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Biodiversity loss part II: portfolio impacts and abatement measures

A quantitative case study on pollination

Executive Summary

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- **Portfolios most exposed to equities and the agriculture and food services sectors feel the pinch of biodiversity loss.** The results of our pilot study on pollination-service loss (PSL) allow for quantitative estimates of financial institutions' portfolio exposure to biodiversity-related risk. Applying the shocks to a representative portfolio of an average German life insurer leads to rather modest impacts: The overall portfolio loss comes out at 0.17%, mainly because of low exposure to the sectors that will be hit the hardest (agriculture and food services) and to equities in general. In contrast, portfolios with larger equity shares (e.g. US insurers) would likely experience larger losses overall.

- **How much will it cost to abate PSL?** In estimating these abating costs, we focus on seven agricultural measures that protect pollinators. The cost estimates differ widely per measure and country. At the country level, for instance, costs for measures in Germany range from USD45mn for computer-assisted decision-support systems to over USD3.5bn for nematode application. At the measure level, costs for the use of organic fungicide, for example, range from USD135mn in the Netherlands to USD2.4bn in France, due to different adoption rates.

- **However, the decisive question is not the cost of each measure per se, but how these costs compare to the economic value of pollination services.** In a first step, we identify measures whose cost of implementation are less than the economic value of 10% PSL. This applies to five measures (out of seven) in the Netherlands but only to two in the other countries, except for Italy (three measures). Considering how much PSL can be abated in reality by these measures, the analysis shows that in France, Germany or the UK, no measure would pass this test of economic viability.

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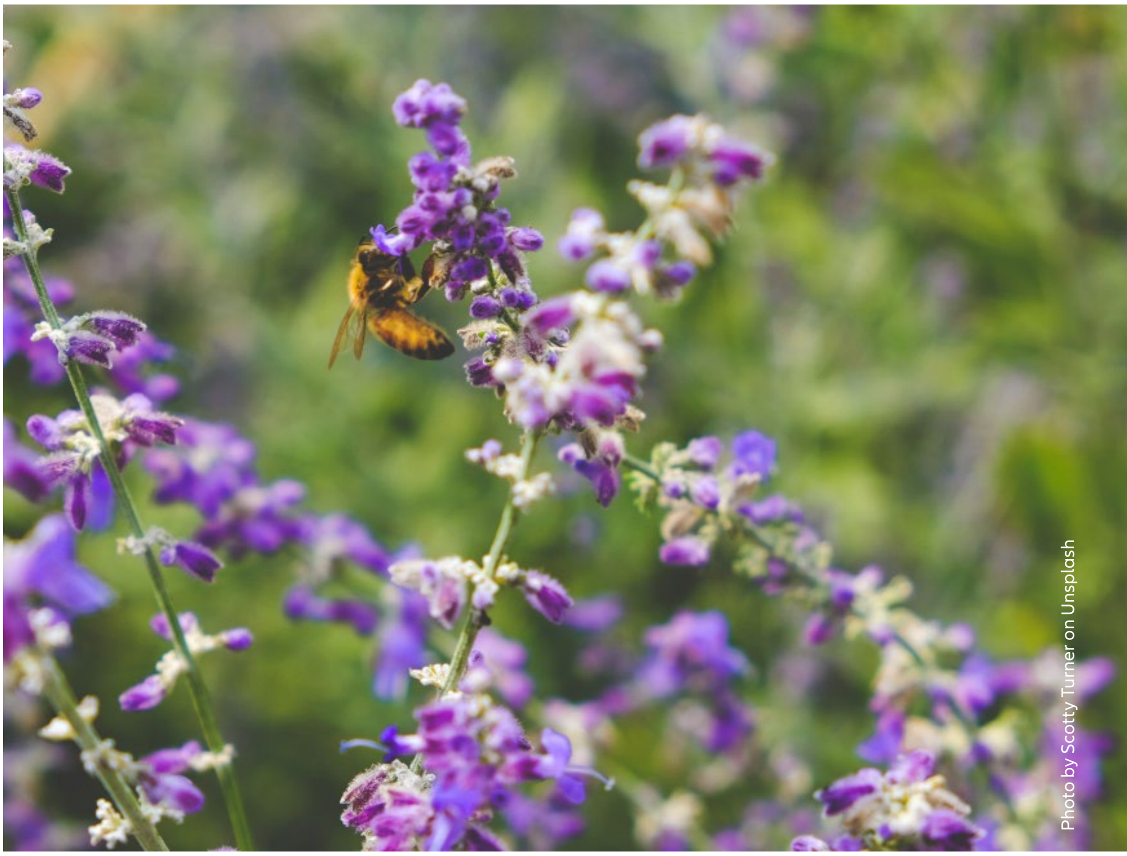


Introduction

In our previous research[1], we established the conceptual framework of how to measure the impact of biodiversity loss on the economy. Business activities depend on ecosystem services (ESs) supplied by natural capital assets (NCAs). Biodiversity – the variety of species and habitats – is part of diverse NCAs that provide ESs such as water, soil quality, dilution, pollination, pest control and flood protection. A decline in biodiversity and loss of habitats and species causes a reduction in the ability of NCAs to provide ESs essential for the economy and decreases the productivity of businesses (measured by the value of output obtained with one unit of economic input) dependent on ecosystem services.

In our analysis, we applied this general framework on one particular ES, namely pollination, using the MAGNET[2] general equilibrium model. Our main findings suggest that a complete elimination of pollination would cut agricultural output by between -2.0% in the UK and-7.9% in Belgium, reducing annual gross domestic product by between -0.04% (the UK) and -0.4% (Portugal). In absolute terms, this would be equivalent to between USD1bn (Portugal) and USD28bn (US) annually. On the other hand, the scenario also showed that the industrial and service sectors could grow as reduced pollination can increase the production of sectors that benefit from the land, capital and labor released by the contracting agricultural sector.

