmers to implement them on their farms as well as support policy and decision-making [21]. Few studies have linked economic analyses of implementing agri-environmental measures with social analyses exploring their feasibility based on the farmer perceptions, knowledge, and attitudes [22,23].

Building on a previous study demonstrating how flower strips affect pollinator visitation and seed set in sunflower fields [24], here, we assessed the social viability and cost effectiveness of installing flower strips in sunflowers crops. Specifically, we: (a) performed a cost–benefit analysis to explore the economic viability of installing flower strips under different plausible future scenarios of subsidies, and (b) conducted a social viability analysis based on the perceptions and attitudes of sunflower farmers in relation to flower strip implementation. Our results are expected to reveal the pros and cons of installing flower strips in sunflower fields, uncovering technical and financial implications in the context of the ongoing reforms of the EU Common Agricultural Policy (CAP).

2. Methods

2.1. Study Area

The study area (Figure 1) encompassed five municipalities in the Province of Cuenca (Autonomous Community of Castilla-La Mancha), Spain. The agricultural landscape of this region is dominated by non-irrigated cereals and oilseed sunflowers, cultivated under an annual rotation regime. Crops cover nearly 22,000 ha, making this area one of the most important producers of sunflower oil in Spain. Sunflowers are farmed under an intensive regime that includes the use of herbicides and various types of fertilizers.

2.2. Sampling Design and Data Collection

Data from 22 experimental sunflower fields were used for the analyses. Eleven fields had flower strips installed, while the other 11 fields had no flower strips, and were used as control sites. The flower strips covered 0.12 ha per plot (100 m × 12 m) and were composed of 12 melliferous species of herbaceous plants (*Borago officinalis*, *Calendula arvensis*, *Coriandrum sativum*, *Salvia pratensis*, *Melilotus officinalis*, *Diplotaxis erucoides*, *Echium plantagineum*, *Silene vulgaris*, *Vicia sativa*, *Nigella damascene*, *Sinapis alba*, *Medicago sativa*). These species were selected to provide season-long bloom (February to September), maintaining food resources for pollinators. All flower strips were sown in March 2017 and resown in February

2018. The seeds were sown by a pneumatic seed drill, with a sowing density of 12 kg/ha. In 2018, the floral composition of the mixture and the relative abundance of each species was adjusted based on the germination success and growth patterns observed in 2017 [24].

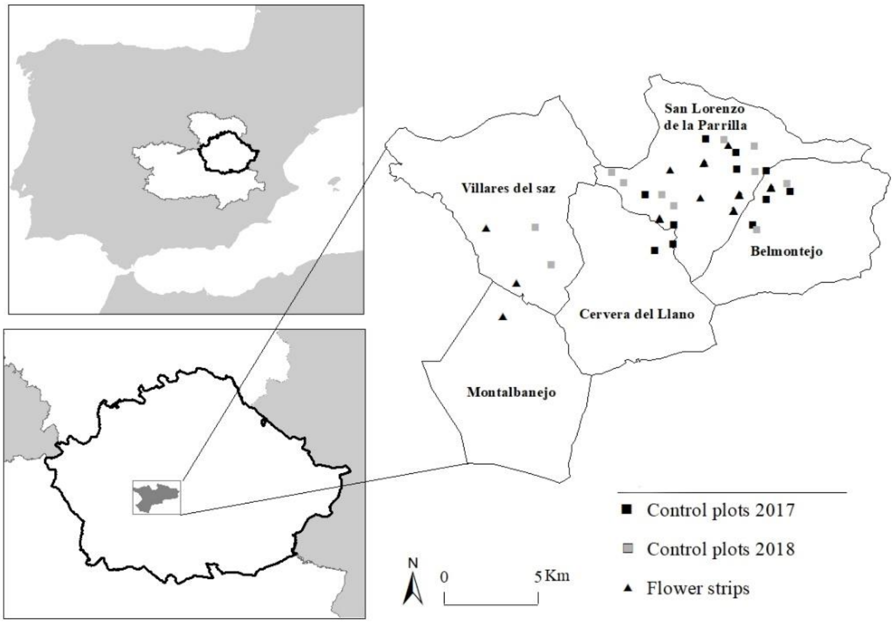

Figure 1. Location of the sampling plots in the study area in Cuenca, Spain.

