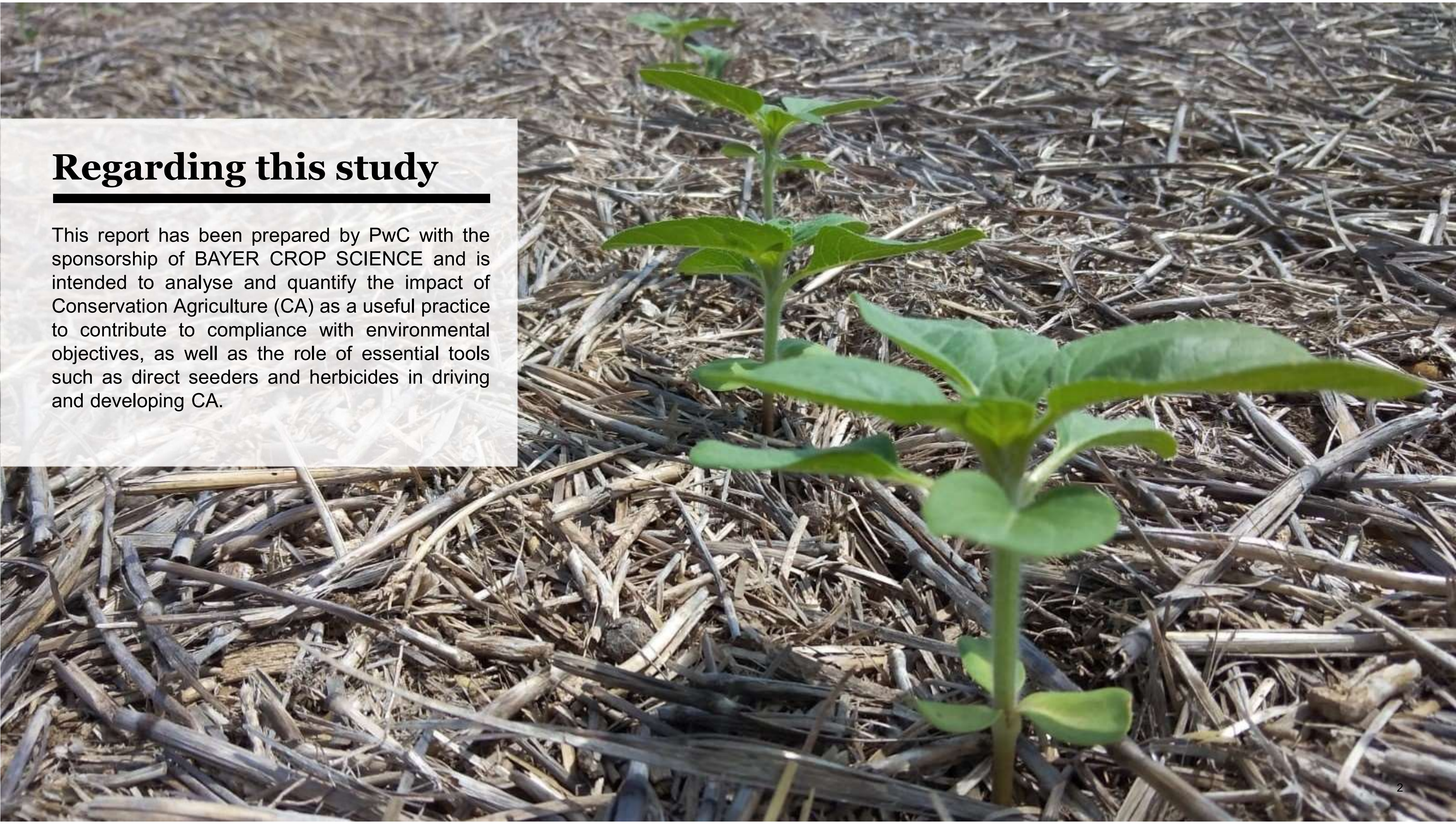
Conservation agriculture and the tools for its implementation in the context of the European Green Deal

September 2021

Collaborating entities:



Regarding this study

This report has been prepared by PwC with the sponsorship of BAYER CROP SCIENCE and is intended to analyse and quantify the impact of Conservation Agriculture (CA) as a useful practice to contribute to compliance with environmental objectives, as well as the role of essential tools such as direct seeders and herbicides in driving and developing CA.

Content

Executive Summary

The European Green Deal and European environmental and food strategies have established ambitious compliance objectives for which the agricultural sector and sustainable practices such as Conservation Agriculture will play an essential role

The **European Green Deal**, presented by the European Commission at the end of 2019, constitutes a road map to make the **EU economy sustainable and climate neutral** in 2050. It establishes an action plan to encourage the **efficient use of resources** by moving to a clean and circular economy and to restore **biodiversity** and **reduce pollution**.

The new **Common Agricultural Policy** (CAP) post-2020 will be built around a new, more ambitious environmental architecture adapted to the European Green Deal and aligned with the new «Biodiversity strategy for 2030» and «Farm to Fork strategy».

The following are notable among the large agriculture and sustainability projects:

«Farm to Fork» strategy

Allows the EU's current food system to become more healthy and sustainable.

«Biodiversity strategy for 2030»

A complete, systemic, ambitious and long-term plan for protecting nature and reversing the degradation of ecosystems.

Conservation Agriculture is a farming practice that offers multiple environmental, economic and social benefits. It can contribute to attaining the objectives of the European Green Deal and European strategies, as well as the specific objectives established by the European Commission for the new CAP.

Specific Objectives (SO) of the European Commission through the new CAP post-

(Contribution of CA to the objectives)

Economic sustainability	Environmental sustainability	Social sustainability
SO1. Guarantee fair income for farmers	SO4. Take action against climate change	SO7. Support of generational change
SO2. Increase competitiveness	SO5. Protect the environment	SO8. Maintain dynamic rural areas
SO3. Rebalancing of power within the food chain	SO6. Preserve landscapes and biodiversity	SO9. Protect food and health quality

Conservation Agriculture is a farming system with the essential objective of conserving, improving and more efficiently using natural resources

Conservation Agriculture is a farming system that seeks to respond to environmental problems and has been determined to be an alternative that is particularly respectful and efficient in terms of natural resources.

Spain currently has **2.1 Mha under CA cultivation** and this figure is growing at an average annual rate of 4.3%**.** CA still has far to go and could reach 13 Mha.

Principles on which CA is based

1. **Not altering arable land** through tilling actions
2. Permanent **vegetation coverage** on the surface.
3. **Rotation of crops** and/or diversification of crops

Relevance of CA in Spain

(latest data available)

2.1 Mha

Surface area cultivated under CA (15% of cultivated farmland)

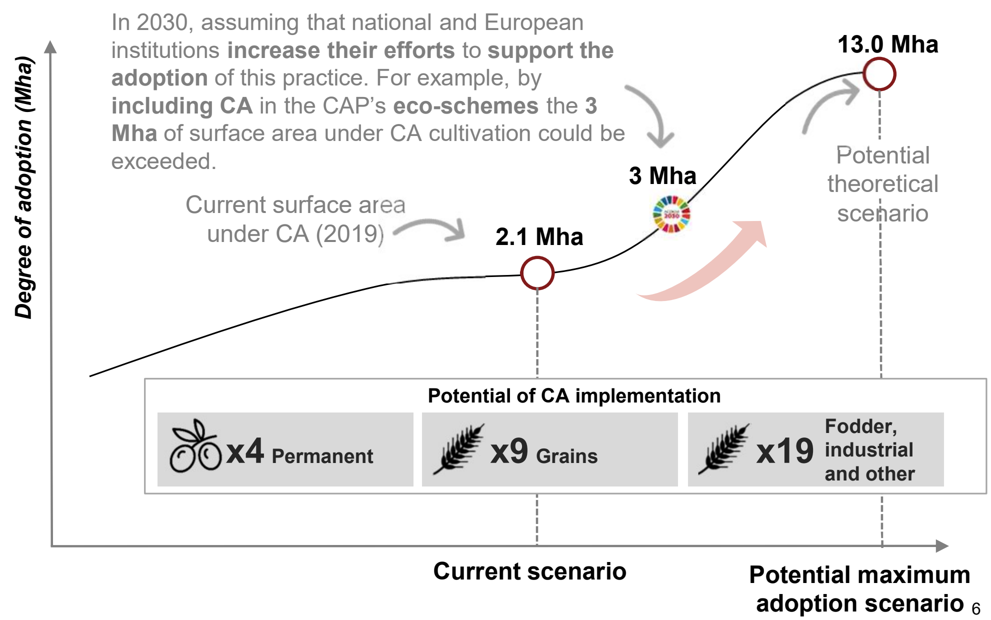
11.9 Mt

Production of CA crops

3,668 M€

Value of CA production (12% of farm production)

Conservation Agriculture implementation scenarios



Conservation Agriculture techniques are associated with a series of benefits that fulfil dual objectives: protect the environment and guarantee the financial viability of farming operations

Benefits of CA

Environmental benefits of CA

OE4 Benefits for the climate

- **Carbon sequestration** Not tilling the soil allows it to absorb the carbon previously sequestered by the crop through photosynthesis.
- **Lower CO_2 emissions** CO_2 is reduced in two ways: (i) due to the fact that the soil is not altered, the atmospheric CO_2 previously captured is not re-released; and (ii) the lower use of machinery associated with this farming system reduced the consumption of fuels and, as a result, the emissions associated with combustion.

OE5 OE6 Benefits for water

- **Reduction of runoff and increase in absorption** The presence of organic residue on land surfaces allows runoff to be limited in two ways: (i) lower runoff velocity on the surface; and (ii) greater protection of the soil against rain drops, which cause surface crusting.
- **Improvement of water quality** CA techniques reduce the necessary amount of fertiliser, herbicides, etc., which would otherwise be dissolved and transported by runoff water or absorbed into sediment.

OE4 OE5 OE6 Benefits for the soil

- **Erosion reduction** The vegetation coverage that characterises CA practices prevents erosion due to both water and wind. Organic crop residue left in fields encourages the retention and reduced the impact of rain, thus decreasing erosion potential. The same principle applies with respect to wind erosion, since the vegetation coverage prevents the loss of soil due to permanent contact with the wind.
- **Improvement in soil quality** The reduction of erosion improves the structure of soil and encourages the retention of organic materials, which provides greater amounts of nutrients and improves soil fertility.

OE6 Biodiversity benefits

- **Increase in the number of species** Vegetation coverage and not tilling permits a living structure to be established in the soil, consisting of microorganisms, worms, insects, etc., which contribute to the formation of the soil and its fertility.

Socio-economic benefits of CA

OE1 OE8 Benefits for the farmer

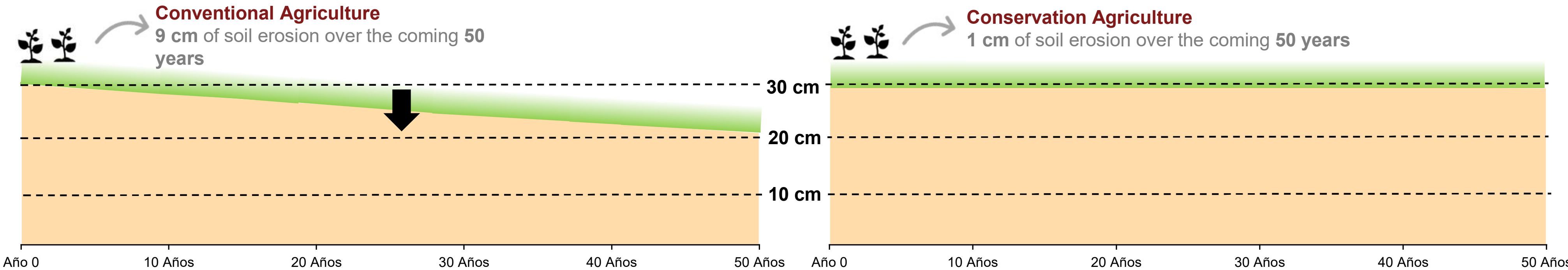
- **Time savings factor for farmers.** The CA characteristic of not tilling saves time for the farmer, which can then be dedicated to other production operations on the farm.
- **Energy savings.** The reduction of the use of machinery to prepare the soil translates into fuel savings and lower machinery maintenance costs.
- **Improvement in the profitability of operations.** The items listed above result in a decline in operating costs for farmers. Since conventional and conservation agriculture yields are usually the same, Conservation Agriculture provides greater benefits per hectare compared with conventional techniques based on tilling.

Contribution of CA to the objectives of the Green Deal / CAP

Source: Analysis by PwC and AEAC.SV

CA prevents the loss of nearly 13 tonnes of soil per hectare and year compared with conventional agriculture, which represents financial savings in terms of depreciation of 157 M€ per year and this figure could be as high as 811 M€ in a potential maximum adoption scenario

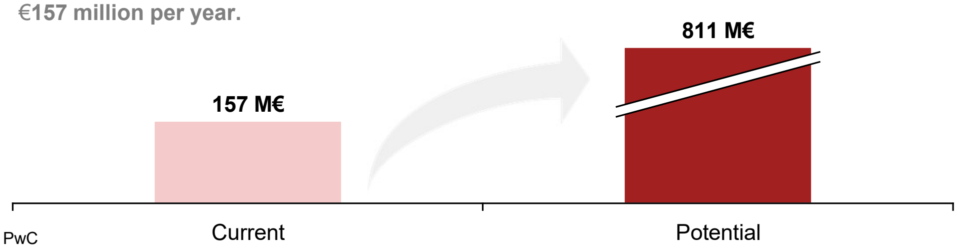
Comparison of the degree of soil erosion under Conventional Agriculture and CA scenarios



Annual financial benefits of using CA on farmland

The financial value of the land saved when using CA techniques on the total surface area of farmland is **€157 million per year.**

Soil loss valued at €811 million annually could be prevented under the potential maximum adoption scenario in which all of the potential arable land uses CA techniques (13 Mha).



13 t/ha

CA prevents the loss due to erosion of nearly **13 tonnes** of soil per hectare and year compared with conventional agriculture.

76 €/ha

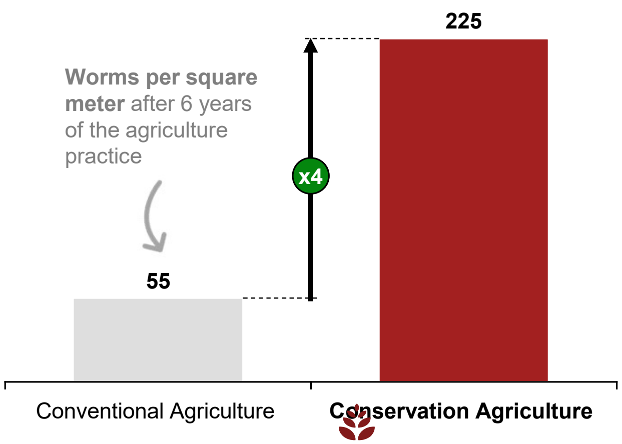
Savings in the value of the land totaling **€76** could be attained per arable hectare/year.

The adoption of Conservation Agriculture is also associated with an increase in biodiversity, resulting in a multiplication of living organisms in the soil by between 2 and 7.5 times the level under conventional agriculture

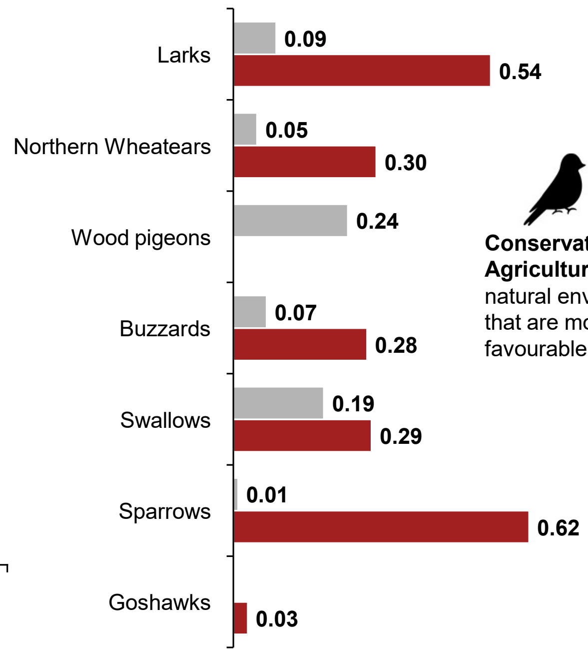
Contribution of CA to the increase in biodiversity

Soil biodiversity

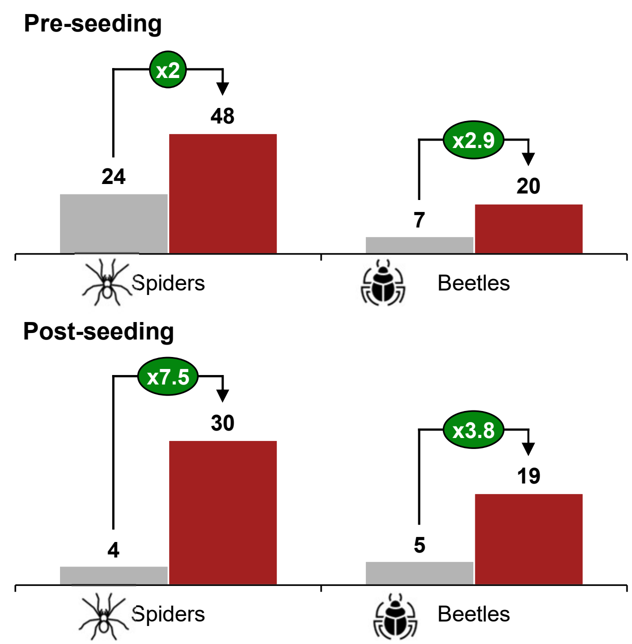
Conservation Agriculture multiplies by up to x4 the number of worms living in a square meter of land compared to **conventional agriculture**



Ornithological and epigenous biodiversity (individuals/meter)



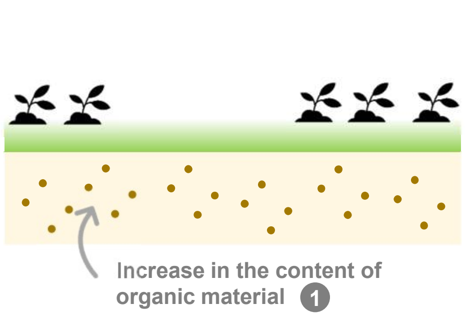
Conservation Agriculture creates natural environments that are more favourable for **birds.**



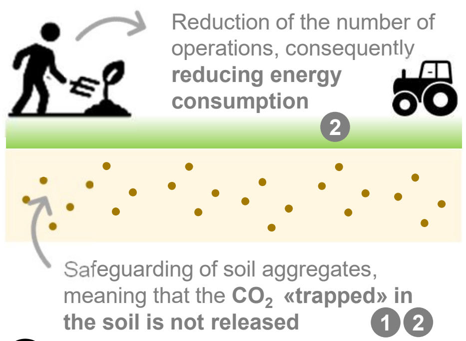
CA also contributes to mitigate climate change by preventing the emission of 10 Mt of CO_2 each year, and this amount could be as high as 55 Mt under the potential maximum adoption scenario, which would have an economic value of 242 M€ and 1,360 M€, respectively

Effects of CA on CO_2 emissions

Vegetation residue on soil



Elimination of soil tilling



1 Greater **sequestration of CO_2** in the soil

2 **Reduction** of **CO_2 emissions** into the atmosphere

4.7 t/ha

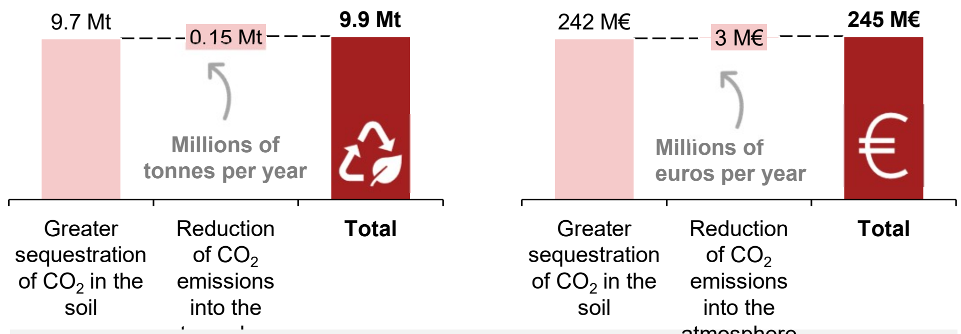
Each additional hectare using CA practices allows **4.7 tonnes of** CO_2 to be saved.