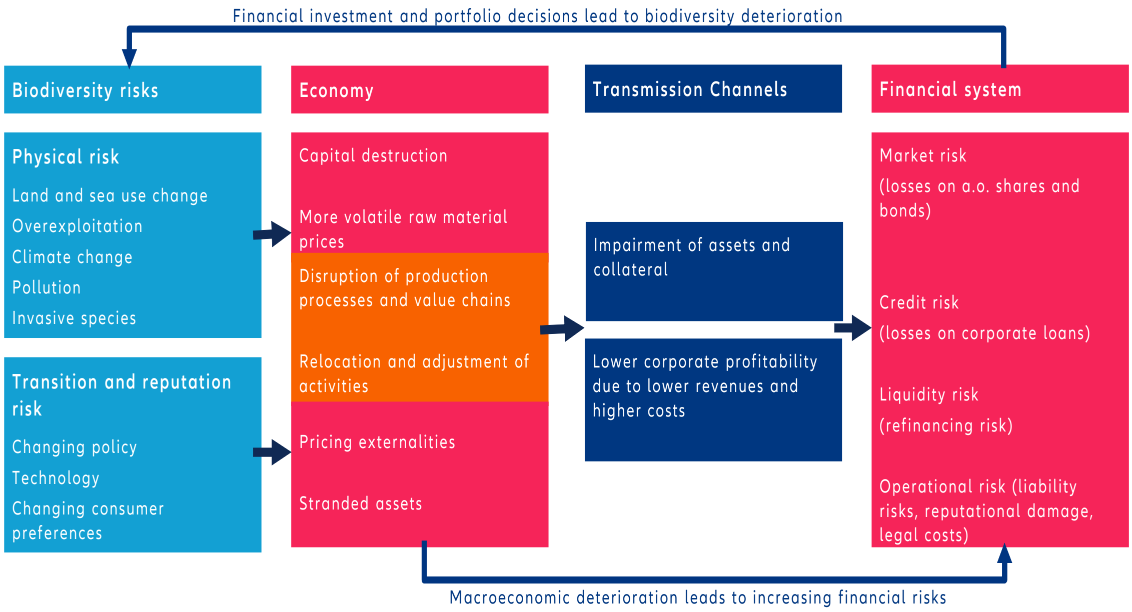
In this report, we go a step further. Using these monetary results, we quantify possible portfolio impacts of biodiversity loss and show the economic viability of abatement measures for different countries based on the monetary results, followed by the implementation costs of the measures. Such detailed analyses are an important prerequisite for a nature-positive economy as they can spur all stakeholders, including the financial sector, into action[3].

[1] 2023-02-28-Biodiversity.pdf (allianz.com).
[2] MAGNET (Modular Applied GeNeral Equilibrium Tool) is a multi-regional, multi-sector applied computable general equilibrium (CGE) model, which builds on GTAP datasets (Woltjer et al., 2014). In MAGNET, perfect competition is assumed and actors choose the cheapest combination of production factors: labor, land, capital and natural resources. Contrary to partial agrifood models, MAGNET includes income feedback loops between primary and industrial sectors in order to cover the full (bio)economy.
[3] This study is based on the modelling efforts and results described in the forthcoming Wageningen University & Research report titled "Bending the curve for biodiversity loss and economy: Case study evidence from pollination services loss" authored by Haki Pamuk, Marcia Arredondo Rivera, Jurrian Nannes, Willem-Jan van Zeist, Nico Polman and Markus Zimmer.

How biodiverstiy loss impacts the financial sector

Financial institutions could face financial, market, reputational and legal risks when they invest in economic activities that cause adverse effects on biodiversity or are highly dependent on natural capital (Figure 1). Understanding and evaluating the associated risks is vital for the financial sector's performance, and disclosing these risks is the core of the EU's evolving Corporate Sustainability Reporting Directive (CSRD).

Figure 1: How biodiversity risks impact the financial sector



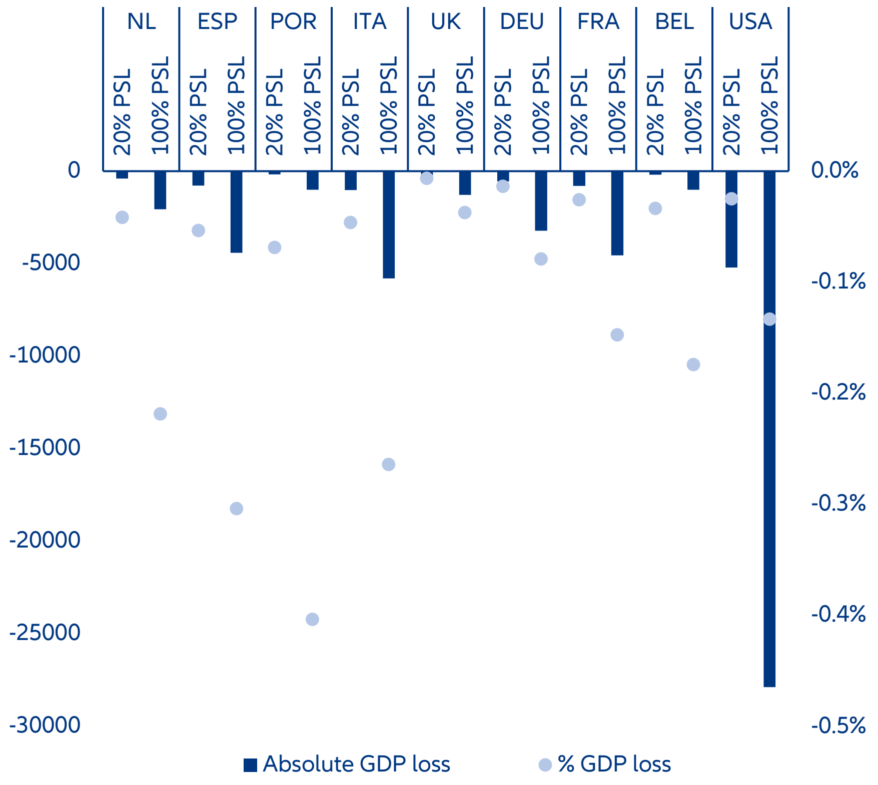
Sources: Pamuk et al. (2023), Allianz Research.