The control plots included sunflower fields with natural or semi-natural edges, which mainly contained small patches of Mediterranean scrub, covering an equivalent or larger area than that of the flower strips (Figure 2). Sunflowers and cereals are cultivated under an annual rotation regime in the study area. Thus, the control fields were different in 2017 and 2018 (because the fields with sunflower in the first year had cereals in the second one). In the case of flower strips, the mixture was always sown on the edge between a field with sunflower and a field with cereals, so that in 2017, we could sample one field and in 2018 the other, with both fields being influenced by the same flower strip (see Figure 2).

During the peak flowering period of sunflowers (July–August 2017 and 2018), we monitored pollinator visitation through direct 1-min observations of 32 sunflower heads in each field. Focal sunflowers were located at fixed distances from the flower strips and semi-natural borders (0, 15, 30m and 60 m), with eight sunflowers being used for each distance. We only focused on honeybees and wild bees (Apidae), as they represent the key pollinator guilds of sunflower. Pollinators were monitored between 9 and 12 h in the morning, and between 17 and 20 h in the evening, avoiding windy and cloudy days. Each year, the observations totaled 2816 min (about 47 h), and 94 h across both years.

In mid-September of 2017 and 2018 (when seeds were already mature), four sunflower heads were collected at each distance from the flower strip and semi-natural edge. These heads were air-dried and stored. Seed set was evaluated by counting the total number of florets (not fertilized), empty seeds, and full seeds in each sunflower head. The full seeds were also weighed with a precision balance. These values were used to compare the productivity per ha in fields with and without flower strips.