118 €/ha

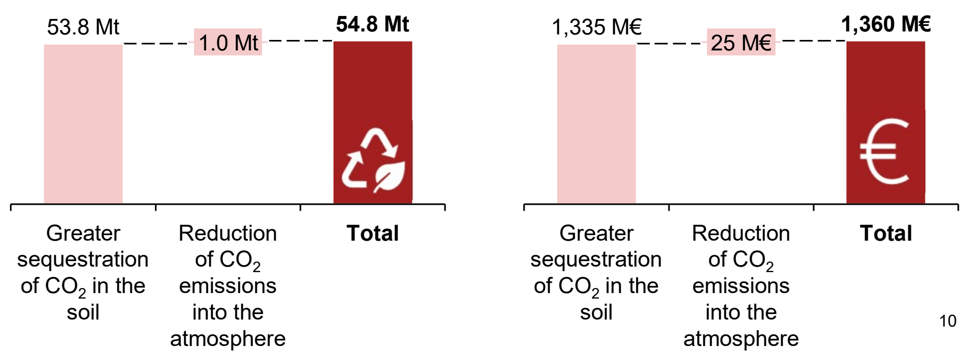
Each additional ha using CA practices avoids emissions valued at **€118.**

Impact of CA on CO_2 emissions

Current scenario

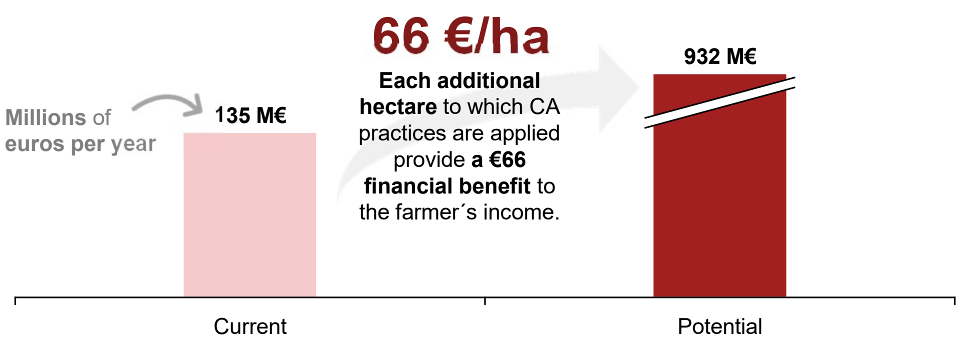


Potential scenario



CA is associated with lower costs and working time, which increases income for farmers by 135 M€ annually, reaching up to 932 M€ under the potential theoretical maximum adoption scenario

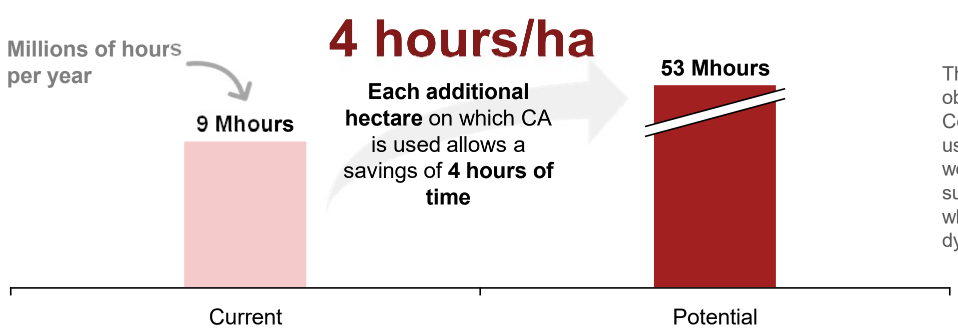
Improvement in the profitability of CA operations compared with conventional farming



CA causes **an improvement in operating profits** for farmers, greater sustainability of the activity and an increase in financial conditions.

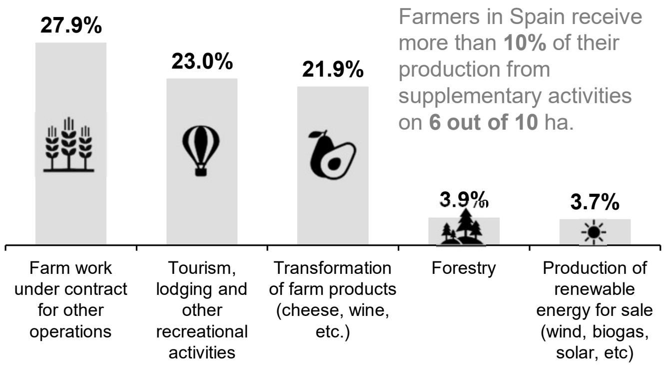
Working time savings allow farmers to have additional time that can be used to perform other activities on and outside of the agricultural operation.

Savings on labour costs deriving from CA compared to conventional farming



The greater available time obtained through the use of Conservation Agriculture can be used to reconcile home and working lives or for other supplementary farming activities, which can make rural areas more dynamic.

Main activities that supplement farming operations (2016)



Farmers in Spain receive more than **10%** of their production from supplementary activities on **6 out of 10** ha.

The environmental, economic and social benefits of Conservation Agriculture contribute to more dynamic rural areas and help fight against migration

Socio-economic contribution of CA in Spain

CA-related farming activities directly contribute to the economy, such as through GDP and the employment created in the farming sector, while simultaneously providing indirect or induced benefits through the economic activities that they promote within the supply chain, thanks to family consumption habits.

Direct contribution to GDP

€2,213 million

Direct contribution to employment

108,824 jobs

Total contribution[1] to GDP

€4,285 million

Total contribution[1] to jobs

150,498 jobs

CA as an instrument to make rural areas more dynamic and to fight against migration

- **Environmental benefits** (Mainly reduction in soil erosion and biodiversity improvements)
- **Economic benefits** (Greater profitability of operations)
- **Social benefits** (e.g. time savings and supplemental nature of other socio-economic activities)

Agriculture and migration

25%

Twenty five percent of farmland is at great risk of abandonment.

+ 5 Mha

More than 5 million hectares are at risk of rural abandonment.

68%

Low-population areas are the homes of 68% of farmers.

15%

Poverty and/or social exclusion risks affect more than 15% of homes in rural areas.

1) Total impact includes the direct, indirect and induced impacts, estimated using an input-output model.

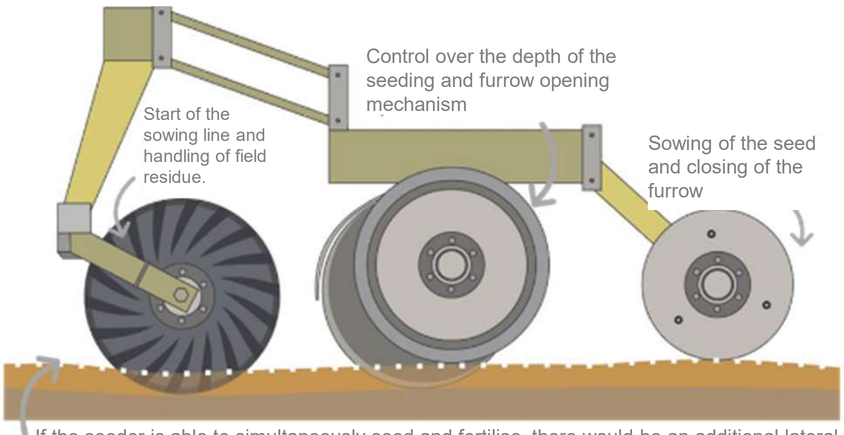
The tools essential to putting CA into practice notably include direct seeders and herbicides and glyphosate is the most used herbicide to control weeds and to protect soil nutrients

Essential tools for CA practices

Direct seeders

The **sowing machinery** is more solid and must apply high pressure to the soil to ensure proper cutting and the positioning of the seeds. This means that they tend to be heavier than those used in conventional seeding systems.

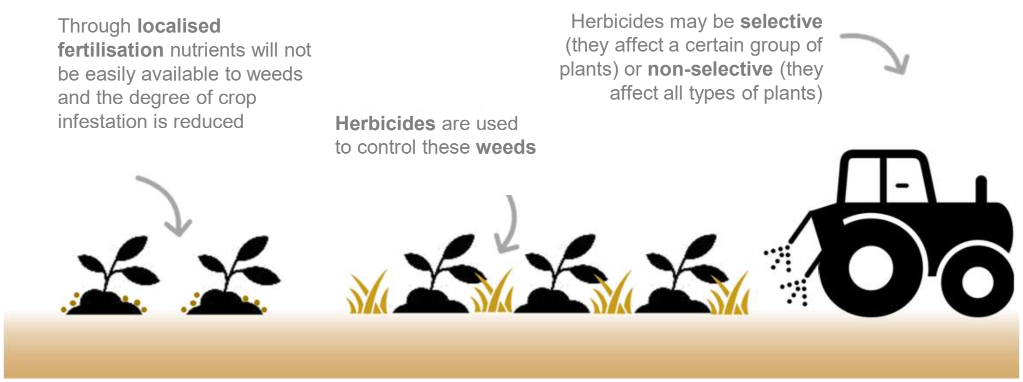
Example of the direct seeding mechanism on a disc seeder



Herbicides

The use of conservation agriculture physically and chemically improves the soil thanks, in part, to the use of phytosanitary products such as herbicides. The elimination of weeds through the use of herbicides during fallow and pre-seeding is essential for crops to most efficiently use water and nutrients.

The active substance glyphosate is one of the most used herbicides on most weeds.

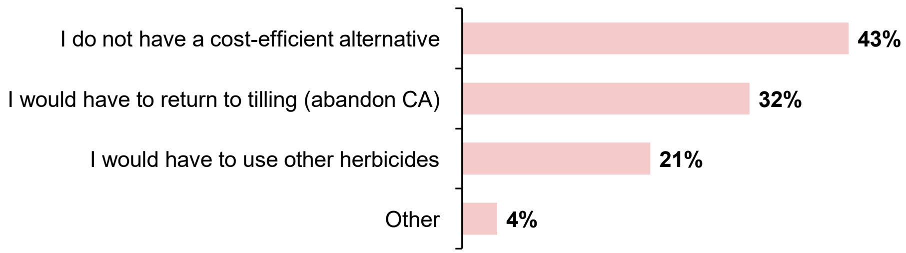


Executive Summary | The role of the herbicide glyphosate and its socio-economic and demographic contribution

Glyphosate, which is essential to CA practices, contributes to more effective and efficient weed control than other alternatives and its use is associated with higher productivity and lower costs

In total, **25% of farm output** in Spain **uses glyphosate** as a **means of production** to control weeds at some time during the growing season.

Alternatives that would be chosen by farmers if glyphosate were not available (2020)[1]



Difference in the cost between the use of glyphosate and other alternative

The cost of non-glyphosate alternatives is:

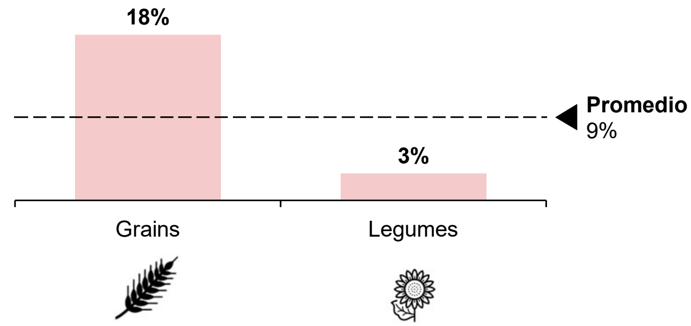
x4,3 on arable crops

x1,9 on permanent crops

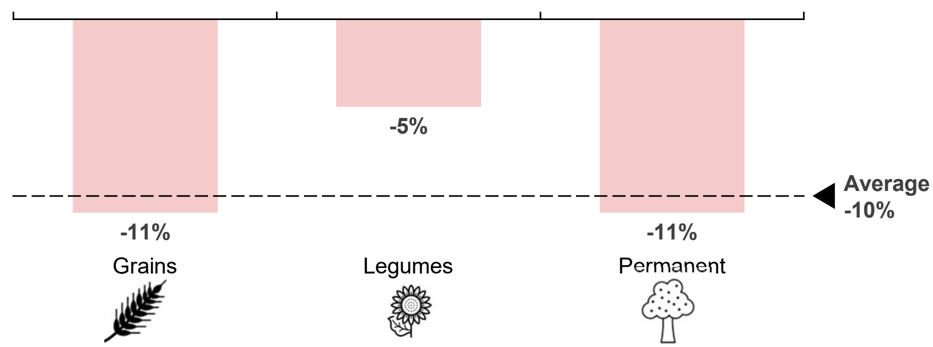
Lack of chemical alternatives to glyphosate for some crops

Some active substances that could be an alternative to glyphosate (although more expensive) cannot be used in all cases, as **some herbicides are not authorized for use on certain crop**.

Changes in variable costs if glyphosate is eliminated (%/ha)



Changes in production if glyphosate is eliminated (%/ha)



1) European Conservation Agriculture Federation (ECAF, 2020). Survey of all farmers in Mediterranean basin countries (Portugal, Spain, France, Italy and Greece).

Glyphosate makes an important macroeconomic contribution, due to its relevance in the farming sector and the effect generated in associated sectors, totaling more than 2,431 M€ in terms of production, 1,087 M€ in GDP and more than 23,000 jobs

Macroeconomic contribution of the use of glyphosate in Spain

The use of glyphosate has a **direct impact** on the farming sector. The increase in production and the reduction of costs per type of crop gives rise to an impact of **€893 million** on production, **€485 million** in **terms of GDP** and nearly **11,600 jobs**.

If associated sectors and the increase in household consumption is taken into account in addition to the direct impact, the use of glyphosate has a total associated impact of **€2,431 million in terms of production** (0.11% of domestic production) and **€1,087 million in terms of GDP** (0.09% of domestic GDP). In terms of jobs, the impact on farm production and that of the other sectors is associated with **more than 23,000 jobs** (0.12% of domestic employment).

Glyphosate also allows the generation of a positive **foreign trade balance** in the farming sector of more than **€750 million.**

Summary of the estimated impacts associated with the use of glyphosate in agriculture (2019)

	Impact on the farming sector	Impact on associated sectors	Impact on households	Total impact
Production	893 M€	914 M€	624 M€	2,431 M€ (0.11% of domestic production)
GDP	485 M€	280 M€	322 M€	1,087 M€ (0.09% of domestic GDP)
Employment	11,598 jobs	5,497 jobs	5,987 jobs	23,082 jobs (0.12% of total jobs)
Trade balance	754 M€			

1

Scope and Methodology

Conservation Agriculture brings significant social, economic and environmental benefits and plays an increasingly prominent role in the fight against climate change, as well as being key to the conservation of rural land and communities.

Conservation Agriculture as a response to increased environmental ambition and climate action

Agriculture plays a key role as a source of production of essential foods keeping people fit and healthy. It is a **strategic sector** whose activities bring major **economic, social and environmental** benefits and it plays a prominent role in the **fight against climate change**, **environmental protection** and **landscape and biodiversity preservation,** as well as being key to the **conservation of rural land and communities.**

This sector and its related activities are at a key turning point. Progress is currently being made in the design and definition of European and domestic agricultural and environmental strategies and the decisions taken in these areas will largely shape the industry's future in coming years.

Specifically, Spain's post 2020 **CAP Strategic Plan** is being completed this year, 2021. Spain is expected to formally present it in late 2021. This plan is largely based on the European Commission's legislative proposals for the future of CAP, which include increased environmental ambition and climate action. In this respect, the national plan should be aligned with the **European Green Deal.** This Deal, which was presented in late 2019, is the European Commission's roadmap to ensure that the European Union's economy is sustainable and seeks to turn climate and environmental challenges into opportunities.

The main actions in the European Green Deal roadmap include two with an important impact on the agricultural industry: the EU's "**Farm to Fork"** and **"Biodiversity for 2030"** Strategies**.** These initiatives point to a new balance of nature, food systems and biodiversity in order to protect people's health and well-being and at the same time, increase the European Union's competitiveness and resilience.

The next CAP will bring in a new concept: **eco-schemes,** a new instrument, included in pillar 1, **based on agricultural practices that are beneficial for the climate and the environment.** The provisional listing of eligible agricultural practices to be included in future eco-schemes includes **Conservation Agriculture**.