So far, however, this evaluation has been done on a purely qualitative basis. This is largely due to a lack of hard data. The results of our pilot study on pollination-service loss (PSL) enable us now to produce quantitative estimates of the impact at the portfolio level, assessing portfolios' biodiversity-related risk exposure in money terms. The methodology is straightforward and involves weighting the estimated sector-country economic losses by the share of financial assets in those sectors and countries.

What would a biodiversity stress test for a financial institution look like? The results of the previous report provide the basis for showcasing the following exemplary biodiversity stress test on the asset portfolio of a typical German insurance company. The underlying scenario relates to 100% pollination-service loss that materializes linearly between 2020 and 2050.

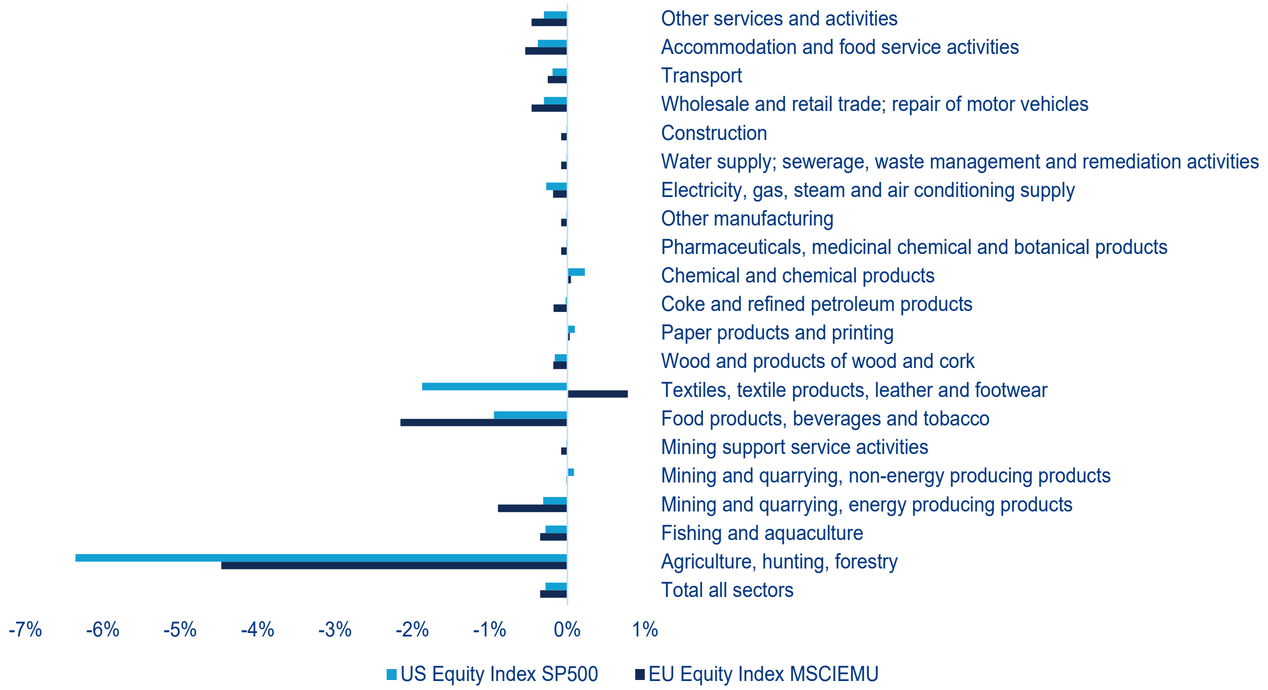
In order to obtain the financial impacts of the pollination-loss scenario, the Allianz forecast methodology is used to estimate impacts on yields, equities, real estate and further financial variables from the sectoral gross value impacts. The methodology is a simplified and adjusted version of Frankovic (2022) and is similar to the financial climate stress-testing methodology used by Allianz. The assessment models sectoral impacts from GDP changes by using sectoral "scaling factors" like in Frankovic (2022); the scaling factors are derived from the sectoral results of the multi-region production network MAGNET model. In principle it would be preferrable to use the sectoral impacts directly, which would require a better alignment of the sector classifications used for the pollination-loss model and the financial stress-test model (the sector correspondence and shares are listed in Table A2 in the Appendix). Starting from the GDP shocks shown in Figure 2, the fiscal balance of the modeled countries is impacted, which in the (assumed) absence of monetary policy induces a change in government yield. Changes in the growth rate further impact current and expected corporate earnings, leading to additional shocks on equities, alternative investments and corporate spreads. Particularly for equities and corporate bonds, further sector modifiers, the aforementioned scaling factors, which are based on changes in sectoral GVA (gross value added) shares (see Table A1 in the Appendix), are applied in order to account for the variance of sector impacts. The resulting equity shocks are shown in Figure 3 for the US as well as the EU aggregate.

Figure 2: GDP change due to losses in pollination services



Sources: Pamuk et al. (2023), Allianz Research.