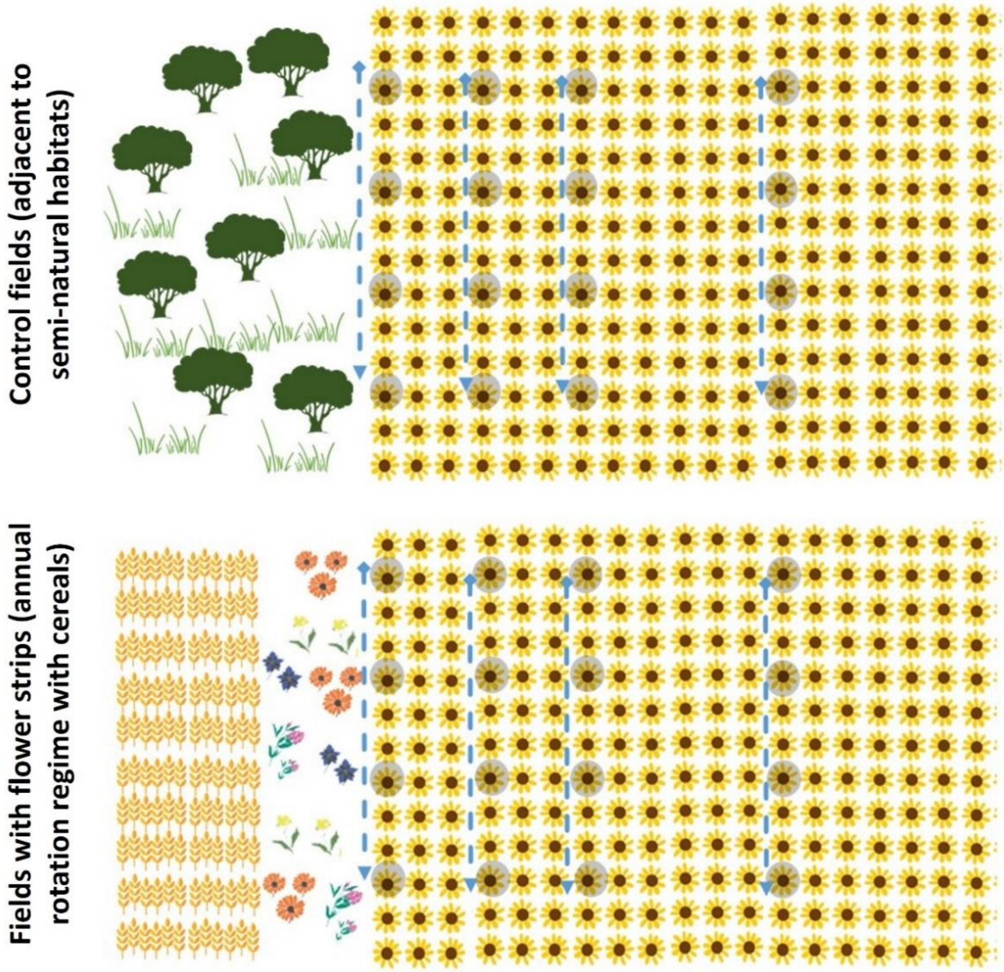

Figure 2. Schematic representation of the sampling design in sunflower fields with flower strips installed (**bottom**) and sunflower fields adjacent to semi-natural habitats (**top**) (modified from Hevia et al. [25]).

2.3. Economic Analysis

We performed a cost–benefit analysis by comparing changes to the production recorded with the cost of installing and maintaining flower strips in sunflower fields. All values were estimated per hectare of sunflower with a flower strip of 0.12 ha on the edge (Figure 2). This reference field size is consistent with Buhk et al.'s [26] estimation of 10% of the area covered with flower strips in order to obtain effective results. Furthermore, we did not take the distance to the flower strip into account, as no effect on the seed set was found up to 60 m in a previous study [24].

Gross profit was estimated from changes to yield in plots with flower strips compared to the control plots (kg increase per hectare) and was transformed to market prices using the average market price for sunflower seeds from 2007 to 2017. A previous study showed that flower strips needed to be present for 2 years to promote higher crop pollination [27]; thus, we assumed that pollination services only became optimal in the second year after installing flower strips [26]. Thus, the value of productivity increase from 2018 was extrapolated to subsequent years in the cost–benefit analysis.

Costs were calculated by adding an annual maintenance cost to the initial cost of the flower strip establishment. The initial cost was calculated by valuing the market price of seeds in the floral mixture necessary for achieving a planting density of 10 kg/ha, and the cost of installing two nest boxes for wild bees per field. Recurrent annual costs included an estimate of crop loss due to a reduction in crop acreage (0.12 ha per field), plus a maintenance cost based on a farmer's salary, the required agricultural machinery, and an estimated annual 10% replenishment of flower plants (see Table 1 for details).

Table 1. The costs and benefits used to calculate the net present value, estimated per hectare.

Cost–Benefit Analysis		Concepts	Price	Description	Total
Gross profit		Yield increase	97 € ha^{-1} yr^{-1}	Calculated as the difference in productivity between plots with flower strips and the control plots, using the average price from 2007 to 2017 for sunflower seeds in Cuenca: 0.348 €/kg [a] (applied only to 88% of the field and excluding the 0.12 ha occupied by the flower strip)	97 € ha^{-1} yr^{-1}
Initial cost		Nest boxes for wild bees	43 € ha^{-1}	Estimated as the cost of installing two nest boxes per flower strip, each formed by a metallic support and 90 bamboo canes of six different diameters (3–8 mm)	141 € ha^{-1}
		Flower seeds	98 € ha^{-1}	Calculated as the cost of the seed mixture necessary to sow 0.12 ha with a planting density of 10 kg/ha	
Annual cost [b]	Uncultivated area	Crop loss	40 € ha^{-1} yr^{-1}	Calculated as crop losses due to flower strip installation using the productivity of the control plots, and discounting the price of sunflower seeds for 0.12 ha	68 € ha^{-1} yr^{-1}
		Sunflowers seeds	7 € ha^{-1} yr^{-1}		
	Maintenance	Management	25 € ha^{-1} yr^{-1}	Calculated based on farmer salaries and the use of machinery (estimated as 20 min of work per flower strip)	
		Replacement of plants	10 € ha^{-1} yr^{-1}	Estimated as the cost of replacing 10% of plants with the same seed mixture from the first year	

[a] Spanish Ministry of Agriculture, Fisheries and Food [28]. [b] Annual cost estimation = (Crop loss for not cultivating 0.12 ha—Sunflower seeds for 0.12 ha) + Maintenance.