Conservation Agriculture is based on the application of three principles: no tilling, permanent soil cover with crop residues and extended crop rotation. This practice brings important **environmental advantages (**for the soil - reduction of erosion**,** increase in organic matter etc. - , for mitigating climate change - carbon fixation and reduced CO_2 emissions, **-** for water and for biodiversity) alongside **economic benefits for farmers** (cost reduction and time savings)**.**

The tools essential to putting CA into practice notably include direct seeders and herbicides and glyphosate is the most used herbicide to control weeds.

Conservation Agriculture Essential Tools

In order to put Conservation Agriculture and its three principles into practice, **tools** are needed to allow cultivation work such as **seeding and weed control** to be carried out.

One of these tools is the **direct seeder,** a specific type of machinery that allows direct seeding without tilling. **Herbicides** are another essential tool in Conservation Agriculture, **glyphosate** being extremely important in weed control.

Glyphosate is a broad spectrum herbicide widely used to control weeds in agriculture and is a **basic production tool**, particularly in the practice of Conservation Agriculture although it is also used in conventional agriculture. Glyphosate is currently the most efficient alternative in practising Conservation Agriculture and there is no alternative method for controlling unwanted vegetation at such an affordable cost and with such a favourable eco-toxicological profile.

For this reason and in order to promote the development of Conservation Agriculture in Spain, we need to **create awareness of the characteristics** and most significant **benefits** associated with **the use of direct seeders and glyphosate.**

This report aims to analyse Conservation Agriculture as a useful practice to contribute to compliance with environmental objectives, as well as the role of essential tools in driving and developing CA.

Study objectives and analysis

The study's objectives are **threefold**:

- Describe and quantify the **main environmental and socio-economic benefits of Conservation Agriculture**, against the backdrop of the **European Green Deal.**
- Calculate the contribution of Conservation Agriculture **in terms of GDP and employment**, specifically, its relevance to **making rural areas more dynamic** and **combatting migration**.
- Detail the benefits and characteristics of the **two essential tools** to practice Conservation Agriculture (direct seeders and the herbicide glyphosate).

Analysis conducted in the study

Agriculture and sustainability
Description of the **strategic and regulatory** landscape impacting the agricultural sector and European and national **sustainability** objectives**.**

Description of CA
Description of the **practice of Conservation Agriculture** and discussion of its main **characteristics and benefits.**

Quantification of CA's main benefits within the context of the European Green Deal
Quantification of the contribution of CA to **soil improvement and biodiversity, climate change mitigation** and **cost savings** for farmers. All this against the backdrop of achieving the objectives of the **European Green Deal.**

Socio- economic contribution of Conservation Agriculture and its significance in revitalising rural areas
Estimating **CA's socio-economic contribution** in terms of **GDP and employment** and description of its relevance to **revitalising rural areas and combatting migration.**

Conservation Agriculture Essential Tools
Description of the characteristics and benefits of the use of **direct seeders and glyphosate** in practising Conservation Agriculture.

Note: Estimated impacts generally refer to 2019,as the year for which the latest information is available on the main variables of interest for the agricultural sector. For more information on the methodology used in the analyses performed, please refer to the appendix to this document.

2

Strategic and regulatory context of agriculture and sustainability

In the last few years, the regulatory context on a national and European level has evolved with more ambitious objectives. The COVID-19 outbreak and with it, the arrival of European Funds, have triggered a unique opportunity to speed up this transformation.

Regulatory context

Climate change and environmental degradation are a threat to agriculture. In the last few years, national and European institutions have committed to promoting environmental sustainability and presented a series of action plans to foster and speed up the transition to a more sustainable economy.

Specifically, the main agricultural and sustainability projects include:

- on a European level: the **Green Deal** and its related strategies with **«Biodiversity for 2030»** and **«Farm to Fork »** and a new greener **Common Agricultural Policy (CAP)** for the period 2021-2027[1];
- on a national level: the **Law on Climate Change and Energy Transition,** which sets out sustainability goals and objectives and looks to channel the assistance received through European funds.

Main milestones in agriculture and sustainability in the past few years (May 2021)

11 December 2019
Presentation of the European Green Deal

4 March 2020
Proposal for a European climate law in order to ensure that the European Union becomes climate neutral by 2050

11 March 2020
European Commission's Proposal for an Action Plan for the Circular Economy centred on the sustainable use of resources

20 May 2020
Presentation of the EU's "Biodiversity for 2030" strategy aimed at protecting the planet's fragile natural resources and "Farm to Fork" strategy designed to enhance the sustainability of food systems.

30 April 2021
Presentation of the Recovery, Transformation and Resilience Plan *España Puede* ("Spain Can")

20 May 2021
Law on Climate Change and Energy Transition in Spain

1) Due to the negotiations under way between the European Parliament and Council of the European Union, the proposed reform was provisionally put off until 1 January 2023.
Source: European Commission, the Ministry for Ecological Transition and the Government of Spain.

The European Green Deal is one of the most ambitious action plans globally, with measures in 9 fields, 7 of which are directly and indirectly related to agriculture.

European Green Deal

Climate change and environmental degradation are a major threat to the EU member states as a whole. In order to make more sustainable and efficient use of resources, the European Union has drawn up the so-called European Green Deal, setting out **a new roadmap to enable the EU to achieve a sustainable economy.**

In this respect, the European Green Deal establishes an action plan that involves **9 action initiatives.** Three of these (biodiversity, the "Farm to Fork" strategy and sustainable agriculture) are directly connected with how we achieve sustainable production of the products that we need.

Action initiatives under the European Green Deal

- **Biodiversity** (directly related to agriculture)
  Measures to protect the ecosystem
- **Climate action** (closely related to agriculture)
  Aiming to make the EU climate neutral in 2050
- **«Farm to Fork»** (directly related to agriculture)
  Ways of guaranteeing a more sustainable food chain
- **Sustainable agriculture** (directly related to agriculture)
  Sustainability in agriculture and in rural areas of the EU
- **Clean energy** (closely related to agriculture)
  Policies aimed at facilitating ecological transition
- **Build and renovate**
  The need to clean up the building industry
- **Sustainable industry** (closely related to agriculture)
  Ways to ensure more sustainable and environmentally friendly production cycles
- **Sustainable mobility**
  Encourage more sustainable means of transport
- **Eliminate pollution** (closely related to agriculture)
  Measures to quickly and efficiently reduce pollution

EUROPEAN GREEN DEAL

Initiatives directly related to agriculture | *Initiatives closely related to agriculture*

Source: European Commission, "Communication and roadmap on the European Green Deal. (2019).

Within the European Green Deal, noteworthy are a series of strategies that look to restore the biodiversity of forests, soils and wetlands and guarantee the sustainability of food systems.

«Biodiversity for 2030» and «Farm to Fork» strategy

European «Biodiversity for 2030» strategy

60% fall in world wildlife population in the past 40 years

1M species in danger of extinction

Principal actions considered:

- Create **protected areas**
- Restore degraded marine and terrestrial ecosystems throughout Europe
- Unlock €20,000 million a year for biodiversity
- Make the EU a global leader in tackling the global biodiversity crisis

Costs of inaction in agriculture:

- Declining **crop yields**
- Increasing **economic losses** resulting from flooding and other catastrophes
- Loss of new **potential sources of plant health**

75% of world food crops rely on animal pollinators

It is estimated that each degree increase in temperature will decrease global **yields of rice, corn and wheat** by **3% to 10%**

European «Farm to Fork» strategy

European foods which are **safe, nourishing and high quality,** produced with **a minimum impact on nature**

More efficient food **production systems**

Improved **storage and packaging**

Transformation and **more sustainable** agricultural transport

Healthy diets and reduction in food loss and food waste

Objectives in delivering the "**Farm to Fork**" **strategy**

- **Ensuring** that the **transition is just and equal** for all those working in the agricultural sector
- **Significantly reducing reliance on,** and risk and use of **chemical pesticides** as well as fertilizers and antibiotics
- **Developing innovative agricultural techniques** that protect crops from **plagues and disease**
- Combating **food fraud,** ensuring that **imported food products** from third countries **meet EU environmental standards**

Source: European Commission (2020). EU Biodiversity Strategy for 2030 – Bringing nature back into our lives

The new CAP will also presumably bring in more ambitious environmental objectives, with measures aimed at soil conservation, nutrient management or the promotion of eco-friendly farming practices

Sustainable agriculture and the new common agricultural policy (CAP)

The new post 2021 CAP will be built around a new more ambitious green architecture, adapted to the European Green Deal and aligned with the new «Biodiversity for 2030» and «Farm to Fork» strategies».

Of the nine objectives defined by the European Commission for the new CAP, 3 of them strictly concern **actions aimed at the environment and climate.** Of the environmental measures envisaged, noteworthy are:

- **Soil preservation** through requirements to protect carbon rich wetlands and practice crop rotation;
- An **obligatory nutrient management tool,** designed to help farmers improve water quality and reduce ammonia and nitrous oxide on farms; and
- A new **source of financing, «eco-schemes»**, through the CAP's budget for direct payment, which will serve to support and act as an incentive for farmers to take up agricultural practices beneficial to the climate, biodiversity and the environment. **Conservation Agriculture** figures on this provisional listing which includes agricultural practices qualifying for future **«eco-schemes»**.

Specific Objectives (SO) of the European Commission through the new post 2020 CAP

Economic sustainability
- SO1 To ensure a fair income to farmers
- SO2 To increase competitiveness
- SO3 To rebalance the power in the food chain

Environmental sustainability
- SO4 Climate change action
- SO5 Environmental care
- SO6 To preserve landscapes and biodiversity

Social sustainability
- SO7 To support generational renewal
- SO8 Vibrant rural areas
- SO9 To protect food and health quality

Source: European Commission (2021), Common Agricultural Policy post-2020: Benefits and simplification.

In parallel but on a national level, Spain has established a roadmap to fight against climate change, with specific goals for 2030 and areas of action through which to channel European aid and recovery funding

Law on Climate Change and Energy Transition

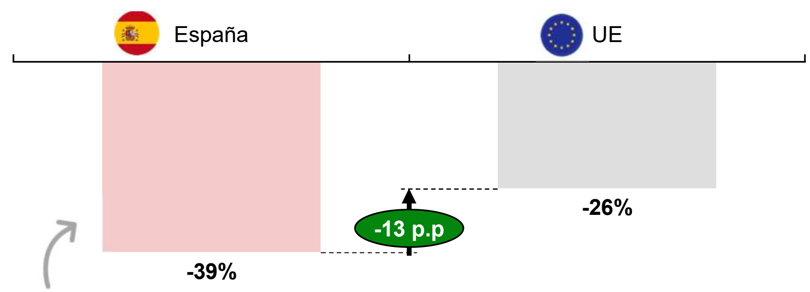
Spain has recently approved the Law on Climate Change and Energy Transition which seeks to achieve so-called **climate neutrality** (meaning that the country can only emit the greenhouse gases which can be absorbed by natural sinks, for example, forests) and **help channel recovery funds.**

Of the five main areas of action of the Law (mobility, electricity industry, fossil fuels, energy efficiency and building rehabilitation, adaptation and biodiversity and financial risks), **noteworthy for agriculture are the measures connected with biodiversity protection**. Specifically, among other aspects, the Law establishes that the government should approve a national climate change adaptation plan every five years, which should include, inter alia, an assessment of climate change impacts and risks and reports on ecosystem and territory vulnerability.

The strategies and actions promoted under this Law are aligned with the Recovery, Transformation and Resilience Plan "España Puede". This plan is founded on 4 pillars, 2 of them being closely connected with agriculture: **ecological transition** and **social and territorial cohesion.**

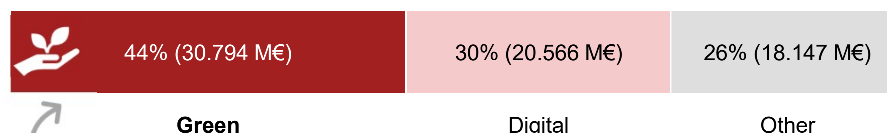
Each pillar is made up of guiding policies for action. With respect to sustainability, noteworthy are **green investments** amounting to more than **€30,000 million.** For agriculture, **the urban and rural agenda** should be noted, together with the fight against migration and agricultural development (**€14,407 million**) with specific measures for environmental and digital transformation in the agri-food sector.

Greenhouse gas emissions reduction target for 2030



12% of greenhouse gas emissions in Spain are produced by **agriculture** (the industry is the sector that produces most greenhouse gas emissions, accounting for 21% of the total)1

Investments envisaged in the Recovery, Transformation and Resilience Plan, España Puede (May 2021)



These green investments are equivalent to turnover in the agricultural sector as a whole in one year[2]

1) Ministry for Ecological Transition with 2019 data 2) In 2019 invoicing of crop production amounted to €29,993 million according to MAPA (Ministry of Agriculture, Fisheries and Food).Source: European Commission, the Ministry for Ecological Transition, MAPA and Government of Spain

3

Relevance of Conservation Agriculture in Spain

3

Relevance of Conservation Agriculture in Spain

3.1. Characteristics and degree of implementation of Conservation Agriculture

Conservation Agriculture, through direct seeding and cover crops, is intended essentially to conserve, improve and make more efficient use of natural resources

Features of CA

Conservation Agriculture is a farming practice that seeks to **answer environmental issues** and has proven to be more respectful and efficient in the use of natural resources.

The main goal of CA is to achieve environmentally sustainable agriculture that is economically profitable. This type of farming employs cultivation and soil management techniques that **minimise the action of harmful natural processes** such as erosion and degradation.

The use of this agricultural practice helps both to **improve the quality and biodiversity of the cultivable area** and to enhance the **economic feasibility** of farming. To achieve these benefits, Conservation Agriculture is based on **three principles**:

1. **No disturbance of farm soil** through tillage

2. Permanent **crop coverage**

3. **Crop rotation** and/or diversification

Basic Conservation Agriculture techniques

Direct seeding

This technique is used essentially to grow herbaceous crops. It consists of **seeding on the remains of the previous crop**, removing any kind of mechanical preparation of the seeding bed or soil disturbance.

Cover crops

This technique is employed in woody crops. It consists of **protecting the soil between tree rows** with cover crops throughout the year. There are three types of cover: **spontaneous, seeded or inert.**

Source: PwC analysis, Ministry of Agriculture, Food and Environment, AEAC.SV and FAO

Conservation Agriculture is practised on a cultivated area of 2.1 Mha and produces 3,668 M€, representing 15% of the cultivated area and 12% of domestic output in monetary terms

Implementation of CA by crop group

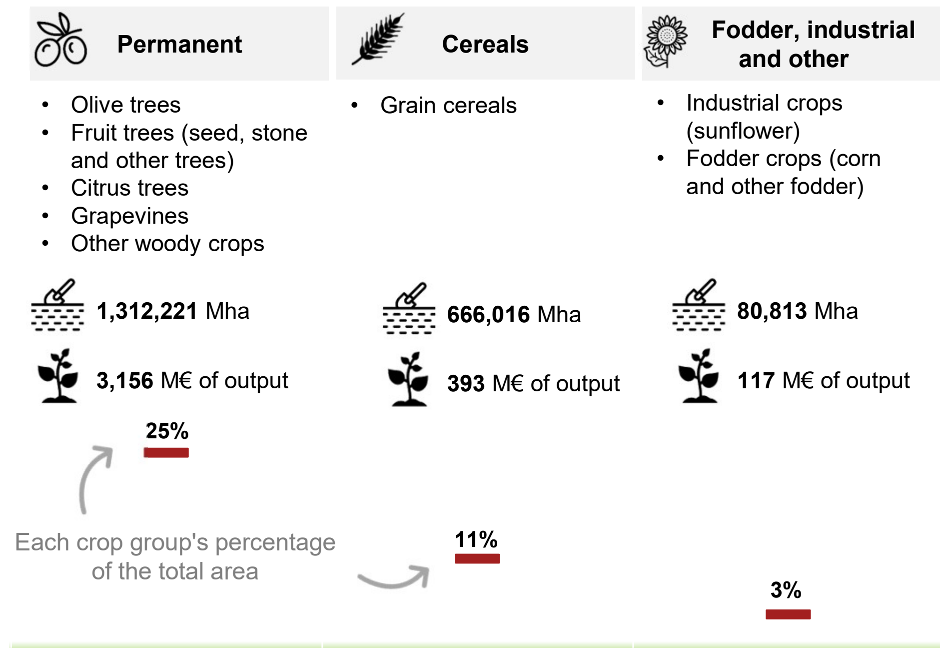
In Spain, Conservation Agriculture is practised on an area of **2.1 million hectares**, representing **15% of the total** farmland.[1]

The main crops include those in the **permanent** group, which are grown in an area of 1.3 Mha or 25% of the total CA area. Within this group, **olive trees** cover an area of 835,000 hectares (31%), followed by **fruit trees** in an area of 290,000 hectares.

Conservation Agriculture is also well represented by **cereals**, accounting for 11% of the crop area and, to a lesser extent, by **legume, industrial and fodder** crops, on 3% of the area.

In monetary terms, **crop output** using this approach amounts to **3,668 M€** or 12% of total domestic output.[2] The fact that the weight of CA is higher in terms of area than in production value terms is explained by the fact that this technique is not applied to **vegetable growing**, which is not highly significant in terms of crop area but is relevant from an economic viewpoint.

Implementation of Conservation Agriculture in terms of area and output (2019)



1) Farmland excluding fallow land, family vegetable gardens and flowers and ornamental plants. 2019 data. 2) Output estimated using data on total output and the proportion of CA area, assuming that the yield from this technique is equivalent to that of conventional agriculture. Source: PwC analysis and Ministry of Agriculture, Food and Environment

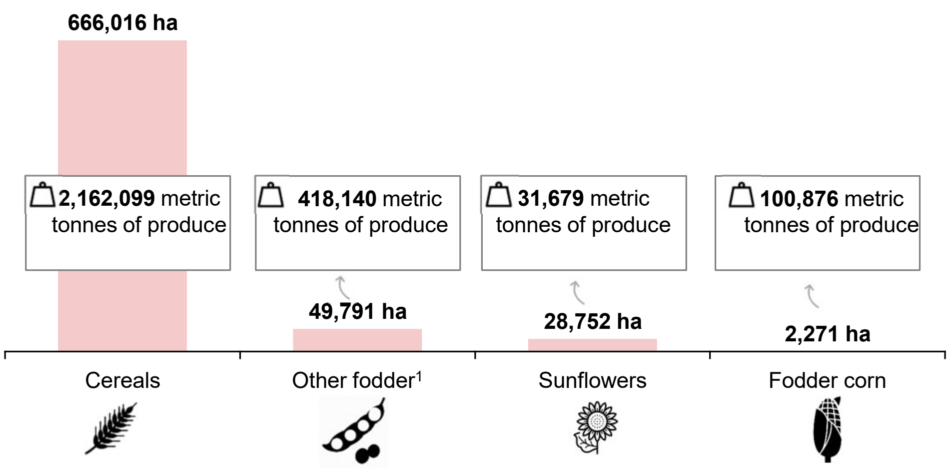
The adoption of Conservation Agriculture is relevant for both the direct seeding of herbaceous crops and cereals, and cover crops for permanent farmland such as olive groves

Implementation of both CA techniques

Direct seeding

In Spain, direct seeding is practised on **746 thousand hectares** or 36% of the CA area. This area produces **2.7 million tonnes**. CA is applied mainly to herbaceous crops such as cereals and industrial crops such as sunflowers and fodder crops.