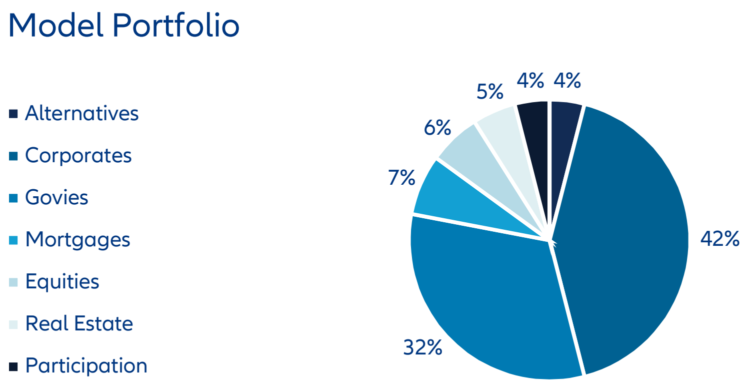
Figure 3: Impact of losses in pollination services on equity in different sectors



Sources: Pamuk et al. (2023), Allianz Research.

The shocks where then applied to a representative portfolio based on the asset allocation of an average German life insurer (Figure 4). The impacts on the different components of the portfolio are listed in Table 1. The main findings suggest that the overall portfolio loss remains moderate at 0.17%. While equities and alternatives are hit by a relatively large shock, portfolio impacts are driven by the revaluation of the fixed income portfolio. One driver is the increase in government yields due to the shocks on GDP, inducing a decrease in the fiscal balance, which leads to an increase in yields (a monetary policy response is not modeled). Other important factors are the shocks on equities and corporate credit spreads, which impact the sectors to different degrees. The impacts on real estate modeled herein are indirect effects from changes in GDP and yield but do not consider changes in land use. The impact on participations is modeled as the equity impact on the financial sector, which in turn is mainly driven by the impact on the general economy.

Figure 4: Portfolio share of a typical German insurance company



Source: GDV, Allianz Research.

The main reason for the limited overall effect is the limited exposure to sectors subject to the largest impacts (agriculture and food services). While these sectors have a notable share in overall GDP, exposed capital is typically not held by institutional investors. Furthermore, there is also limited equity or equity-like exposure due to the portfolio being modeled after German life insurers. Portfolios with larger equity shares (e.g. US insurers) would likely experience larger overall losses. It is also important to note that for a typical life insurer, increases in government yields would be partially offset by a revaluation of liabilities.

Table 1: Relative insurance portfolio shocks from pollination-loss scenario (in 2050)

Asset Class	Portfolio Share	Relative Shocks
Alternatives	4%	-0.30%
Corporates	42%	-0.22%
Govies	32%	-0.03%
Mortgages	7%	-0.05%
Equities	6%	-0.39%
Real Estate	5%	-0.34%
Participation	4%	-0.46%
Total	100%	-0.17%

Source: Allianz Research.

How biodiversity loss can be prevented

Investments in protecting biodiversity provide huge opportunities by securing long-term economic development and offering new business opportunities, not least for the financial sector. However, current investment efforts still remain hugely inadequate. The global financing gap to restore biodiversity until 2030 is estimated to be around USD700bn per year.[4]

It is not hard to understand why this gap is so immense. Biodiversity loss is local by nature, unlike climate change, where local emissions have global consequences. This leads to a very heterogenous map of biodiversity losses and resulting risks. The same applies to possible abatement measures. Without knowing the economic loss in the first place, it is almost impossible to implement adequate counter-measures because a proper cost-benefit-analysis is impossible.

To close the gap, this study – based on our estimates of economic losses due to PSL – estimates the cost of abating PSL for agricultural measures that protect pollinators. Selected measures to restore pollination services are based on a review of academic and grey literature, as well as consultations with agriculture and plant science experts. These practices positively affect biodiversity and pollinators and improve general habitat quality, which will foster a greater biodiversity. One example for this is the introduction of sustainable farming practices to reduce PSL by limiting the extensive use of chemicals. Table 2 below lists the farming practices that prevent PSL as well as their costs of implementation for the Netherlands, for which the most information is available. The findings are based on literature and data for both total cropland and the number of cropland farms of soy and oilseeds, as well as fruit and nut trees dependent on animal pollination (Klein et al., 2007). Although these measures yield other benefits as well (e.g. abating greenhouse gas emissions), these “collateral” benefits are not considered in this study.

[4] See Deutz et al., (2020).

Table 2: Abatement measures for PSL and their implementation costs for the Netherlands. Implementation costs represents costs in 2022[5].

Type	Measure	Cost adjusted to 2022
Precision agriculture		
	Computer-assisted decision support systems for optimal timing of input (e.g., fungicide use)	€625 per farm-year
	Precision spraying	Around €10.413 per farm (one time)
	Sensor-based identification, quantification of diseases and high-resolution spraying with cameras and sensors	Minimum of €104.130 per farm (one time)
Biocontrol		
	Nematode application	€625 per ha-year
	Organic fungicide (trianum)	€274 per ha-year
Ecological principles		
	Wider crop rotations	€10.413 per farm-year
	No-tillage	€52 per hectare-year
	Use of green manures (organic material to improve soil fertility)	€182 per hectare-year

Note: # The sources of costs estimates are as follows: computer assisted decision support systems, (Dacom,n.y.); precision spraying and sensor based identification, NPPL (2020); controlled farming, (DAW, n..y.); nematode application and organic fungicide, Smit et al., (2021); no tillage, De Wolf et al. (2019), wider crop rotations and green manures, KWIN AGV (2018).
*Estimates can include the costs of yield reduction and the investment required to implement the method.

Sources: Pamuk et al. (2023), Allianz Research.