We calculated the net present value (NPV) by following Morandin et al. [20]:

$$NPV = \sum_{Y=n}^{Y} \left[\frac{B_A - C_A}{(1+k)^n} \right] - C_0$$

where BA is the *gross profit* (yield increase) estimated in dollars at Y years, CA is the *annual cost*, C0 is the *initial cost*, n is the number of years, and k is the discount rate that takes into account the time value of money and uncertainty in future returns (a discount rate of 5% was applied). The annual cost was computed from the first year.

NPV was calculated under three subsidy scenarios (*without any subsidy, with a direct initial subsidy, and with an indirect subsidy*). These scenarios were derived from farmer perspectives discussed in the focus group (see below). *Direct subsidy* means a hypothetical monetary subsidy that would finance 50% of the initial cost of the flower strip installation. *Indirect subsidy* is a non-monetary subsidy based on Spanish Royal Decree 27/2018, where melliferous flowers are considered as ecological focus areas (EFAs); these flowers are given a weighting coefficient of 1.5 in relation to fallow land, which is the most widespread EFA in our study area. Under the current CAP regime, farmers cultivating more than 15 ha are obliged to leave 5% of EFAs. Therefore, this subsidy affects the annual costs as it reduces the uncultivated area, allowing farmers to cultivate the equivalent area of sunflower in another plot.

2.4. Social Feasibility

We formed a focus group to uncover farmer perceptions and attitudes toward the implementation of flower strips in agricultural landscapes. The focus group was formed in San Lorenzo de la Parrilla (Cuenca, Spain) in February 2019. The participants that were invited to join the focus group were: (i) farmers who had installed flower strips in their fields, and (ii) farmers who expressed their willingness to install flower strips after participating in a survey of pollinators on farmlands [29]. Ten selected participants attended the focus group. Participants were separated into three subgroups to encourage participation and discussion.

An experienced facilitator led the group discussions on two key topics: (1) farmer perceptions and knowledge of implementing flower strips, analyzing the positive and negative consequences perceived by farmers, and (2) the required actions/proposals to make the implementation of flower strips in sunflower fields more socio-economically feasible and appealing to farmers. The proposals and conclusions of the three subgroups were discussed in a final plenary session, searching for consensus.

3. Results

3.1. Effect on Flower Strips on Sunflower Productivity

In the first year after flower strips were implemented, we did not observe any significant differences between fields with and without flower strips with respect to the honeybee (Mann–Whitney test; U = 56.5; $p = 0.809$) and wild bee (U = 44; $p = 0.286$) visitation rates, nor seed set (U = 86; $p = 0.101$). However, in the second year, the wild bee visitation rate was significantly higher in fields with flower strips compared to the control fields (U = 94; $p = 0.027$), with honeybee visitation being marginally higher (U = 87; $p = 0.086$). The seed set was also marginally higher in fields with flower strips (U = 90; $p = 0.056$) (Figure 3). Overall, we estimated an average 2.9% and 11.4% seed set increase in 2017 and 2018, respectively, in fields with flower strips compared to the control fields. Based on the seed set and weight, we estimated an average yield of 951.4 kg/ha (SD = 562.9 kg/ha) in the control plots and 1268.1 kg/ha (SD = 614.2 kg/ha) in plots with flower strips.