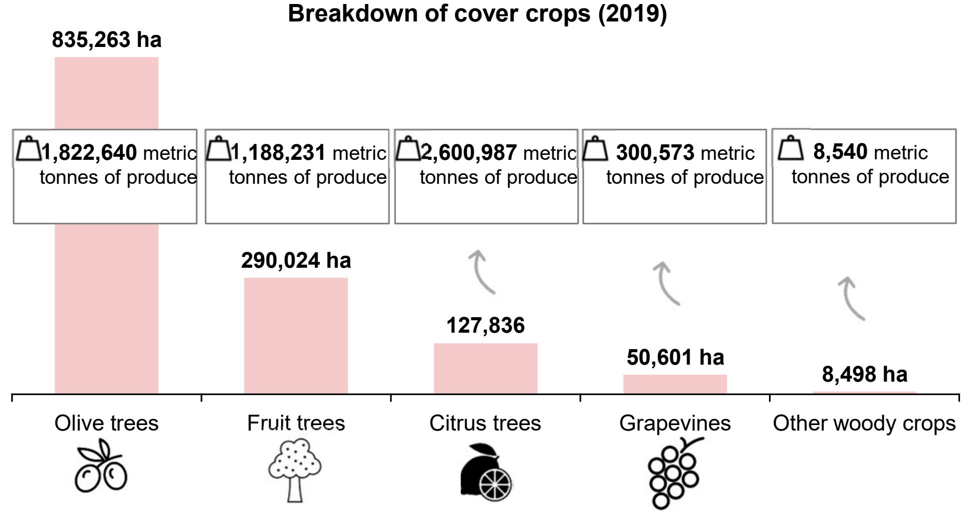
Breakdown of direct seeding crops (2019)



Cover crops

Cover crops are used on **1.3 million hectares** of farmland or 64% of the land devoted to Conservation Agriculture, totalling **9.2 million tonnes** of produce.

Breakdown of cover crops (2019)



1) Includes legume, tuber and industrial crops.
Note: Output has been estimated using production data per crop and the proportion of CA area.
Source: PwC analysis and Ministry of Agriculture, Food and Environment

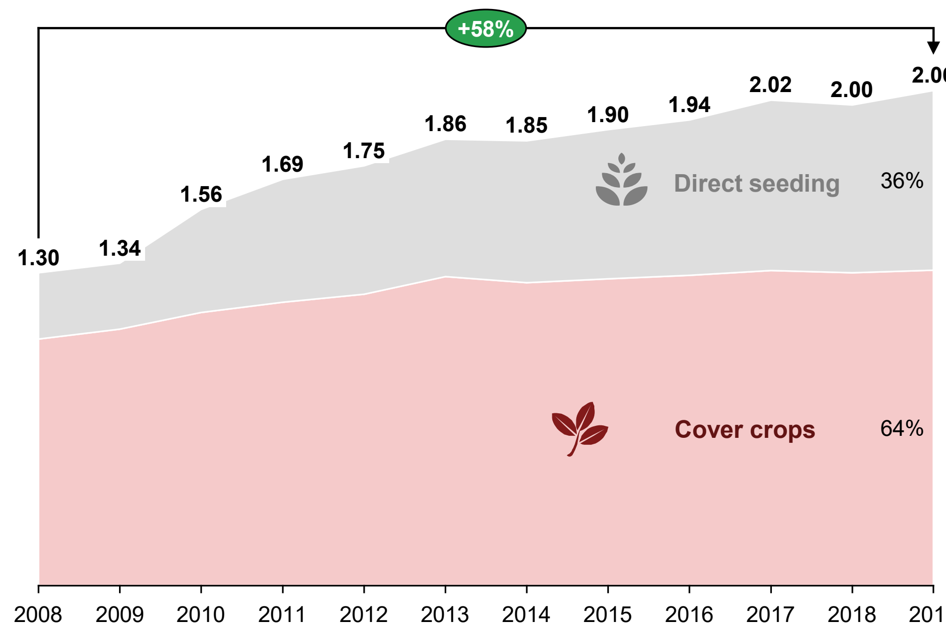
In recent years, Conservation Agriculture has developed quickly, the area having grown by 58% from 2008 to 2019

CA trend

Since 2008, the area devoted to Conservation Agriculture has grown at an **average annual rate of 4.3%** and reached 16.7% in 2010. From 2008 to 2019, the number of hectares farmed using CA techniques rose by 58.3% from **1.3 million to nearly 2.1 million hectares**.

Depending on the technique employed, **direct seeding** increased from an area of 0.27 million hectares to over **0.75 million hectares**, entailing **10.4% average annual growth**. Its overall significance in CA also increased from 21.1% in 2008 to 36.3% in 2019. The technique applied to **woody crops** also grew from 1.03 million to 1.31 million hectares, representing an increase of over **2.3% per annum on average**.

Increase in the Conservation Agriculture area 2008-2019 (million hectares)



Source: PwC analysis and Ministry of Agriculture, Food and Environment

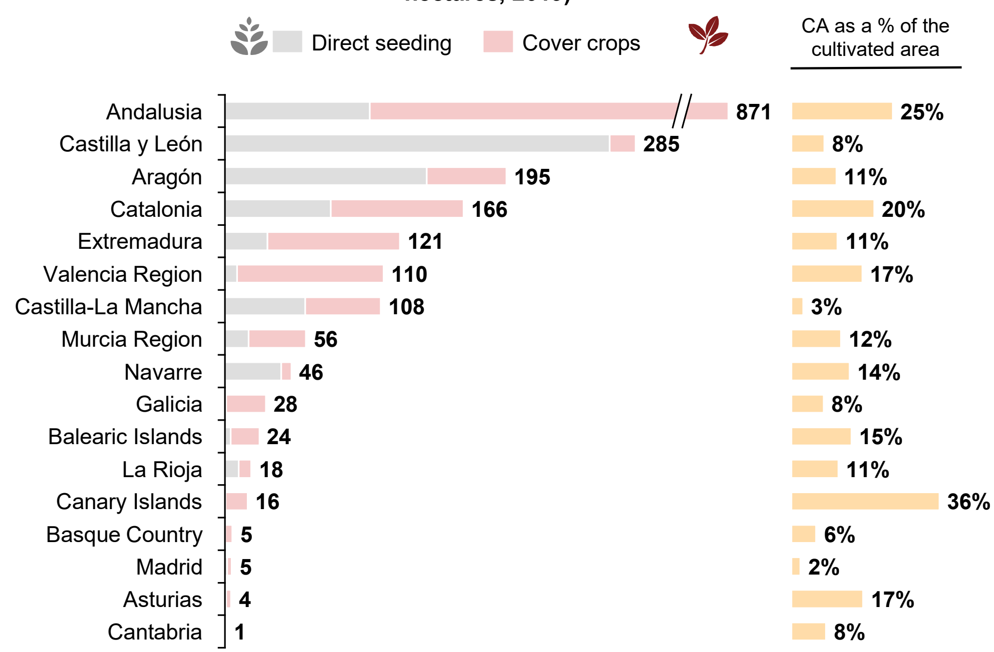
In Spain, Conservation Agriculture has been applied to different degrees in each Autonomous Region

Level of CA implementation at the regional level

The relative significance of Conservation Agriculture by type of crop varies considerably, which in turn entails significant variability at the regional level.

The region with the **highest level of CA adoption** is Andalusia, with 871 thousand hectares, followed by Castilla y León, Aragón and Catalonia. CA is also relatively important in Andalusia and Catalonia at above 20% in both cases, only exceeded by the Canary Islands (36%).

Implementation of Conservation Agriculture by Autonomous Region (thousands of hectares, 2019)



Source: PwC analysis, Ministry of Agriculture, Food and Environment, and AEAC.SV

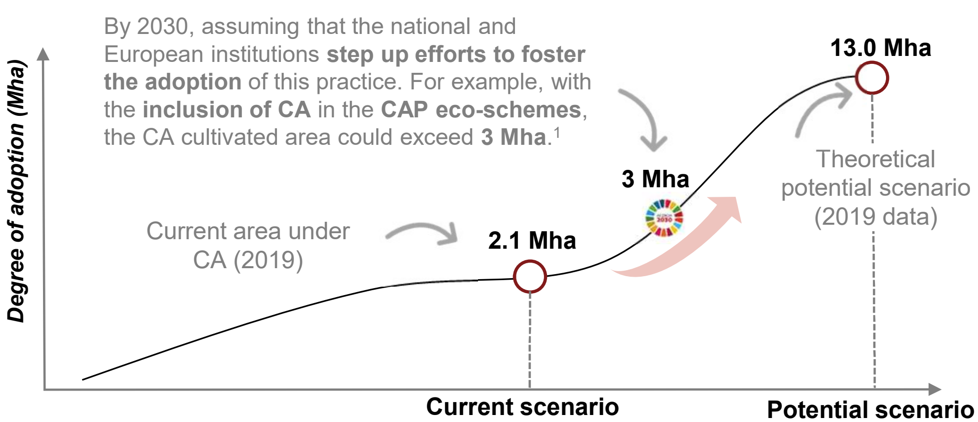
Conservation Agriculture techniques could be applied to 92.7% of the total cultivated area or nearly 13 Mha

Potential for the adoption of CA

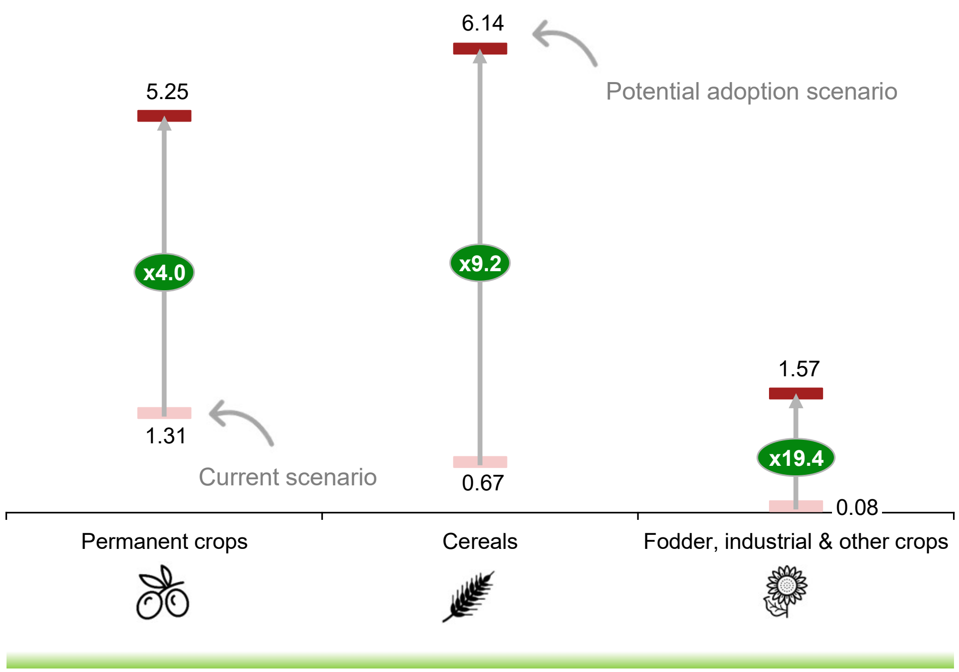
Conservation Agriculture still has great potential. Assuming full adoption for crops that may be grown using CA techniques, the CA area would amount to **13.0 Mha** or **92.7%** of the cultivated area (total cultivated land excluding vegetables, for which Conservation Agriculture is not applied due to the nature of the growing process).

By crop group, the implementation of Conservation Agriculture could increase **ninefold** in the case of **cereals**, **fourfold** in the case of **permanent crops** and **19** times in the case of **industrial and fodder crops**.

Conservation Agriculture implementation scenarios



Potential implementation of Conservation Agriculture by crop group (Mha, 2019)



1) It is assumed that new incentives to adopt CA will assure a growth rate similar to the last 11 years. CA is therefore assumed to grow by 58% in the coming 11 years to over 3 Mha (3.3 Mha) by 2030.
Source: PwC analysis, Ministry of Agriculture, Food and Environment, and AEAC.SV

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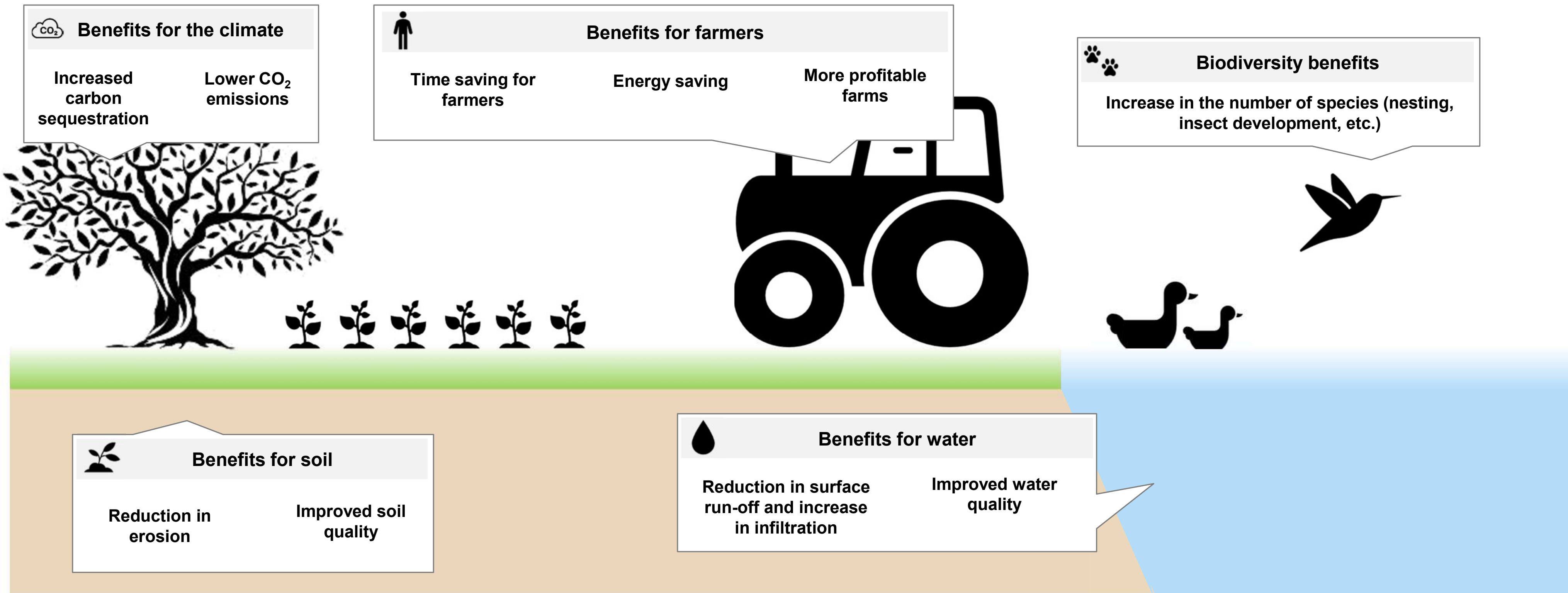
Relevance of Conservation Agriculture in Spain

3.2. Quantification of the benefits of Conservation Agriculture

Conservation Agriculture techniques are associated with a series of benefits that fulfil a dual purpose: protect the environment and guarantee the economic feasibility of farms

CA benefits



Source: PwC analysis and AEAC.SV

The main benefits of CA are environmental and affect the climate, soil, water and biodiversity; and economic benefits for farmers, who can improve farm profitability thanks to time and cost savings

CA benefits

Environmental benefits of CA

Benefits for the climate

- **Carbon sequestration.** By not tilling the land, the soil can absorb the carbon previously sequestrated by crops through photosynthesis.
- **Lower CO2 emissions.** CO_2 emissions are reduced in two ways: (i) thanks to not disturbing the soil, atmospheric CO_2 previously fixed is not released again; and (ii) less use of machinery in this type of agriculture reduces fuel consumption and thus combustion emissions.

Benefits for water

- **Reduction in surface run-off and increase in infiltration.** Crop residues on the surface of the soil limit surface run-off in two ways: (i) lower surface water speed; and (ii) increased soil protection against rainfall, favouring surface sealing.
- **Improved water quality.** CA techniques allow a reduction in the amount of fertilizers, weed killers, etc. which are carried in the surface run-off water or absorbed by the sediment.

Benefits for soil

- **Reduction in erosion.** The crop cover that characterises CA prevents both water and wind erosion. Crop residues favour retention and reduce the impact and erosive power of rainfall. The same principle applies to wind erosion, where the crop cover prevents the loss of soil due to permanent contact with the wind.
- **Improved soil quality.** The reduction in erosion improves soil structure and favours an increase in organic material, providing more nutrients and enhancing fertility.

Biodiversity benefits

- **Increase in the number of species.** Crop cover and no-till farming favour the development of a living structure of micro-organisms, worms, insects, etc. in the soil, which helps soil formation and fertility.

Socio-economic benefits of CA

Benefits for farmers

- **Time saving for farmers.** By not tilling the soil in CA, farmers can devote more time to other productive activities on the farm.
- **Energy saving.** The reduction in the use of machinery to prepare the soil brings fuel savings and cuts machinery maintenance costs.
- **More profitable farms.** The aspects mentioned lead to a reduction in the farmer's operating costs. Bearing in mind that there is generally no difference between yields from conventional and conservation agriculture, Conservation Agriculture brings greater benefits per hectare in comparison with conventional tillage-based techniques.