Among the selected measures presented here, some ensure that pollinators face less artificial inputs such as pesticides (precision farming), while others provide resources and habitat for pollinators to thrive (biocontrol and ecological principles). These practices offer wider benefits to biodiversity and ecosystems supporting agricultural production (Riemens et al., 2021) and are thus recognized by the EU Common Agricultural Policy to support wild pollinators in farmed land (Cole et al., 2020). However, the exact number of pollinators benefiting from the measures and the increased service in pollination that they can offer is very difficult to estimate. This is because any effects following the implementation of any of these practices will be dependent on the local environment, ecosystem conditions of the farm and its surroundings. When analyzing specific cases, for instance implementing measures to reduce pesticide use (e.g. precision spraying, computer-based systems), results are reported as increased amount of pollinator visits to flowers of a particular crop. This correlates with pollinator conservation and with increased pollination services and yields (Pecenka et al., 2021).

[5]These indicative costs were adjusted for inflation using the growth rate of GDP deflator January 2021 compared to GDP deflator January 2022 of the EU.

Methodology

We estimate the abatement cost of PSL per measures in France, the UK, Germany, Italy and the Netherlands with the following formula:

$$\Delta AC_{pc} = AR_c \times C_p \times \Delta AD_p \quad (1)$$

p indicates the practices and c depicts the country. ΔAC_{pc} indicates the change in the country level abatement cost of a practice from 2023 to 2035, AR_c is the area (in hectares) of cropland or number of farms, C_p is the cost of implementing the practice per hectare (or per farm) from Table 2 (i.e. based on the costs for the Netherlands) and ΔADp represents the expected change in the adoption rate of the practices from 2023 to 2035.[6] The data on the area of cropland (AR_c) was obtained from the FAO[7], taking into account crops growing on „arable land" as well as areas covered with „permanent crops". The data on the number of farms is from EUROSTAT under the category of „crop specialists"[8], including data for the same crops as in FAO. This data was available for all countries except for the UK. The data on the number of farms for the UK was added from the Department for Environment Food and Rural affairs[9]. Wageningen University Research's expert opinion is used to predict the expected change in the adoption rates of those practices from 2023 to 2035 (AD_p). In their predictions, the consulted experts considered the current adoption rate and potential upcoming regulations concerning the measures, as well as the suitability of farms for measure adoption. As input in the abatement cost calculation, the difference between the present and future adoption rates for each measure and country was calculated. The changes in adoption rates, which are presented in Table A3 of the Appendix, represent a maximum for each measure and country. To check the robustness of the predictions, experts have separately been consulted.[10]

An important caveat: Our study solely focuses on measures regarding agricultural land use. However, other measures can positively contribute to improving natural habitats, biodiversity and pollinator populations, too. These include sustainable forestry and the development of landscape elements such as flower margins, hedges and green roofs in a more urban setting (Passaseo et al., 2021). A rough cost estimation based on the new EU Forest Strategy for 2030[11] and the EU's pledge to plant 3bn trees by 2030 would indicate that implementing forestry as a measure to restore pollination services would cost around USD 3bn in total for EU.

The country-level implementation costs of the different measures vary by cropland size and range between USD4.6mn (Netherlands – Computer-assisted decision support systems) to USD5.6bn (France – nematode application). Table 3 presents the estimated costs of implementing a selection of crop-protection measures in Germany, the Netherlands, the UK, Italy and France using formula (1). All figures in the Table show the annual cost of implementing the measures except for sensor-based systems and precision spraying, which require a one-time investment. The costs in Germany range from USD45mn for computer-assisted decision-support systems to over USD3.5bn for nematode application. For the use of organic fungicide, costs range from USD135mn in the Netherlands to USD2.4bn in France. As suggested by the formula, implementation costs grow by country land size and are high in countries with large cropland areas (such as Germany, Italy and France).

[6]Adoption rates are not crop specific. Future studies could explore adoption rates of each measure for different crops and countries.
[7]Food and Agriculture Organization of the United Nations. FAOSTAT, Land Use data. Link.
[8]Farms and farmland in the EU-statistics. EUROSTAT Link.
[9]Agriculture in the UK Evidence Pack. Department for Environment Food and Rural Affairs, 2022. Link.
[10]Instead of experts' predictions, future studies might want to perform empirical studies considering, for example, the feasibility of adoption, willingness to adopt, age of farmers, farm size and crops grown, among others.
[11]EU Forest Policy. European Commission Link

Table 3: Estimated cost of implementing farm-management measures to abate PSL by country, USD mn (2022).

Measure	Cost-type	Germany	Netherlands	United Kingdom	Italy	France
Computer-assisted decision support systems	Per year	$46	$5	$26	$318	$77
Precision spraying	Per year	$345	$110	$194	$2,409	$582
Sensor-based systems	One time	$3,448	$1,100	$1,940	$24,087	$5,823
Nematode application	Per year	$3,507	$308	$1,781	$2,738	$5,608
Organic fungicide	Per year	$1,537	$135	$781	$1,200	$2,458
Wider crop rotations	Per year	$690	$110	$388	$4,817	$1,165
No-tillage	Per year	$195	$17	$99	$152	$312
Use of green manures	Per year	$568	$50	$289	$444	$909

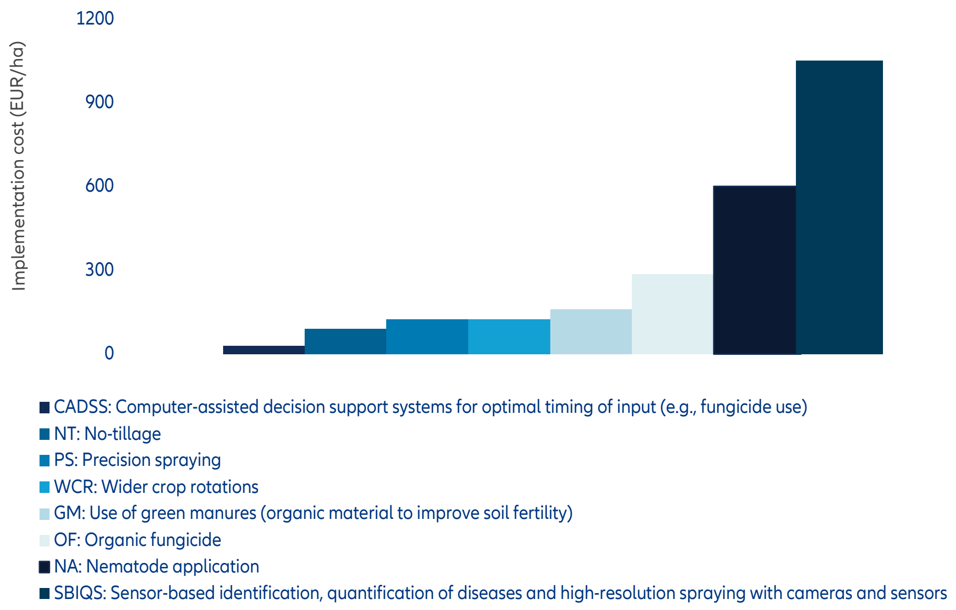
Sources: Pamuk et al. (2023), Allianz Research.