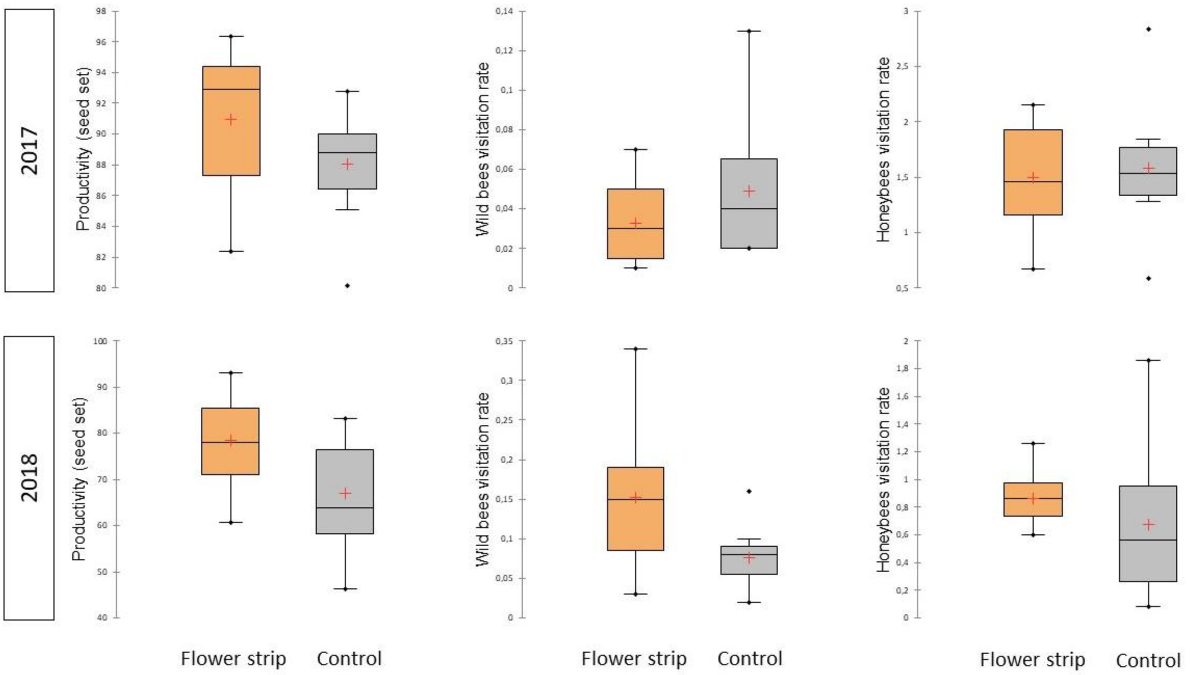

Figure 3. Box-plots showing the differences between fields with the installed flower strips and control fields regarding the productivity-seed set (**left**), wild bee visitation rate (**middle**), and honeybee visitation rate (**right**).

3.2. Economic Viability Analysis

The additional gross profit in sunflower fields with flower strips was estimated at 97 €/ha per year. The initial cost of installing flower strips was estimated at 141 €/ha, and the annual maintenance cost was estimated at 68 €/ha for subsequent years (Table 1).

NPV analysis showed that the flower strips would become profitable between 4 and 5 years after installation, depending on the type of subsidy (Figure 4). Under the unsubsidized scenario, 9 years would be required to recover the initial investment and obtain economic benefit (also termed the amortization time). The *direct subsidy* that finances 50% of the initial cost of flower strip installation (70.5 €) showed an amortization time of 5 years. In contrast, the *indirect subsidy* based on Spanish legislation would reduce the time required to recover costs to 4 years and could generate extra profit, based on allocating more production space on fallow lands. In the most favorable subsidy scenario, we estimated that once the initial investment was recovered, farmers could increase their annual benefits by 8.7% (29 €/ha per year).

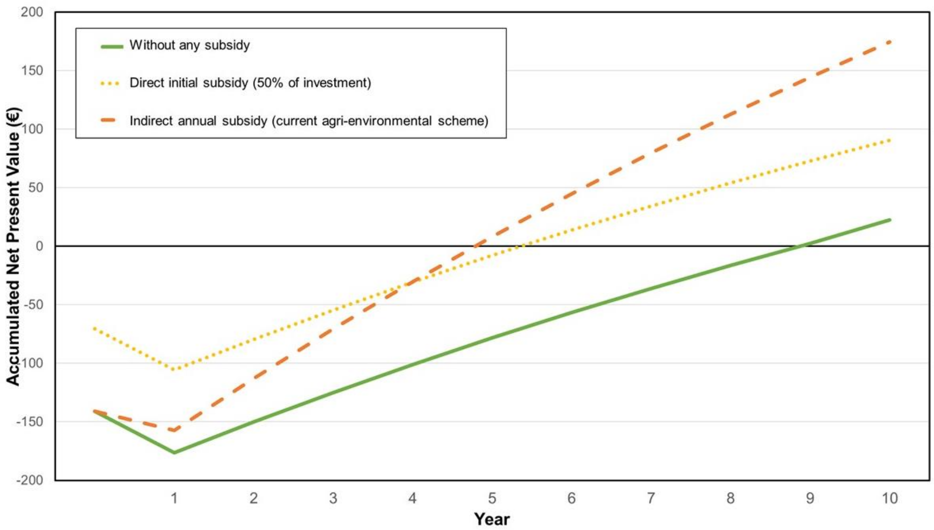

Figure 4. The accumulated net present value (€) with 1.05% discounted rate per annum; estimated from the benefits derived from yield increase by pollination and the costs of installing and maintaining the flower strips. Scenario 1, no subsidy; Scenario 2, with a hypothetical direct initial subsidy financing 50% of the initial cost of flower strip installation; Scenario 3, with an indirect subsidy based on Spanish Royal Decree 27/2018, where melliferous fallow land is considered an ecological focus area (EFA) with a weighting coefficient of 1.5 in relation to other fallow land.