Source: PwC analysis and AEAC.SV

This section identifies and quantifies the contribution made by Conservation Agriculture in relation to conventional farming in the current adoption scenario (2019) and a potential maximum adoption scenario

CA benefit quantification scenarios

This section of the report quantifies and assigns value to the contribution made by Conservation Agriculture to the environment and to agricultural income in Spain as compared with conventional techniques. The contribution of CA is analysed in the following areas:

Benefits for soil

Contribution to the **improvement of soil** by **saving soil lost through erosion**.

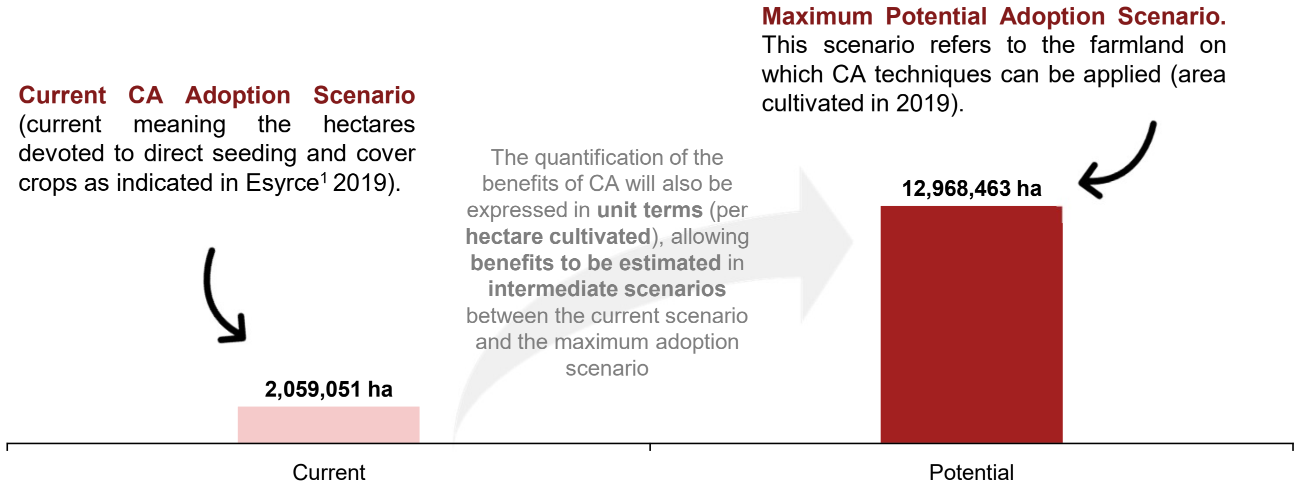
Benefits for the climate

Contribution to **mitigating climate change** in two ways: (i) increased **carbon sequestration and lower emissions from the soil** and (ii) emission savings associated with **less machinery and fuel** needs.

Benefits for farmers

Economic contribution through **cost savings** for farmers, mainly in (i) **fuel** and (ii) **labour**.

Scenarios quantifying the benefits of Conservation Agriculture



In each of these areas, the benefit brought by CA as compared with conventional farming is analysed in unit terms (usually by unit of area). Using these figures, the contribution from CA in two adoption scenarios is calculated: current and potential. In both scenarios, the area devoted to fallow land, family vegetable gardens, greenhouses and vegetable growing has been excluded.

1) MAPA (2019). National Survey on Areas and Yields. Analysis of Soil Maintenance Techniques and Seeding Methods in Spain 2019. Spain
Source: PwC analysis and AEAC.SV

3

Relevance of Conservation Agriculture in Spain

3.2. Quantification of the benefits of Conservation Agriculture

3.2.1 Benefits for soil and biodiversity

Thanks to Conservation Agriculture, the loss of almost 13 tonnes of soil per hectare and year due to erosion is avoided as compared with conventional agriculture

Level of soil erosion using different techniques

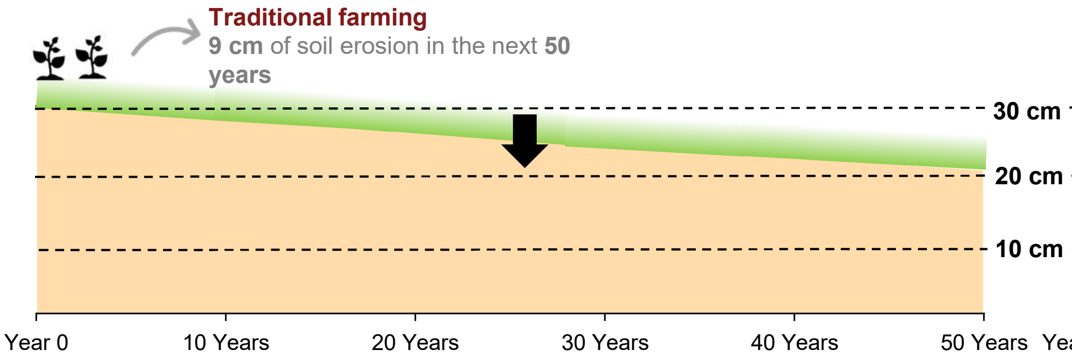
The main benefits of Conservation Agriculture include the **reduction of erosion.** The use of cover crops protects the soil from the two main causes of erosion: wind and water.

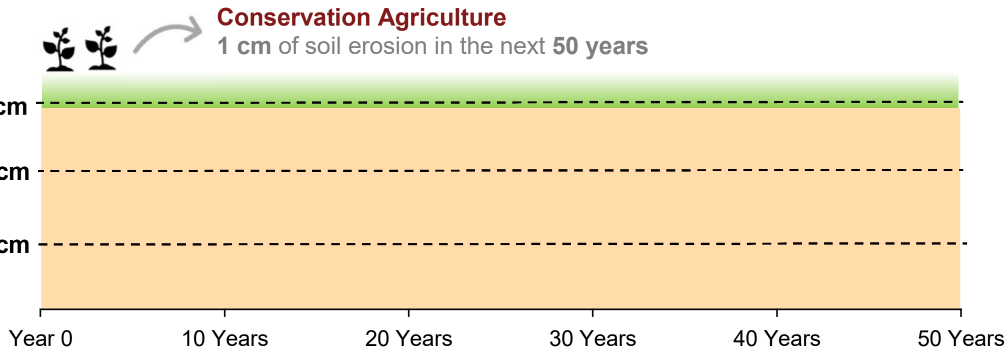
By reducing soil erosion, the **loss of land is avoided** and **productivity** improves. The covering provided by Conservation Agriculture enhances the organic content so that the **soil has more nutrients** and a better quality and structure.

According to the latest data for 2017 from the Ministry for the Ecological Transition and the Demographic Challenge, **14,2 tonnes of soils are lost per hectare and year** on average in Spain.

Conservation Agriculture prevents up to **90%** of erosion in relation to conventional farming systems and around **60%** compared with reduced-tillage systems. Each tonne of earth lost is equivalent to a reduction of approximately **0.0125 cm** of farmland, so Conservation Agriculture would save around **8 cm of soil in a 50-year period**.

Comparison of the level of soil erosion in conventional agriculture and Conservation Agriculture



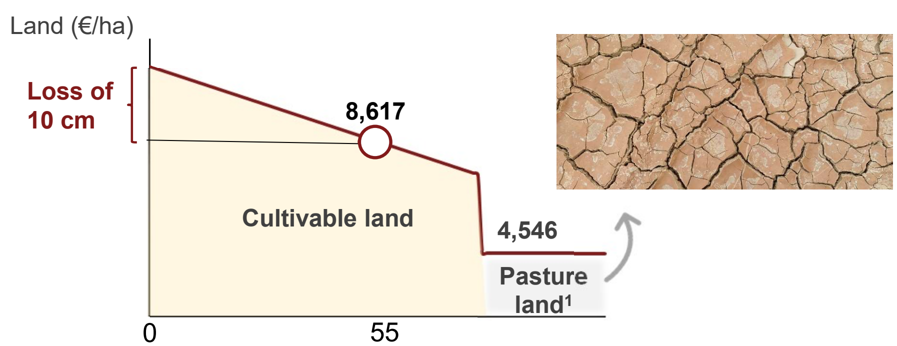


Source: PwC analysis, AEAC.SV, MAPA, MITECO and INE

Avoiding the depreciation of land through erosion entails an economic saving of €157 million, which could increase to €811 million in the maximum potential adoption scenario

Economic benefit thanks to preventing soil erosion

Loss of land value associated with conventional farming



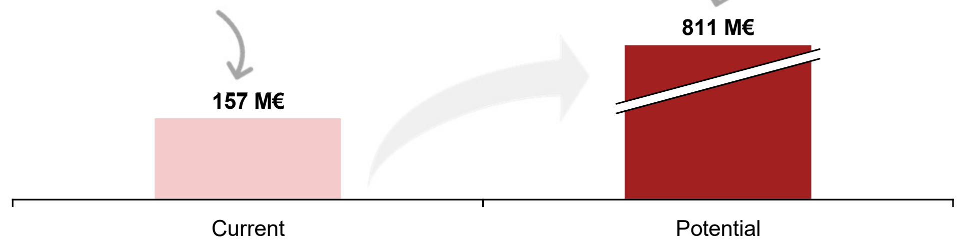
The value of cultivable land in Spain stands at **12,926 €/ha** on average. Assuming that only the top **30 cm** is **suitable for growing**, each cm of earth has a value of **€431**.

Erosion caused by conventional tillage entails the **loss of 0.18 cm/ha** annually, which is valued at **€76 per hectare**. Were it to continue at this rate, **10 cm** of cultivable land would be lost **in a period of 55 years**.

Annual economic benefits of Conservation Agriculture

For the total area cultivated under Conservation Agriculture, the economic value of the conserved land is **157 M€ per annum.**

In the maximum potential adoption scenario, in which all the potentially cultivable area employs CA techniques (13 Mha), **the loss of land valued at 811 M€ per annum would be avoided**.



76 €/ha

For each hectare cultivated under CA, an annual saving of **€76** could be made in lost land value.

€7,600

Annual saving for a **100 ha farm** (the average size of a farm owned is 25 ha).

1) Average price in 2019 of usable land, which includes permanent meadows and grasslands, and other pasture land.
Note: Case studies on farmland fertility by: Schmitz, M., et al. (2015). The Importance of Conservation Tillage as a Contribution to Sustainable Agriculture: A Special Case of Soil Erosion and Brown, L., et al. (1996). Effects and interactions of rotation, cultivation and agrochemical input levels on soil erosion and nutrient emissions.
Source: PwC analysis, AEAC.SV, MAPA and INE

Many highly eroded areas in Spain are considerably depopulated. The adoption of CA on this land would reduce soil degradation and improve harvests, which would ultimately help combat rural depopulation

CA to halt soil degradation and combat rural depopulation

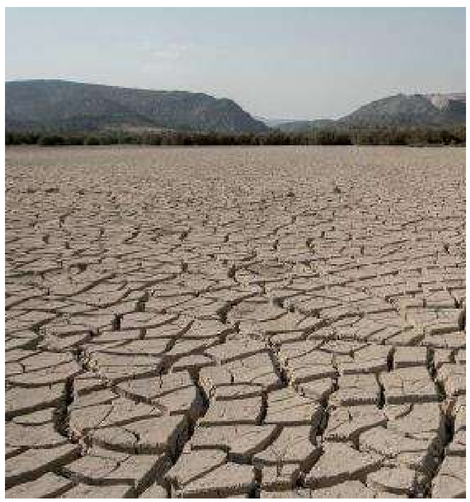
Soil erosion is one of the main factors that accentuate the desertification process or loss of fertile, productive land.

In Spain, this issue is increasingly serious, as one of the **European countries at most risk of desertification** due, among other factors, to **weather conditions**.

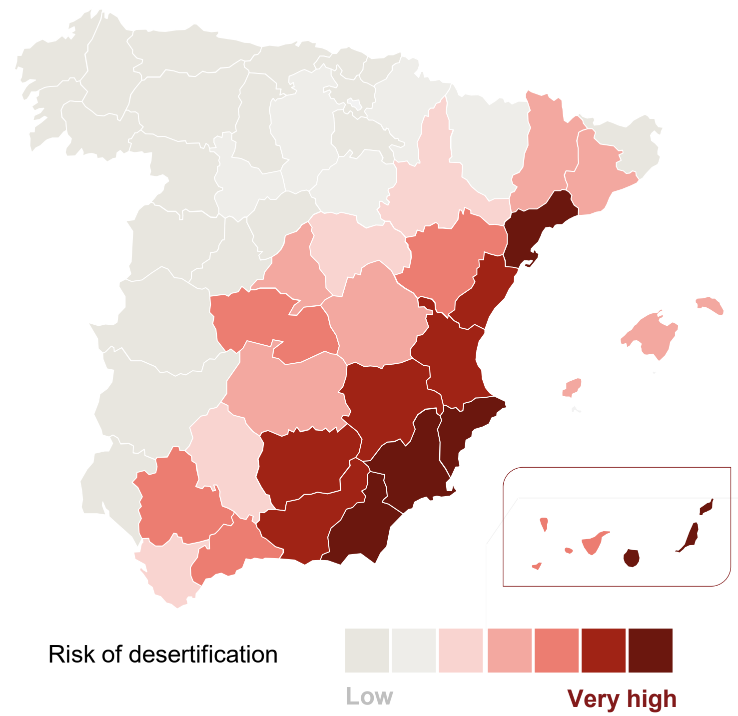
Specifically, **more than two thirds of Spain's area** are potentially at risk of desertification, including arid, semi-arid and dry sub-humid areas. The areas worst hit by this phenomenon are the **Mediterranean coast and a part of the islands**.

The erosion process takes place mainly on farmland, over **50% of which is classed as at medium-high risk of erosion**.

CA can be turned into a **solution to this serious problem**, as it **halts soil degradation** and favours **fertile and productive soil**. The continuity of farming in these areas can also help **combat rural depopulation**, which is a salient issue in some areas.



Desertification risk map by province in Spain



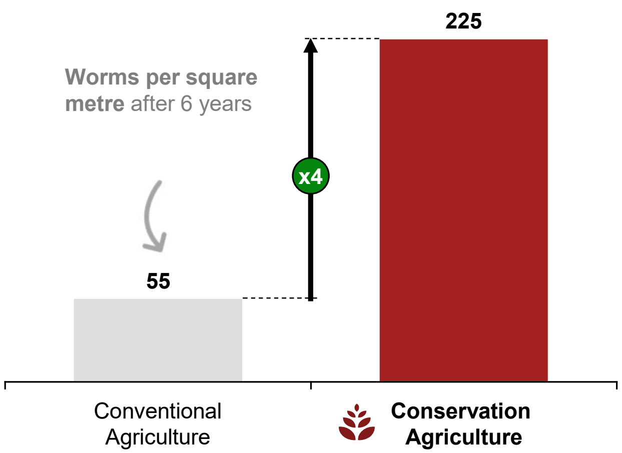
Source: PwC analysis, Ministry of Agriculture, Food and Environment (National action Programme against Desertification) and AEAC.SV

The adoption of Conservation Agriculture is also associated with an increase in biodiversity. The numbers of species living in the soil can multiply between 2 and 7.5 times more than in conventional agriculture.

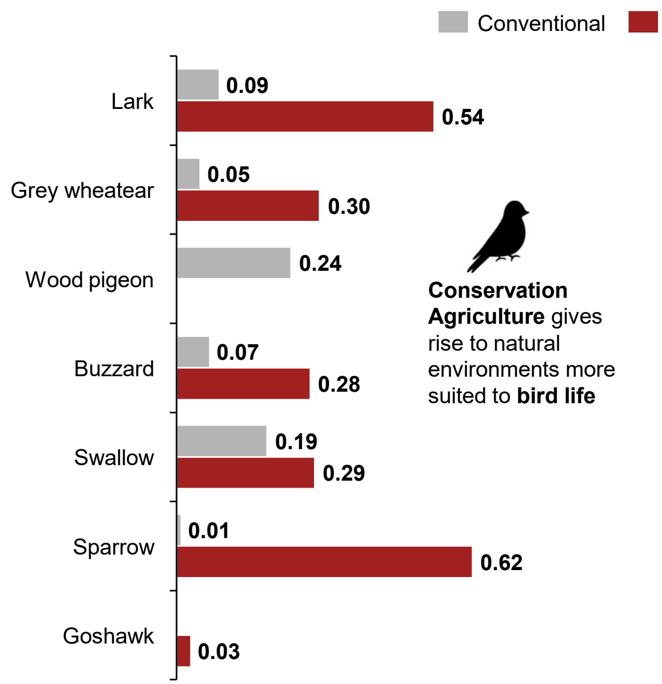
CA's contribution to increasing biodiversity

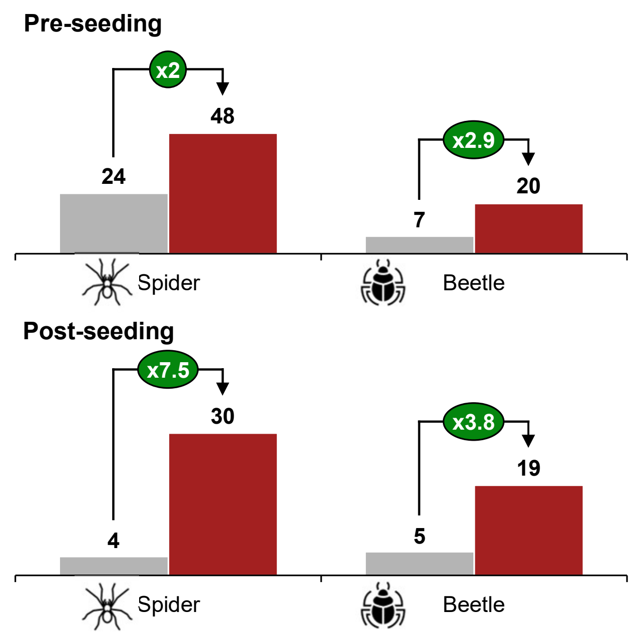
Soil biodiversity[1]

Conservation Agriculture multiplies the number of worms living in a square metre of soil **up to four times** compared with **conventional farming**



Ornithological and epigean biodiversity (individuals/metre)[2]





(1) Guy, Stephen & Bosque-Pérez, Nilsa & Eigenbrode, Sanford & Johnson-Maynard, Jodi & Patten, Roy & Bull, Brad. (2021). RESEARCH PROJECT TITLES: Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Crop, Variety, Soil, and Insect Responses in Years 4-6 and Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Nitrogen Fertility, Soil, and Insect. (2) Søby, Julie Marie (2020). Effects of agricultural system and treatments on density and diversity of plant seeds, ground-living arthropods, and birds.