Figure 5 shows the annual implementation costs for additional land covered from 2023 to 2035 by each pollination-protection measure for an aggregate of the five European countries (France, Germany, Italy, the Netherlands and the UK). The Y-axis indicates the costs per hectare per year for each measure[12]. The estimation of the additional cropland is based on each measure's additional adoption rates estimated by the expert panel and corrected for the (average) percentage of cropland on which the measure is already implemented[13]. The area of each bar thereby shows the total cost of implementing those measures from 2023 till 2035. It is assumed that for each measure, the implementation cost per hectare and year are equal for each of the countries considered.

The essential question, however, is not the cost of each measure per se, but how these costs of farm-management measures compare to the economic value of pollination services. We answer this question by comparing the previously estimated economic value of PSL with the cost figures from Table 3. Figure 6 presents the results for Germany, the UK, the Netherlands, France and Italy. The blue lines in the figures show the economic value of PSL for different levels of PSL (e.g. 10% of loss). For example, in the 100% PSL scenario, economic losses in Germany would amount to about USD3.2bn. Therefore, the economic value of 100% pollination services is assumed to be the same. The orange dots indicate the cost of country-level implementation of the identified measures. In Germany, the UK and France, there are two farm-management practices with implementation costs higher than the economic value of a complete (100%) PSL while in Italy and the Netherlands there is one such practice. On the other hand, there are five measures in the Netherlands and three in Italy – but only two in the other countries – whose cost of implementation is less than the economic value of 10% PSL. This shows the relative importance of PSL as well as the low cost of implementing countermeasures in the Dutch economy.

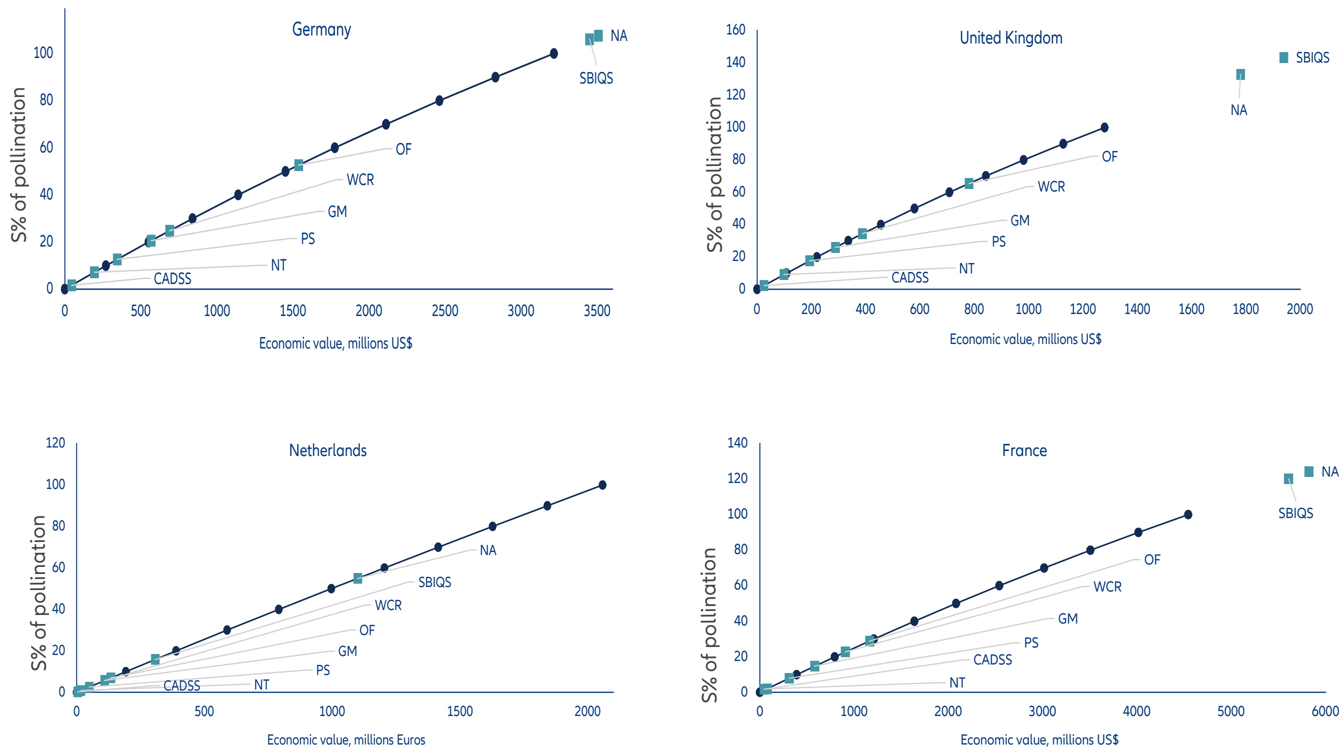
[12]Note that the bars along the X-axis are not showing cumulative results but rather individual results. This means that, for example, computer-assisted decision support systems (CADDS) for optimal timing of input (e.g. fungicide use) have a larger potential land area for implementation than no tillage (NT).
[13]Note that the figure does not incorporate the fact that using multiple measures on the same hectare could be unnecessary or inefficient. Adoption rates are provided individually and independent from other adoption rates.