3.3. Social Feasibility Analysis

Participants in the focus group agreed that flower strips positively enhanced the presence and abundance of pollinators in their fields (Table 2). All farmers also acknowledged the environmental value of flower strips, and their contribution to biodiversity conservation and landscape heterogeneity as well as their significance to the beekeeping sector as providers of food resources for honeybees. However, only a few participants in the focus group perceived a slight increase in sunflower production due to flower strips, with most farmers not noticing any yield increase.

On the negative side, all participants agreed that flower strips could facilitate the spread of some invasive weeds. They perceived that these species dispersed outside the flower strips, affecting nearby farmland, which would increase the costs of weed control in the fields. Another negative aspect identified by some participants was the added difficulty for cropland management (particularly when using large machinery) because of the spatial positioning of the flower strips in fields. Although the surface area of each field allocated to flower strips was usually less than 5%, almost all participants stressed the loss of a potentially cultivated area because of the presence of flower strips.

Focus group participants proposed several ways to increase their willingness to install and maintain flower strips in sunflower fields. We grouped these proposals into three categories: (a) economic issues, (b) technical support, and (c) design improvements.

Table 2. The major positive and negative effects of flower strips as perceived by farmers.

Positive	Negative
• There was consensus on the positive effect of flower strips on the community of pollinators, although this was not perceived as an element that significantly increased the production of sunflower.	• Flower strips were perceived as a potential source of invasive plants, which is a disadvantage associated with the need to increase management efforts for their control.
• There was consensus on the environmental benefits of flower strips and their positive contribution to biodiversity and the landscape as well as their relevance to the beekeeping sector.	• Placement of flower strips at the edges of farmland generated management problems in fields, especially when using large machinery in areas close to them (although there was no full consensus on this point). • The loss of potentially cultivable areas due to the installation of flower strips was perceived as negative.

The two economic proposals that generated more consensus among participants were: (1) financial support for acquiring specialized machinery to sow flower strips, and (2) a new subsidy to compensate for the disadvantages of establishing a 'new mini-crop' in their fields, which required adapting farm management to operate in these small plots, where regular machinery could not be deployed. The establishment of this new compensatory subsidy was considered as a requirement to make flower strip installation viable in the long-term. In all cases, farmers considered that economic and financial aid should be provided by the EU, and supported by the Spanish government through the new CAP.

Farmers also strongly agreed that more training and support was needed. They requested specialized training on plant species suitable for flower strip installation. They also requested additional technical advice during the whole lifetime of the flower strips, supported by regional agricultural authorities.

Some technical improvements in the design of flower strips were also proposed by the farmers to avoid the disadvantages of integrating flower strips in sunflower fields. Participants proposed that large "islands of flowers" (ca. 2 ha) should be distributed in the landscape, particularly associated with extensive fallow land, as a better and more feasible strategy. This approach would simplify management and maintenance, avoiding complicated management based on flower strips installed in parts of individual fields.

To increase the appeal and acceptance of flower strips, the participants also highlighted that promoting the use of perennial aromatic plants would be better than planting annual herbaceous plants. Farmers considered that perennial aromatic plants would simplify the maintenance and management of flower strips, providing additional economic profits to farmers, as these plants could be periodically harvested.

4. Discussion

Installing flower strips represents an effective management practice that maintains biodiversity and ecosystem services in intensive agricultural landscapes [30]. This practice also improves the quality and yield of many pollinator-dependent crops [11,20]. However, to date, the implementation of flower strips by farmers has been moderate [31]. Based on our results, we discuss: (a) the benefits and challenges of flower strip installation in sunflower fields; (b) the limitations and current knowledge gaps; and (c) the potential policy implications under the ongoing CAP reform.