3

Relevance of Conservation Agriculture in Spain

3.2. Quantification of the benefits of Conservation Agriculture

3.2.2 Benefits for the climate

Conservation Agriculture also mitigates climate change by fixing CO_2 in the soil and reducing CO_2 atmospheric emissions

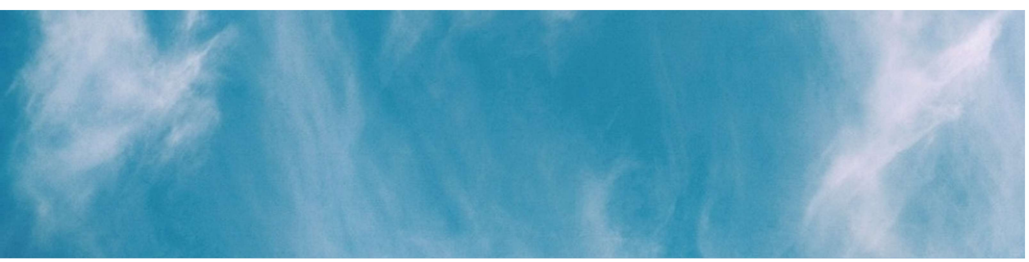
CA benefits for the climate

Conservation Agriculture is effective in **reducing CO_2 emissions** in two ways: increase in CO_2 fixation in soil and reduction in atmospheric emissions of CO_2..

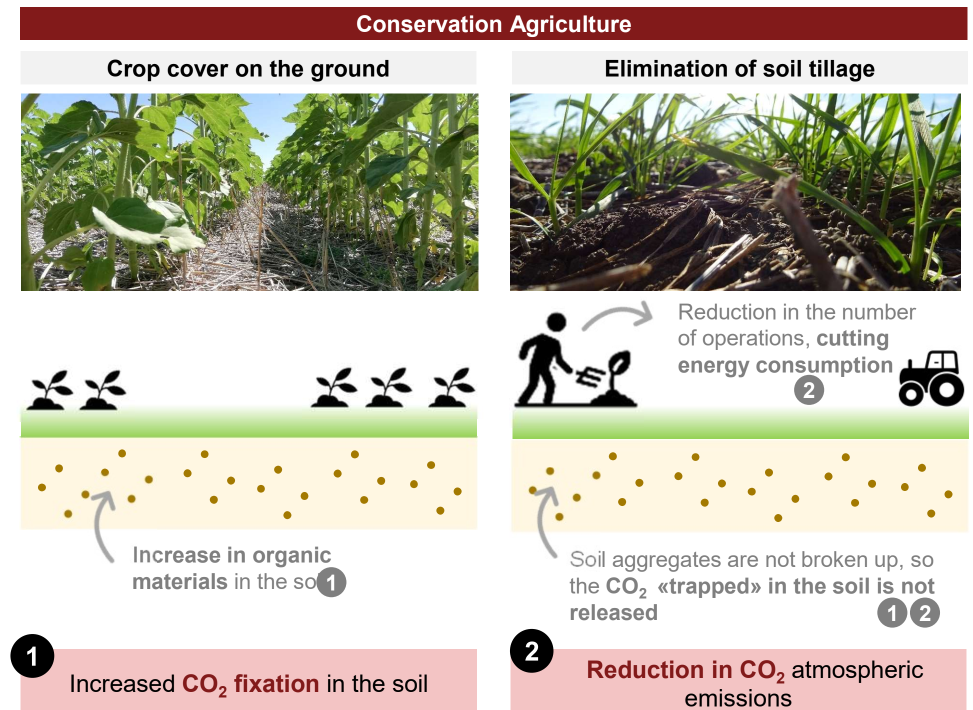
The first effect is the result of **crop residues covering the ground** and becoming integrated, increasing the organic material. This rise in organic material allows **greater carbon sequestration** and thus more CO_2 fixation in the soil.

The second effect is explained by the **elimination of soil tillage**, which has a further two favourable effects:

1. Non-alteration of the soil structure **prevents CO_2 previously fixed from being released** again into the atmosphere. It also **avoids the rapid degradation** of organic material causing CO_2 emissions.
2. By not tilling the soil surface, **less farm machinery is used**, so CO_2 emissions during diesel combustion are reduced.



Emission reduction under CA



Source: PwC analysis and AEAC.SV

By avoiding the emission of 10 million tonnes of CO_2 from soil each year, Conservation Agriculture allows an annual saving of 242 M€ compared with conventional agriculture, which could rise to 1,335 M€ in the maximum potential adoption scenario

Economic benefit of increased CO_2 fixation in the soil

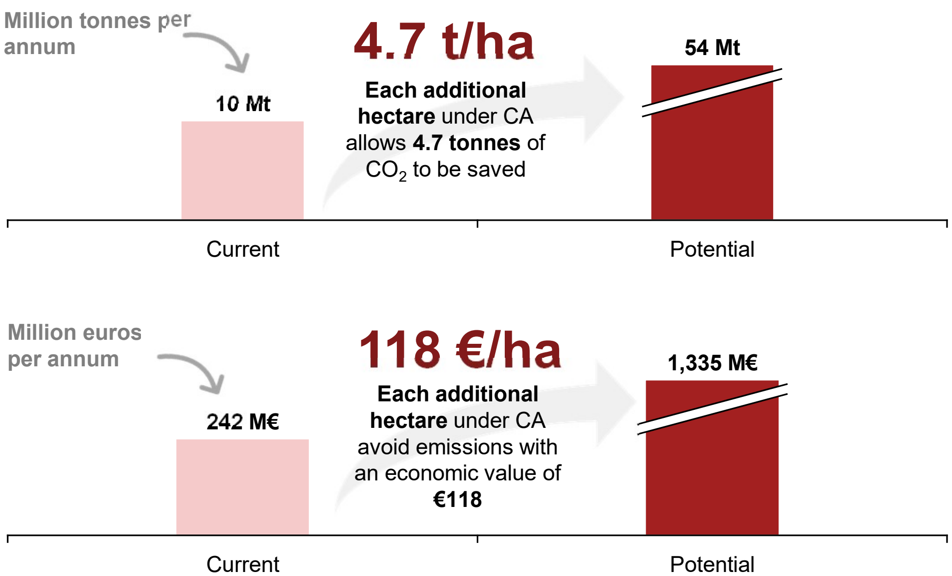
The main way to reduce CO_2 is to **fix carbon in the soil**. This occurs thanks to the crop residues left on the surface and the non-tillage of the soil, which reduce the rate of decomposition and mineralisation of the organic material, favouring carbon sequestration.

Specifically, specialised studies show that both direct seeding and crop coverage have **carbon sequestration rates that exceed those of conventional management** by **0.85** and **1.54** tonnes per hectare per year, respectively.[1]

In terms of CO_2,[1] Conservation Agriculture retains **an additional 9.7 million tonnes of CO_2** per annum (calculated using 2019) compared with conventional farming techniques. This represents a saving[2] of **€242 million each year** in monetary terms.

If Conservation Agriculture were to reach **maximum development**, **over €1,330 million could be saved annually**.

Soil CO_2 emission savings in Conservation Agriculture compared with conventional techniques



1) Carbon sequestration and CO_2 fixation data extracted from: González-Sánchez, E. J., et al. (2012). Meta-Analysis on atmospheric carbon capture in Spain through the use of conservation agriculture and Tebruegge, F. (2001). No-tillage visions - Protection of soil, water and climate and influence on management and farm income.
2) The price per tonne of CO_2 in the emission allowance market for 2019 has been used to calculate savings (24.84 €/tCO_2).
Source: PwC analysis, Sendeco2 and AEAC.SV

In addition, and due to the use of less fuel, CA avoids 136 thousand tonnes of CO_2 each year compared with conventional agriculture, representing an annual saving of €3 million, which could reach €25 million in the potential scenario

Economic benefit of using less fuel

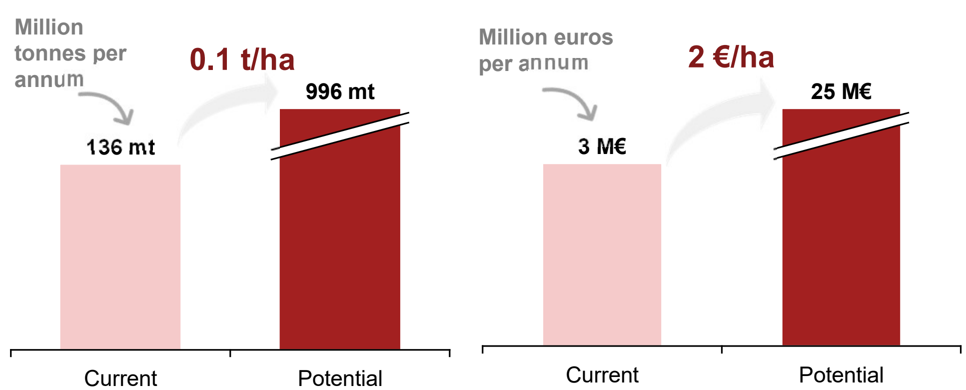
The second way in which CO_2 emissions are cut is the **reduction in the use of fuel for farm machinery**. **Non-tillage of the soil** is an essential principle of CA. By maintaining crop residues on the surface and not tilling the soil, the need for mechanical operations is reduced and also diesel consumed by the machinery.

Fuel consumption in direct seeding is around **38 litres per hectare cultivated**, which is **45,7% below conventional tillage** and **26.9%** below **minimum tillage**.[1]

This lower fuel consumption under Conservation Agriculture means lower CO_2 emissions. Specifically, emission savings due to the use of less fuel in the current CA adoption scenario amount to **136,246 tonnes of CO_2** in relation to conventional tillage, representing an annual saving of **€3 million**. In the potential scenario, the use of Conservation Agriculture techniques would be equivalent to a cut of nearly **1 million tonnes of CO_2** each year, which would mean a saving of **€25 million** per annum in CO_2 emissions avoided thanks to using less fuel.

Diesel needed for machinery (l/ha) when growing cereals

Savings in Conservation Agriculture due to using less fuel



1) Arnal Atares, P. (2014)
Source: PwC analysis

Overall, the use of CA techniques currently saves almost 10 Mt de CO_2 per year, which could reach 55 Mt in the maximum potential adoption scenario, helping to meet the commitments made by Spain for the coming years

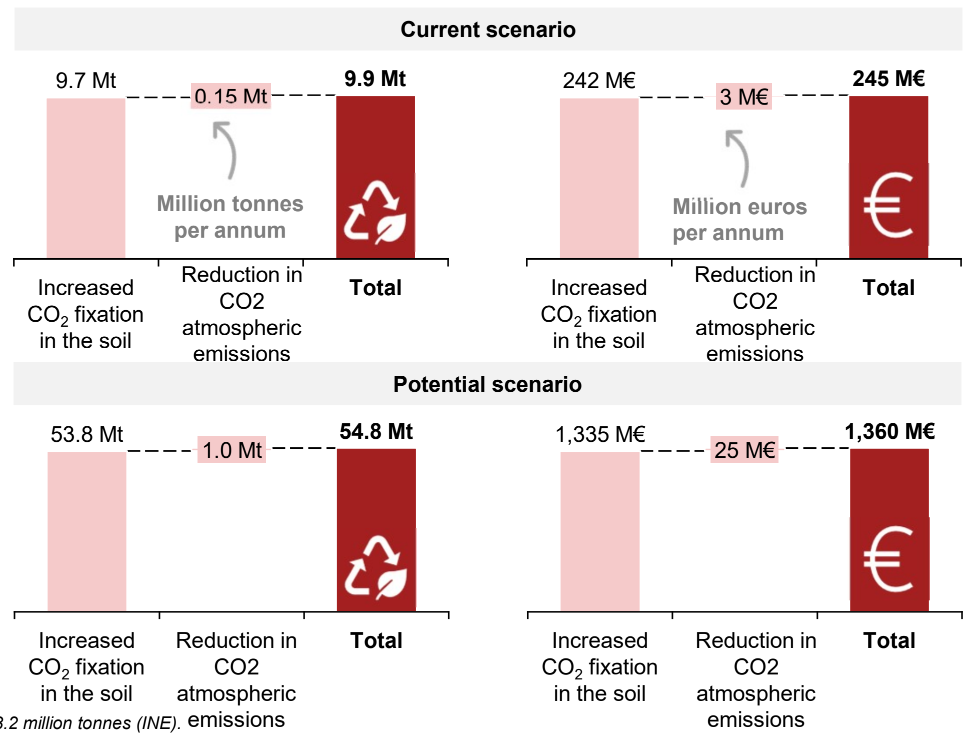
Economic benefit of CA benefits for the climate

Increased CO_2 fixation in the soil and reduced atmospheric emissions of gases gives rise to a saving of **9.9 million tonnes of CO_2** and a monetary saving of **245 M€**.

In a maximum potential adoption scenario, this saving could reach **54.8 million tonnes per annum** or **1,360 M€** in monetary terms.

The benefits for the climate under CA are particularly relevant as agriculture is one of the main industries responsible for CO_2 emissions (12% of the total). In the case of Spain, the new Climate Change Act assumes a reduction of at least **23%** in greenhouse gases by 2030 in relation to 1990. The **maximum adoption of CA** could allow the equivalent of **17%** of the emissions **generated in Spain in a year to be avoided**.[2]

Reduction in emissions thanks to CA (million tonnes and million €)



1) 2019 CO_2 price data are used for consistency with the other information. 2) Greenhouse gas emissions in Spain in 2019: 323.2 million tonnes (INE).
Source: PwC analysis, MAPA, MITECO, AEAC.SV, EUROSTAT, IDAE, INE.

3

Relevance of Conservation Agriculture in Spain

3.2. Quantification of the benefits of Conservation Agriculture

3.2.3 Benefits for farmers

CA helps to save between 18 and 35 litres of fuel per hectare, which in economic terms means that farmers save 34 M€ per annum on the entire cultivable area, which could reach 249 M€ in the maximum potential adoption scenario

Economic benefit of fuel cost saving

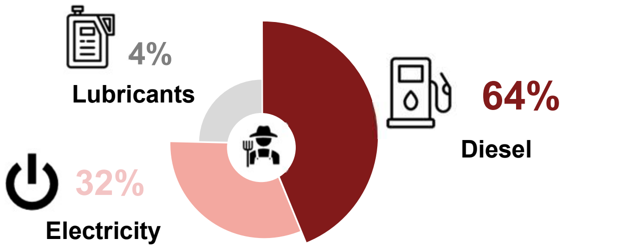
Non-tillage of the soil in Conservation Agriculture means that less fuel is needed per hectare in relation to tillage-based conventional techniques. In particular, for **herbaceous crops** a reduction of **35 l/ha** is achieved, while in **woody crops** it is **18 l/ha**.[1]

A cut in fuel consumption is particularly relevant for farmers. Specifically, diesel accounts for over **64% of fuel and energy costs** on farms, above the cost of electricity and lubricant, so this saving means a considerable **fall in the farmer's operating costs**.[1]

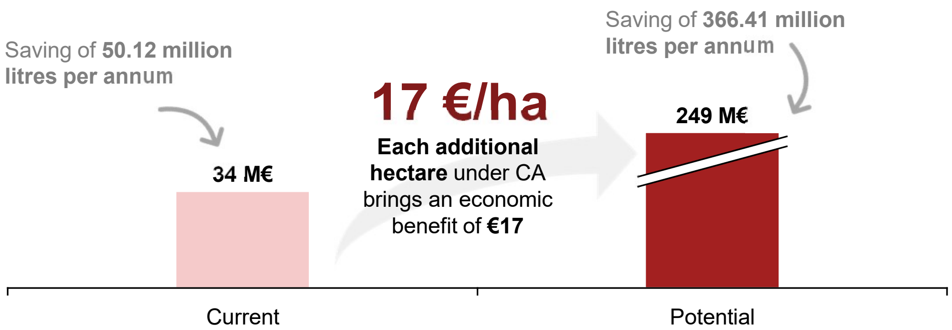
At present, Conservation Agriculture saves close to **50 million litres** per annum compared with conventional tillage techniques, for an annual saving of **€34 million**.

In a maximum potential CA adoption scenario, the annual saving could amount to **366 million litres** of fuel or **€249 million**.

Distribution of farm fuel and power costs



Savings for farmers thanks to Conservation Agriculture



1) IDAE, (2009). Saving and Energy Efficiency with Conservation Agriculture.
Source: PwC analysis, MAPA and INE

Besides using less fuel, Conservation Agriculture cuts work time in relation to conventional techniques by 48% and 41% thanks to direct seeding and crop coverage, respectively

Work time saving

The elimination of tillage in Conservation Agriculture means a **considerable reduction in work times**.

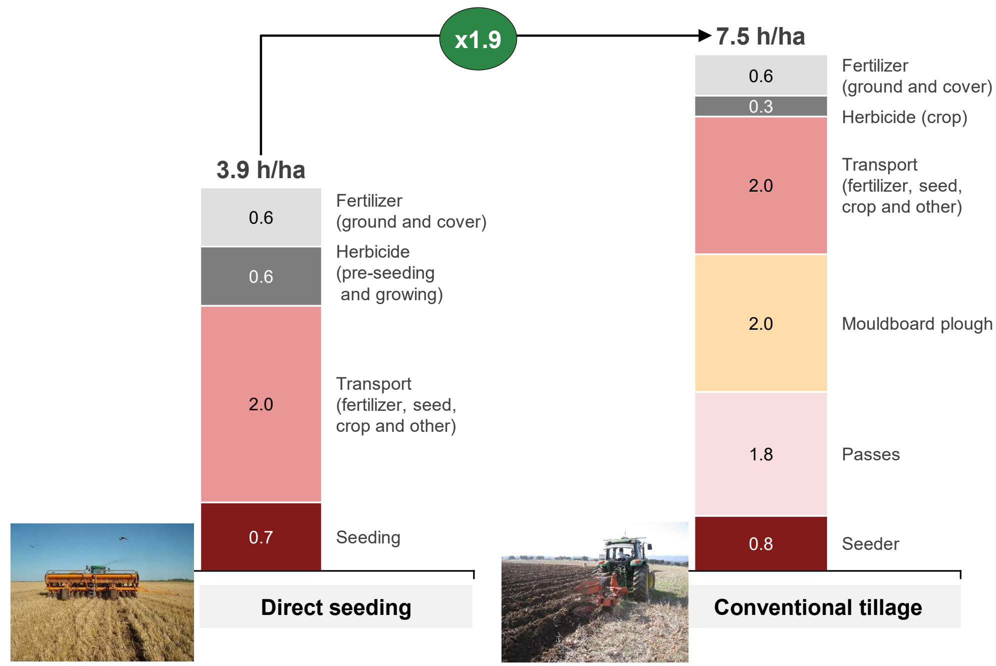
According to data from various field studies, CA work times tend to be 40% shorter than conventional techniques.[1] In the case of **direct seeding**, work times for mechanised tasks per hectare cultivated amount to **3.9 hours**. Bearing in mind the same type of crop, conventional tillage tasks require 7.5 hours per hectare, representing a **reduction of 48%** in work time spent on mechanised tasks in favour of Conservation Agriculture.