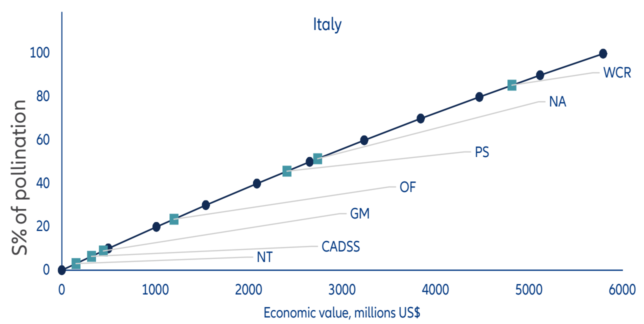
Figure 5: Pollination-protection-measure implementation cost for covering additional cropland. France, Germany, Italy, the Netherlands and the UK combined



Sources: Pamuk et al. (2023), Allianz Research.

Figure 6: Economic value/cost of country-level implementation of abatement measures and percentage of pollination-services loss leading to an economic loss equivalent to the cost of the measure.





CADSS: Computer-assisted decision support systems for optimal timing of input (e.g., fungicide use)
NT: No-tillage
PS: Precision spraying
WCR: Wider crop rotations
GM: Use of green manures (organic material to improve soil fertility)
OF: Organic fungicide
NA: Nematode application
SBIQS: Sensor-based identification, quantification of diseases and high-resolution spraying with cameras and sensors

Sources: Pamuk et al. (2023), Allianz Research.

This comparison already gives a strong indication that implementing farm-management practices may not be economically viable in many countries. The Netherlands is the exception when only considering their economic benefits via their PSL-abatement potential. A more precise answer would need to take into account how much PSL can in reality be abated by these measures. A back-of-the-envelope calculation[14] suggests that wider crop rotation can abate 11.5% of PS and no-tillage can abate 6.9%, while the use of green manures will abate 5.75% in the five European countries considered in our study (see Table 4).

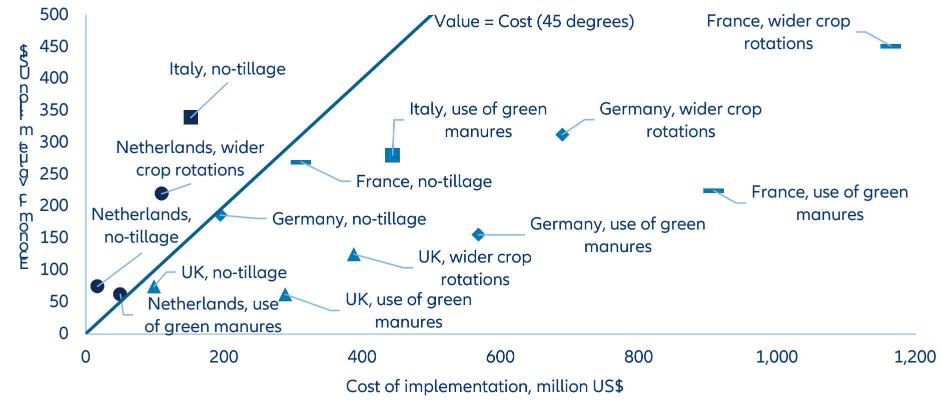
Table 4: Expected pollination-services (PS) improvement for measures based on ecological principles in France, Germany, the UK, Italy and the Netherlands, by ecological measures

		Wider crop rotation	No-tillage	Use of green
(1)	PS improvement value from case studies (%)	23	23	23
(2)	Expected increase in adoption rates in the countries (%)	50	30	25
(1)x(2)=(3)	Expected PS improvement at the country level (%)	11.5	6.9	5.75

Sources: Pamuk et al. (2023), Allianz Research.

In Figure 7, the cost of implementing different technologies in each country is compared to the economic value of 11.5% of PSL through wider crop rotation, 6.9% of PSL through no-tillage and 5.75% of PSL through the use of green manure[15] in each country. Local measures that fall on the left side of the green line can be considered as "no-regret" as the cost of implementing the technology is already lower than the pure local economic value of abating PSL without accounting for further co-benefits or positive spillovers. However, the analysis shows that wider crop rotation and green manure are only economically viable in the Netherlands. No tillage is economically viable in Italy and the Netherlands, but not in France, Germany or the UK. For the latter three countries, in fact, no measure would pass the cost-benefit analysis, though no-tillage comes very close in all three.

Figure 7: Comparison of cost and economic benefit of farm-management measures in terms of PSL



Note: wider crop rotation for Italy was omitted because of the cost.
Sources: Pamuk et al. (2023), Allianz Research.

[14]Assuming that the country-level adoption rates of ecological principles such as wider crop rotations, no-tillage and use of green manures are expected to increase by +50%, +30% and +25%, respectively, the impact can be approximated by multiplying this increase with the potential to abate PSL of each measure. For the sake of simplicity, based on literature, we assume that this potential is 23% on average and similar for all measures (Morandin et al., 2016; Pecenka et al., 2021).
[15]To find the corresponding economic of 11.5%, 6.9%, and 5.75% PSL, we assume that the economic value within 0-10%, 10%-20% PSL intervals are linearly increasing.