4.1. Benefits and Challenges of Flower Strip Implementation

Although subsidies are the main motivation for farmers to apply agri-environmental measures in their fields [32], other motivations could help ensure that they are sustainable and durable including environmental, agronomic, and unsubsidized financial benefits [33]. Our results show that farmers perceived flower strips as a positive measure to conserve pollinator communities in the agricultural landscape. Nature conservation has been identified as an intrinsic motivation that is often reflected in a personal sense of environmental responsibility and accountability [33,34]. Thus, environmental enhancement could be an important element for encouraging farmers to apply agri-environmental measures such as flower strips.

Regarding productivity, most farmers in our case study did not perceive a significant yield increase from the flower strip installation. The perception of productivity is probably the most important criterion for the farmers to implement new measures in their fields [35,36]. Our results concur with those of previous studies, which suggested that flower strips provide both environmental and direct economic benefits to farmers [11,20]. Once flower strips have been established, and the initial costs recovered, farmers obtain direct economic benefits through yield increases. Considering that these increases are not well-perceived by farmers, a key future challenge is to demonstrate the environmental and economic benefits of flower strips to farmers through a clear evidence base.

Beyond the direct economic benefits, unsubsidized financial benefits could be another motivation for farmers. In our study area, farmers proposed using perennial aromatic plants to make flower strips more attractive, and provide additional economic profits based on the periodic harvesting of these plants. Farmers strongly agreed on the relevance of flower strips for the beekeeping sector. Thus, installing flower strips could attract the installation of apiaries in simplified agricultural landscapes where food resources for honeybees remain scarce. Furthermore, co-designing flower strips with stakeholders could foster their implementation, because bottom-up proposals could connect extrinsic and intrinsic motivations by combining small economic incentives with win–win management based on ecosystem services [33].

In addition, instead of implementing flower strips in individual fields, farmers in our study site proposed using large plots of flowers distributed across the landscape, particularly associated with large fallow land. This is consistent with Buhk et al.'s [26] recommendation of a network of flower strips covering a total of 10% of the landscape. Despite the administrative challenge that this would represent, landscape-scale management based on collaborative measures might be a potential tool to improve environmental effectiveness and agricultural benefits [37,38]. Researchers have demonstrated that the effectiveness of agri-environmental measures depends on the landscape-wide availability of resources [39,40]. Therefore, it is promising that local farmers have proposed collaborative measures at the landscape scale, because the abundance and diversity of pollinating species visiting crops are strongly associated with landscape diversity [41].

Furthermore, setting up additional structures in fields was perceived to cause management problems, with flower strips potentially attracting the establishment of unwanted invasive weeds in adjacent cropland. Most farmers considered that continuous modernization and mechanization (e.g., specific machinery or more use of agrochemicals) is necessary to maintain "clean fields" [42]. Thus, a productivist mentality persists, conflicting with conservation objectives [43,44]. In this regard, the farmers from our study area requested more training and support. Programs to raise awareness are fundamental to show farmers that proper biodiversity management of agricultural lands generates both agronomic and economic benefits.

4.2. Limitations and Knowledge Gaps

Economic incentives are a potential tool for encouraging farmers to implement agri-environmental measures in their fields [21]. However, some limitations and knowledge gaps must be overcome to facilitate the wider application of pollinator-friendly practices such as flower strips.

There is increasing evidence that wild bees enhance the quality and yield of many pollinator-dependent crops [12,18,45]. However, there remains no scientific consensus on whether flower strips increase yields [11,37,40,46]. Although flower strips have been proven to be effective in simplified agricultural landscapes, their effectiveness might vary both temporally and spatially [24,40,47]. Wild bee communities are highly influenced by the availability of resources in adjacent natural and semi-natural habitats [41]. Therefore, changes to production due to increased pollination services are dependent on both the particular measures adopted at the field scale and a combination of practices at the landscape scale [40].

Typically, economic studies do not usually include more than 2–3 years of data (but see [48]), whereas wild bees require time to adjust, as their populations fluctuate widely across years [49]. The diversity and abundance of pollinators as well as plant–pollinator interactions exhibit high temporal variability [49,50]. Key influencing factors include climatic and soil conditions, together with crop management such as crop rotation, nutrient inputs, and pesticide applications [40]. Therefore, under uncertainties associated with global climate change, longer-term studies that include the landscape context are needed to illustrate the real effects of flower strips on pollinator communities and crops.