As regards **crop coverage**, the work time needed is **7 hours** per hectare. Compared with the 11.8 hours per hectare needed using conventional techniques, the use of cover crops **cuts work time by 41%**

-48% work time saving in **direct seeding** compared with conventional tillage

-41% work time saving using **cover crops** compared with conventional tillage

Comparison of work times for mechanised tasks in Conservation Agriculture compared with conventional farming (h/ha)



1) *Labour needs per cultivation technique extracted from: Arnal Atares, P. (2014). Saving of energy, work time and costs in conservation agriculture and González-Sánchez, E. J., et al. (2010). Agronomic and environmental aspects of Conservation Agriculture.*
Source: PwC analysis, MAPA, AEAC.SV and INE.

The improvements achieved in labour times thanks to Conservation Agriculture account for a reduction of close to 9 million hours compared with conventional tillage, with a value of €93 million in annual terms

Economic benefit of work time saving

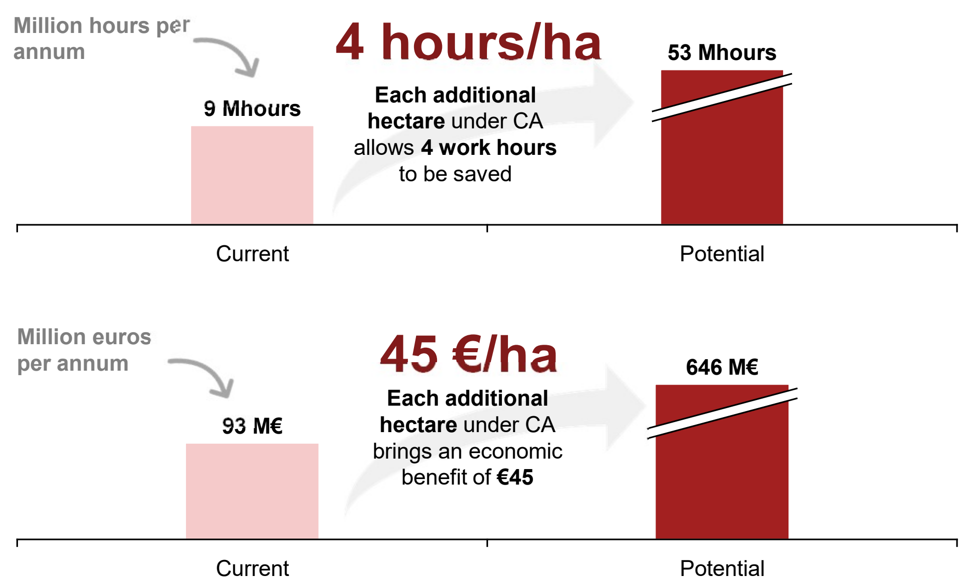
Conservation Agriculture assures a relevant work time saving for farmers. To estimate the aggregate saving, we considered the hectares currently devoted to Conservation Agriculture (2019 data) and we applied the time savings per hectare associated with each type of crop.

Conservation Agriculture allows a **saving of 9 million work hours** compared with a crop under conventional tillage techniques in the current adoption scenario. In monetary terms, based on the price per farmer work hour, this saving has a value of **€93.4 million**.

In the maximum potential adoption scenario, the saving would amount to **53 million work hours** compared with conventional tillage of the same number of hectares, with an associated economic value of **€646.1 million**.

On a 100 ha farm, the farmer saves approximately **4 days' work per month**.

Conservation Agriculture savings in labour costs compared with conventional tillage per scenario



Note: Considering that a tractor driver's average salary in Spain is 16€/h for herbaceous crops and 8€/h for woody crops (salary extracted from: Arnal Atares, P. (2014). Saving of energy, work time and costs in conservation agriculture and González-Sánchez, E. J., et al. (2010). Agronomic and environmental aspects of Conservation Agriculture.
Source: PwC analysis, MAPA, AEAC.SV and INE.

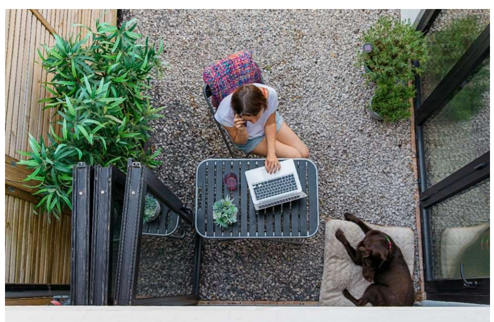
The increase in available time thanks to Conservation Agriculture stimulates rural areas by allowing a work-life balance or other activities that complement farming

Activities complementing farming and stimulation of rural areas

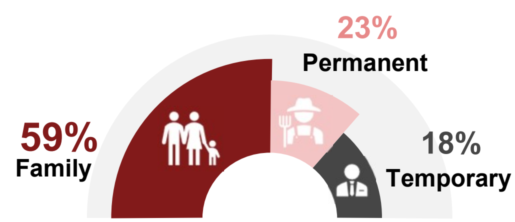
For farmers, Conservation Agriculture enhances farm profitability, business sustainability and economic conditions.

Work time savings allow farmers to devote time to other activities on and off the farm. In particular, **59% of farm labour is family work**. The extra time available could be used by the farmer to balance work and life, as well as in training or leisure activities, improving quality of life.

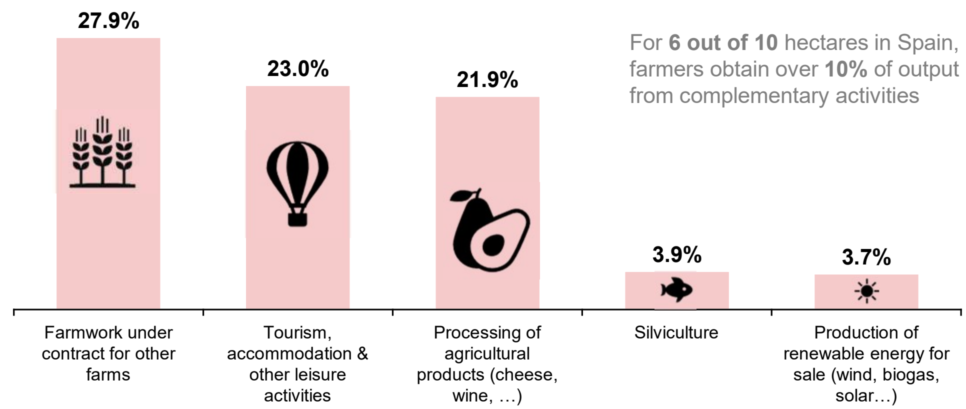
Some farms are engaged simultaneously in other professional activities, so the extra time could be used in activities such as **tourism or the transformation of farm produce**.



Distribution of farm work by type of worker (in % of AWUs, 2016)



Main activities complementing farming (2016)



For **6 out of 10** hectares in Spain, farmers obtain over **10%** of output from complementary activities

Source: PwC analysis, MAPA, AEAC.SV and INE, (2016). Survey on farm structure.

Conservation Agriculture generates greater benefits for farmers that apply this practice thanks to production cost savings

Production costs under CA

The use of Conservation Agriculture **cuts production costs** thanks primarily to **labour** efficiencies and the **fuel use** compared with conventional techniques.

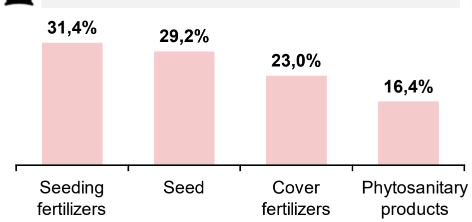
As regards production cost, specialised studies endorse the lower costs of Conservation Agriculture in relation to conventional techniques. For example, González-Sánchez (2010)[1] observed a reduction of 23% and 9% in variable costs in the case of sunflowers and wheat, respectively. Similarly, during the Life+ Agricarbon project (2014)[2], cost savings of 9.5% for wheat, 21.6% for sunflowers and 15.4% for legumes were noted. As may be observed in the table on the right, extracted from Arnal (2014),[3] a 20% cut in cereal cultivation costs was observed.

As regards revenue, there are differences in the literature regarding whether output remains unchanged or increases when Conservation Agriculture is adopted. For example, the Life+ Agricarbon project identified output growth averaging 5% under Conservation Agriculture. Other studies carried out by KASSA[4] in Spain concluded that yields were between 10% and 15% higher for non-tillage compared with conventional farming practices. In any event, the evidence in favour of an increase in productivity under CA is not unanimous, since some studies show lower productivity, as is the case of Arnal (2014), in which CA output is 4% lower.

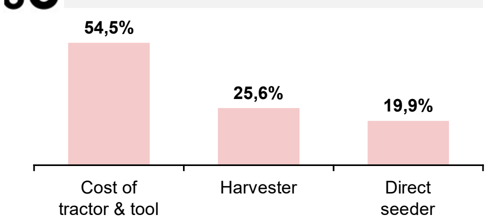
Cost account by winter cereal cultivation technique: conventional tillage and direct seeding (Arnal, 2014)

	Conventional tillage (CT) €/ha	Direct seeding (DS) €/ha	Difference in DS v. CT (€/ha)	Difference in DS v. CT (%)
Costs	**668**	**536**	**-132**	**-20%**
Direct costs	269	274	+5	+2%
Machinery costs	279	211	-68	-24%
Labour	120	51	-69	-58%

DS direct costs (%)



DS machinery costs (%)



1) González-Sánchez, E. J., et al. (2010). Economically sustainable agrarian systems: the case for direct seeding. 2) Life+Agricarbon project (2014). Sustainable agriculture in carbon arithmetics. 3) Arnal Atares, P. (2014). Saving of energy, work time and costs in conservation agriculture. 4) KASSA (2006). The Mediterranean platform, Mediterranean agroecosystems.
Source: PwC analysis

Overall, Conservation Agriculture allows farmers' agrarian income to increase by 135 M€ per annum, which could reach 932 M€ in a maximum potential adoption scenario

Economic benefit of lower production costs

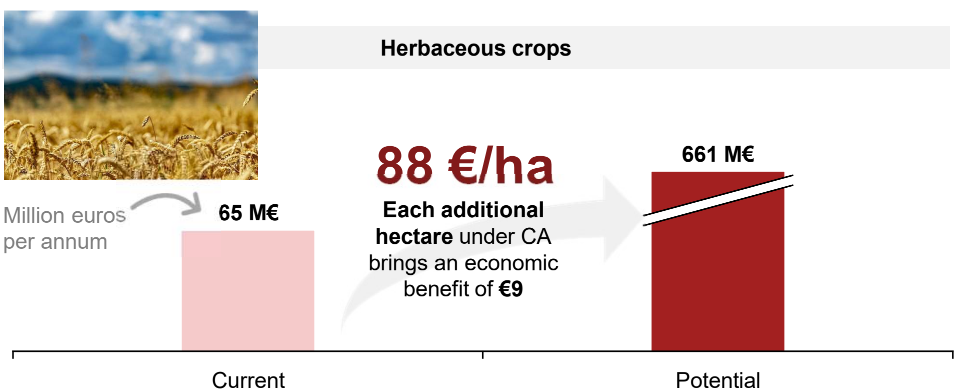
The economic benefit generated on farms currently practising Conservation Agriculture in Spain amounts to **€135 million**.

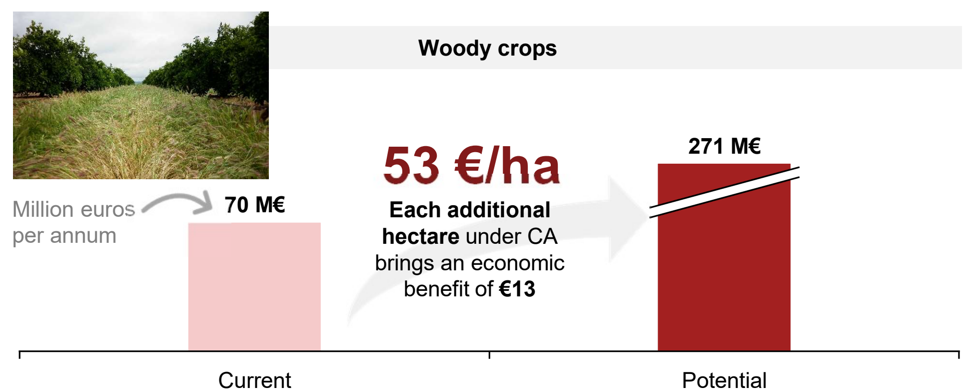
Although the level of CA implementation in **woody crops** is well above that of **herbaceous crops**, the efficiencies obtained using this technique are higher in the second case.

In a maximum potential adoption scenario, efficiencies could amount to **€932 million**.

We have estimated the benefits of the efficiencies associated with Conservation Agriculture using aggregate economic data for farms in Spain (RECAN 2018),[1] which specify costs and revenues by crop type, and we have calculated the impact of the efficiencies generated[2] on farm income statements for each crop type.

We have assumed constant revenue in each system, because most studies refer to the maintenance of output and, although differences are identified in some cases, they are small.[3] Therefore, the estimated benefit derives from account items related primarily to fuel and labour costs.





1) RECAN offers disaggregated economic data on farms for cereals, fruit trees, olive trees, grapevines and vegetables, among others. 2) The efficiencies of the Arnal Atares, P. (2014) study apply to herbaceous crops and those of the González-Sánchez, E. J., et al. study (2010) to permanent crops. 3) Most of the studies that identify output differences do so in Conservation Agriculture systems in relation to conventional systems, so it is a conservative supposition.
Source: PwC analysis

3

Relevance of Conservation Agriculture in Spain

3.2. Quantification of the benefits of Conservation Agriculture

3.2.4 Contribution to the fulfilment of the European Green Deal

55

The environmental benefits of Conservation Agriculture contribute towards meeting the objectives related to the European Green Deal and two of its strategies: «Farm to Fork» and «Biodiversity for 2030»

Contribution from CA to the fulfilment of the European Green Deal

Conservation Agriculture brings numerous environmental benefits, contributing directly and indirectly to the achievement of the **European Green Deal objectives** and its most relevant strategies: **«Farm to Fork»** and **«Biodiversity for 2030».**

Environmental benefits of CA

Current scenario: **26** million tonnes per annum of **soil erosion** and **10** million tonnes of **CO_2** saved, with an associated economic value of **403 M€**

x6

Potential scenario: **166** million tonnes per annum of **soil erosion** and **55** million tonnes of **CO_2** saved, with an associated economic value of **2,171 M€**

«Farm to Fork» strategy

Allowing the **EU's food system** to become **more healthy and sustainable**.

Challenge related to the farming system	CA solution
Guarantee healthy, affordable and sustainable food while caring for **soil and nutrients**. **European Union target**: **50%** reduction in nutrient loss	**Conservation Agriculture** avoids up to **90%** of **soil erosion**, increasing levels of organic matter and soil fertility.

«Biodiversity for 2030» strategy

Full, systemic, ambitious and long-term plan to **protect nature** and **reverse the degradation of ecosystems**.

Challenge related to the farming system	CA solution
Assure that a part of the farmland has **production systems** that **respect and protect biodiversity.**	**Crop residues** generated during CA provide **food and shelter** for many animals, giving rise to a large number of species of birds, small mammals, reptiles and worms, among others.

Source: PwC analysis

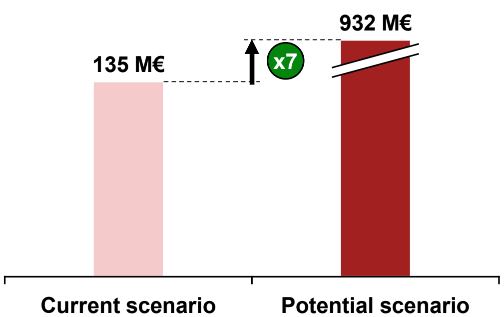
CA also contributes towards the fulfilment of the European Commission's goals for the new CAP thanks to the positive impact on environmental sustainability but also to economic and social sustainability

CA's contribution to the fulfilment of the Specific Objectives (SO) of the new CAP post 2020

Economic sustainability

SO 1. Ensure a fair income for farmers

66 €/ha **Each additional hectare** under Conservation Agriculture brings an economic benefit of **€66** per year for farmers.



Environmental sustainability

SO 4. Climate change action

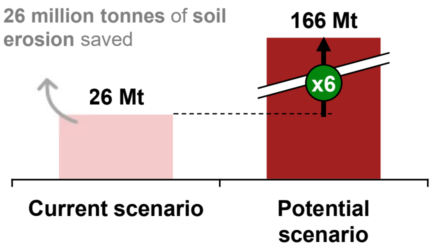
SO 5. Environmental care

SO 6. Preserve landscapes and biodiversity

13 t/ha **Each additional hectare** under CA avoids the loss of nearly **13 tonnes** of soil

Soil erosion

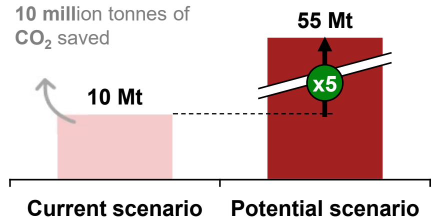
26 million tonnes of soil **erosion** saved



4.7 t/ha **Each additional hectare** under CA allows **4.7 tonnes** of CO_2 to be saved

CO_2

10 million tonnes of CO_2 saved



Biodiversity

x2-7.5 **Conservation Agriculture** multiplies the number of **living beings** in a square metre of soil **by between 2 and 7.5 times** compared with **conventional farming**

Social sustainability

SO 8. Vibrant rural areas

4 hours/ha **Each additional hectare** under Conservation Agriculture allows the farmer's working day to be cut by **4 hours**.