The implications for policymakers are clear. From a purely economic point of view, there might be too few abatement measures, if at all. But considering societal gains at large, this should be seen as under-investment. Some measures can be considered “no-regret” as direct benefits for agricultural production outweigh the implementation costs and potential path dependencies are limited. Yet, implementation may face regulatory hurdles and may need some support to guarantee a level-playing-field for the first movers in pursuing biodiversity-loss abatement. For now, protecting pollination is one of the clear cases for subsidies to reach a sufficient degree of abatement measures to quickly achieve results.

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Appendix

Table A1: Sectoral impacts of 100% pollination loss

	Production change					
Sector in MAGNET pollination loss model	US	Germany	France	Italy	Spain	UK
Services	-6.1%	-3.0%	-0.2%	-3.1%	-3.0%	-0.1%
Agri prod.	-0.1%	-1.0%	-3.4%	-6.3%	-1.0%	-2.0%
Food serv.	-0.7%	-0.2%	-0.7%	-0.2%	-0.2%	-0.1%
Coal & fuels	-1.6%	-0.6%	-0.1%	-0.1%	-0.6%	0.0%
Fertilizers	0.0%	0.0%	-0.8%	-1.3%	0.0%	2.0%
B&T	0.0%	-0.3%	-0.4%	-0.1%	-0.3%	0.1%
Electricity	-0.1%	0.1%	0.3%	3.4%	0.1%	0.1%
Forest prod.	0.0%	2.8%	0.2%	0.2%	2.8%	0.1%
Oil & Gas	3.6%	0.0%	0.3%	0.2%	0.0%	0.2%
Transport	0.1%	0.1%	0.3%	0.3%	0.1%	0.1%
AA&L	0.1%	0.1%	1.5%	0.1%	0.1%	0.9%
PPF&M	0.3%	0.8%	0.2%	1.5%	0.8%	0.6%
Industrials	0.3%	0.2%	0.4%	0.5%	0.2%	0.1%

Table A2: Sectoral correspondance table

Stress test model sector classification		MAGNET pollination loss model sector classification	Share of sector 1 impact; share of sector 2 impact (in aggregated stress test model sectors)									
Industry Code	Industry description	Sector 1; Sector 2	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	UK	USA	Average
D01T02	Agriculture, hunting, forestry	Agricultural products; Forest products	62%; 38%	62%; 38%	62%; 38%	62%; 38%	62%; 38%	62%; 38%	62%; 38%	57%; 43%	67%; 33%	62%; 38%
D03	Fishing and aquaculture	No impact assumed	-	-	-	-	-	-	-	-	-	-
D05T06	Mining and quarrying, energy producing products	Coal & consumable fuels	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D07T08	Mining and quarrying, non-energy producing products	Industrials; Fertilizers	98%; 2%	99%; 1%	100%; 0%	100%; 0%	100%; 0%	98%; 2%	89%; 11%	98%; 2%	98%; 2%	98%; 2%
D09	Mining support service activities	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D10T12	Food products, beverages and tobacco	Beverages and tobacco products; Processed & packaged food and meats	26%; 74%	16%; 84%	20%; 80%	18%; 82%	8%; 92%	36%; 64%	19%; 81%	12%; 88%	15%; 85%	19%; 81%
D13T15	Textiles, textile products, leather and footwear	Apparel, accessories & luxury goods	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D16	Wood and products of wood and cork	Forest products	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D17T18	Paper products and printing	Industrials; Forest products	40%; 60%	33%; 67%	29%; 71%	35%; 65%	28%; 72%	30%; 70%	37%; 63%	58%; 42%	12%; 88%	33%; 67%
D19	Coke and refined petroleum products	Oil & Gas	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D20	Chemical and chemical products	Industrials; Fertilizers	92%; 8%	92%; 8%	97%; 3%	95%; 5%	96%; 4%	92%; 8%	92%; 8%	94%; 6%	94%; 6%	94%; 6%
D21	Pharmaceuticals, medicinal chemical and botanical products	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D22	Rubber and plastics products	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D23	Other non-metallic mineral products	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D24	Basic metals	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D25	Fabricated metal products	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D26	Computer, electronic and optical equipment	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D27	Electrical equipment	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D28	Machinery and equipment, nec	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D29	Motor vehicles, trailers and semi-trailers	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D30	Other transport equipment	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D31T33	Manufacturing nec; repair and installation of machinery and equipment	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D35	Electricity, gas, steam and air conditioning supply	Electricity	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D36T39	Water supply; sewerage, waste management and remediation activities	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D41T43	Construction	Industrials	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D45T47	Wholesale and retail trade; repair of motor vehicles	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D49	Land transport and transport via pipelines	Transport	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D50	Water transport	Transport	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D51	Air transport	Transport	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D52	Warehousing and support activities for transportation	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D53	Postal and courier activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D55T56	Accommodation and food service activities	Services; Food services	17%; 83%	18%; 82%	31%; 69%	29%; 71%	28%; 72%	26%; 74%	20%; 80%	27%; 73%	26%; 74%	25%; 75%
D58T60	Publishing, audiovisual and broadcasting activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D61	Telecommunications	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D62T63	IT and other information services	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D64T66	Financial and insurance activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D68	Real estate activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D69T75	Professional, scientific and technical activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D77T82	Administrative and support services	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D84	Public administration and defence; compulsory social security	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D85	Education	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D86T88	Human health and social work activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D90T93	Arts, entertainment and recreation	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D94T96	Other service activities	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%
D97T98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	Services	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%	100%; 0%

Table A3: Expected increase in the adoption rates of measures to restore pollination services in Europe and the Netherlands from 2023 to 2035.

Measures	Adoption rate in The Netherlands (%)	Adoption rate Europe (%)
Computer-assisted decision support systems	35	55
Precision spraying	50	25
Sensor-based systems	50	25
Controlled traffic farming	0	-
Nematode application	45	45
Organic fungicide	45	45
Wider crop rotations	50	50
No-tillage	30	30
Use of green manures	25	25

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