Cost–benefit analysis represents an easy evidence-based tool for farmers to evaluate the efficiency of installing flower strips in their fields. However, there are also secondary benefits as well as hidden costs and benefits, and other non-monetary aspects of pollinator conservation that are difficult to calculate [51]. Of note, there were less obvious, delayed, or non-monetary factors that could affect the cost–benefit analyses such as an increase in pests and weeds due to flower strips, or the possible absence of spillage (pollinators are attracted to the margins of wildflowers and do not enter the crop) [52].

The benefits of flower strips are multifaceted, and are influenced by multiple factors [53]. The benefits could be overestimated because an increase in crop production is usually extrapolated from plot size; however, the effects of pollinators might decrease with increasing distance to the flower strip [18]. In contrast, the real benefits might also be underestimated, because most studies have only evaluated the monetary income generated through improving a particular ecosystem service (e.g., pollination), while other associated ecosystem services are not usually considered (e.g., pest control, aesthetic value, water quality, soil fertility) [52]. Therefore, cost–benefit analysis is a useful tool, but should be combined with an analysis of stakeholder perceptions [51].

Some other limitations of our cost–benefit analysis should be acknowledged. First, we only included the scenarios of subsidy that emerged from farmer perceptions, but other scenarios that were not analyzed might be plausible under the current CAP (e.g., annual payments to compensate for crops loss and additional costs induced by flower strip implementation, based on a 5-year commitment). Second, we could not fully address the complexity of fallow land management in the study area, which might have biased some subsidy estimations, as farmers usually leave the less fertile zones fallow where yield is expected to be lower. Finally, we need to acknowledge that our cost–benefit analysis would lead to very different results if using the current market price of sunflower seeds (much higher due to the war in Ukraine).

4.3. Policy Implications in the Context of the Ongoing CAP Reform

Political concern over pollinator conservation in Europe has been increasing. Some states have implemented National Plans since 2009. However, most European states are only beginning to develop specific measures to address the pollinator crisis [54]. Therefore, it is important to develop a sound European framework through CAP to promote measures that conserve pollinators in agricultural landscapes.

In the last reform of CAP, some agri-environmental measures (such as flower strips) were incorporated in the green payment of the II pillar (greening) [14]. The Spanish government legislated the establishment of "melliferous fallows" in EFAs based on an indirect subsidy (Spanish Royal Decree 27/2018). Our results show that this type of subsidy is viable to both reduce the time required to recoup the initial costs, and to increase profitability in the long-term. However, our social analysis showed that the farmers strongly preferred direct monetary subsidies to implement new measures in their fields. Moreover, the indirect subsidies would vary depending on annual yield. Thus, developing direct monetary aid to encourage farmers to install flower strips on their farms is recommended.

Although we agree that subsidies might not be a desirable option to render sustainable and effective flower strips in the long-term [33], our results show that this financial tool is a necessary request by farmers, and is fundamental to making the costs profitable in the mid-term (less than 9 years). Buhk et al. [26] concluded that a reduction in bureaucratic obstacles and sufficient incentives, especially in highly productive areas, are necessary to make flower strips attractive to farmers. However, some studies have suggested that once farmers apply conservation measures, their motivation could shift from a financial reason based on subsidies to environmental incentives [55,56].

EFAs have been criticized because farmers sometimes choose measures that are not the best for environmental conservation such as nitrogen-fixing crops, as farmers perceive them as being more easily implemented [31]. Consequently, there is a mismatch between the effectiveness and efficiency of interventions for enhancing pollinators, because the options that farmers perceive as the most effective are not generally the most efficient due to their high cost [22].

In light of the ongoing discussions on the effectiveness of agri-environmental measures to improve biodiversity and ecosystem services [57], our case study showed that flower strips are useful tools that provide both environmental and economic benefits in sunflower landscapes. However, it is fundamental to incorporate the perceptions and opinions of farmers to improve the design of flower strips, and to provide farmers with a specific subsidy and additional technical advice, to upscale the implementation of flower strips.

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