The increase in available time thanks to Conservation Agriculture stimulates rural areas by allowing a work-life balance or other activities that complement farming such as:

- Agrotourism
- Transformation of farm products
- Construction and maintenance of renewable energies

Thanks to CA, farmers can save **9 million hours** each year, which could reach **53 million hours** in the **maximum potential scenario**

Source: PwC analysis

4

Socio-economic contribution of Conservation Agriculture and importance for the revitalisation of rural areas

Using the input-output method, we estimated the contribution from Conservation Agriculture in terms of GDP and jobs

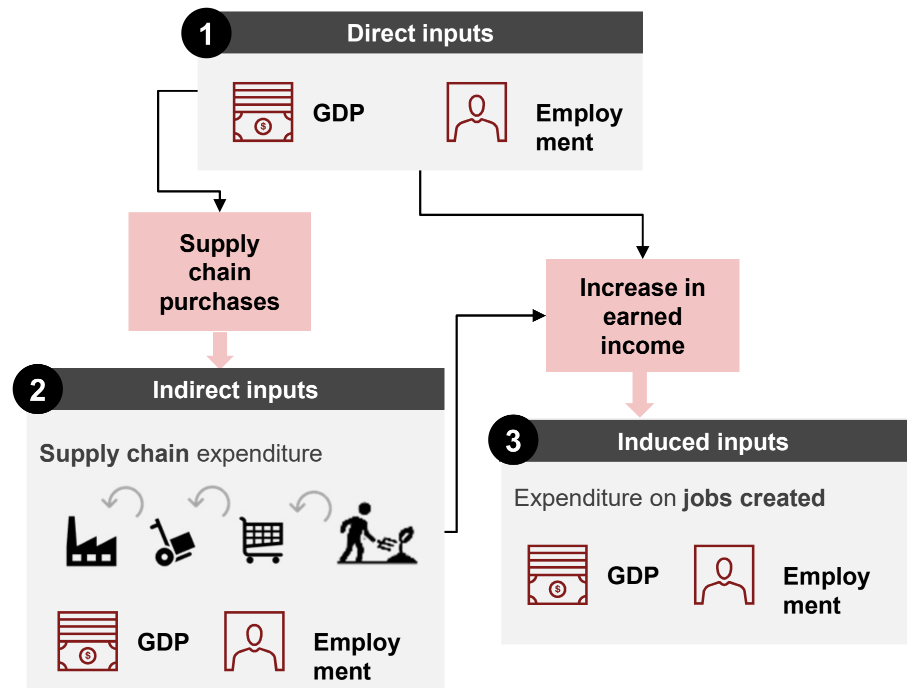
Indicators and method

The economic contribution from Conservation Agriculture in Spain is measured in terms of:

- **Gross Domestic Product** (GDP): measured in all cases in terms of Gross Value Added (GVA).
- **Contribution to employment**: measured in terms of the number of people employed.

We use the input-output method, a standard method tried and tested internationally that allows the quantification of the total inputs generated, including indirect inputs through suppliers and induced inputs through the consumption generated by all economic activity arising from the direct and indirect inputs.

Economic contribution under the input-output method



Note: Appendix A.1 explains in detail the method used to calculate the socio-economic contribution of Conservation Agriculture.
Source: PwC analysis and INE

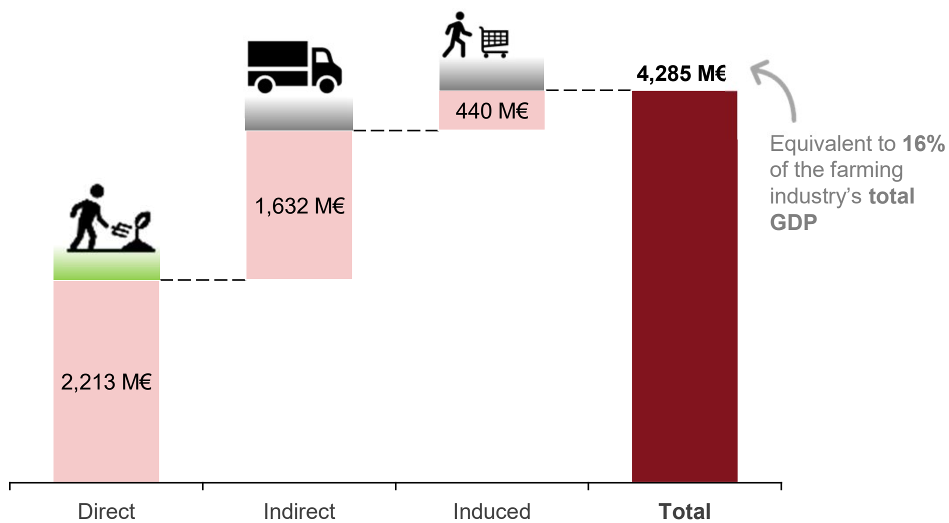
In 2019, the GDP contribution from Conservation Agriculture totalled €4,285 million, representing 16% of the farming industry's total contribution

Contribution from CA in terms of GDP

In 2019, the total GDP contribution from Conservation Agriculture was **€4,285 million**, representing **16% of the total GDP** generated by the farming industry.[1]

51.6% (2,213 M€) relates to direct inputs from Conservation Agriculture and 48.4% (2,072 M€) to the added economic value generated throughout the supply chain and the value generated by new job creation.

Contribution from CA in terms of GDP (M€, 2019)[1]



x2€ For each **€ of GDP** arising **directly** from CA, **€2** of the Spanish economy's **total GDP** is generated

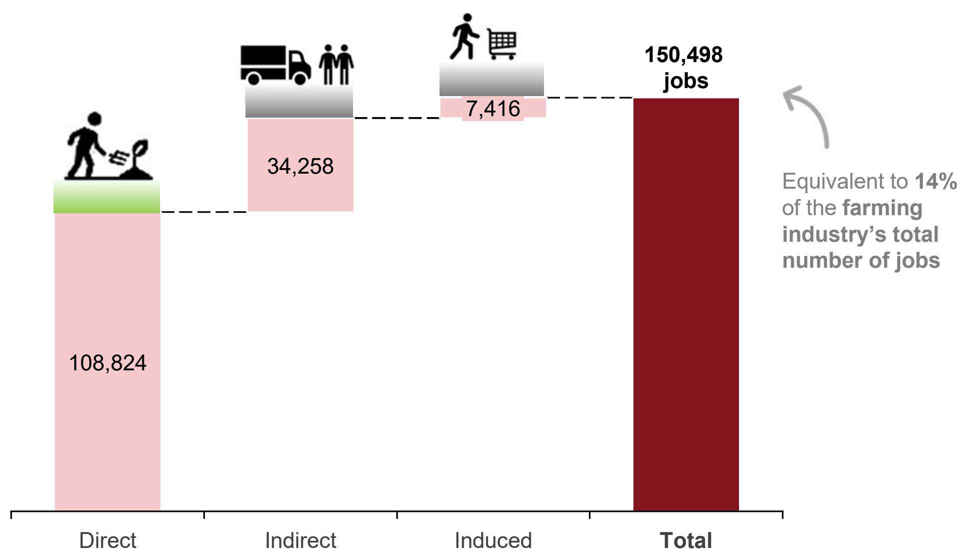
1) GDP impacts are approximate using Gross Value Added at basic prices
Source: PwC analysis and INE

In terms of employment, the total input from Conservation Agriculture was 150,498 workers in 2019, representing 14% of the farming industry's total contribution to employment

Contribution from CA in terms of jobs

Thanks to Conservation Agriculture, a total of **150,498 workers** are employed in a direct, indirect or induced way in Spain, representing **14% of total employment** generated by the agricultural industry. Of that figure, 72.3% (108,824 people) relates to workers directly engaged in Conservation Agriculture, 22.8% (34,258 people) to the number of jobs throughout the supply chain and 4.9% (7,416 people) to jobs created thanks to the increase in income generated by the direct and indirect contributions.

Contribution from CA in terms of jobs (absolute employment, 2019)



x34 **For every million euros of output** under **CA in Spain**, **a total of 34 jobs** are created (direct, indirect and induced) in the economy as a whole

Source: PwC analysis and INE

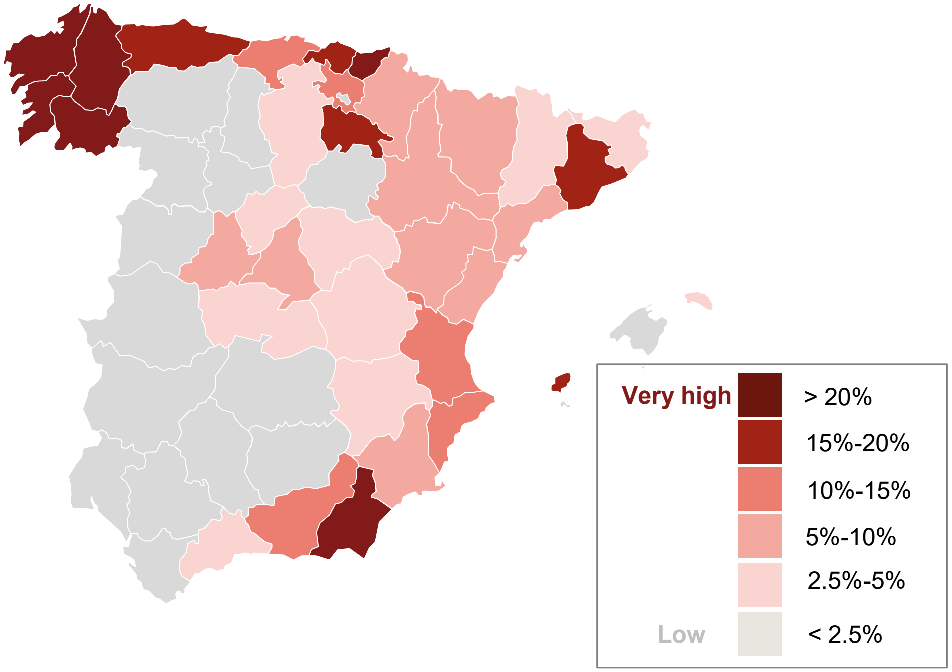
In a context of rural abandonment in which more than 5 million hectares are expected to be rendered useless by 2030, the socio-economic contribution from CA is crucial to revitalise rural areas and combat depopulation

Risk of rural abandonment and socio-economic significance of CA

By **2030**, according to the latest forecasts of the European Commission's LUISA Territorial modelling platform[1], approximately **23 million hectares** of agricultural land are currently exposed to various **potential risks of abandonment**. Specifically, 25% of farmland is estimated to be at risk of abandonment, at percentages of above 10% of the land in question. In absolute terms, this means a fall of over **5 million hectares** in agricultural output and thus rural abandonment**.**

The **regions of Spain** are not all affected in the same way. The worst abandonment prospects relate to the northwest (Galicia, Asturias, Cantabria, Navarre and Basque Country) and southeast (Almería, Granada, Murcia and Valencia). If we analyse the number of hectares affected, the group formed by Zaragoza, Granada, Teruel, Almería, Murcia, Valencia, Huesca and Albacete stand out, with virtually **50% of the land affected.**

Rural abandonment by province in Spain by 2030 (farmland as a % of the total agricultural area used)[1]



1) Study by Perpiña Castillo, C., Coll Aliaga, E., Lavalle, C., & Martínez Llario, J. C. (2020). An assessment and spatial modelling of agricultural land abandonment in Spain (2015–2030). Sustainability, 12(2), 560. There are no estimates for the Canary Islands.
Source: PwC analysis and AEAC.SV

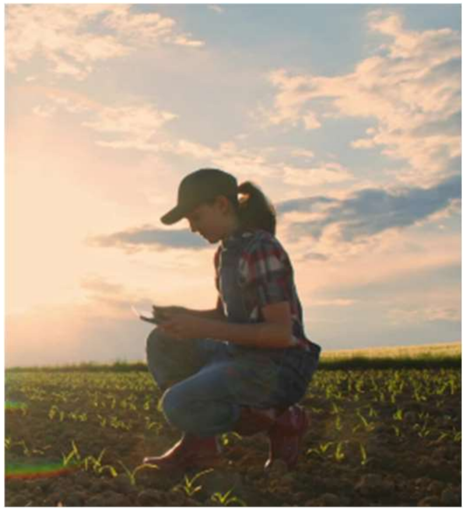
In addition, with risk of poverty in sparsely-populated areas at 15% and close to 68% of farm workers living in these areas, the contribution to agricultural employment from Conservation Agriculture is highly relevant to fix the population to the territory

Relevance of the impact on employment to fix the population to the territory

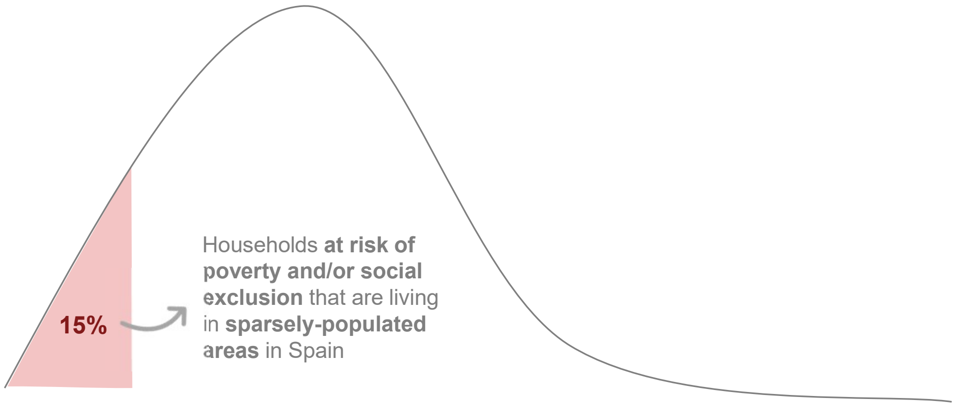
In rural areas, there are a high number of people in a situation of poverty and/or social exclusion. Many of these people are closely related to the agricultural industry.

In particular, around **68% of agricultural workers** in Spain[1], some 530 thousand, live in **sparsely-populated areas**. Bearing in mind that approximately **15%** of households in these areas are **at risk of poverty and/or social exclusion[1]**, CA's contribution to total employment of **150,498** jobs is highly relevant in terms of fixing the population to the territory.

For a household, being in a situation of poverty and/or social exclusion can mean a greater risk of rural abandonment. Considering the income distribution in these sparsely-populated areas, the total population linked to the farming industry that could be **at high risk of rural abandonment** would be around **287 thousand people**.[2]



Distribution of household income in Spain's sparsely-populated areas (2019)



The definition of the at-risk-of-poverty threshold is contained in the European Union's Europa 2020 Strategy, where an individual is considered to be at risk of poverty and/or social exclusion in any of the following situations: (i) his income per unit of consumption is below 60% of the median; (ii) he suffers from severe material deprivation; and (iii) he lives in a household with very low employment intensity.

1) National Institute of Statistics (INE) Living Conditions Survey 2019.
2) Figure estimated based on the following variables: total number of people engaged in farming in Spain (779,000), percentage of agricultural workers in sparsely-populated areas (68%), percentage of households at risk of poverty and/or social exclusion in sparsely-populated areas (15%) and average size of households in these sparsely-populated areas (3.6 people per household).
Source: PwC analysis and INE

5

Essential Conservation Agriculture tools

To progress with the adoption of Conservation Agriculture, it is necessary to build awareness of the benefits and essential tools for developing this practice

Factors limiting an increase in CA adoption

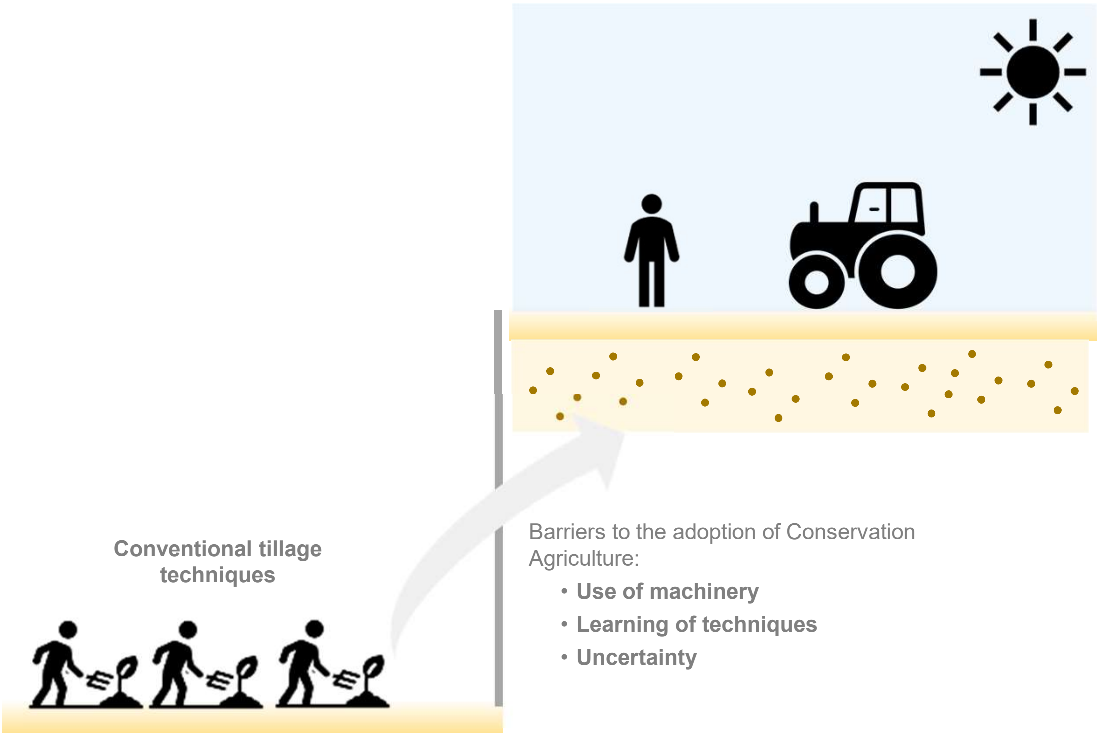
Although Conservation Agriculture has expanded considerably in recent years, there are still certain rigidities and inertia that complicate implementation and are explained in many cases by the inertia of farmers accustomed to conventional techniques.

For this reason, a number of **factors** may be **limiting the development of CA**.

Firstly, Conservation Agriculture requires the **use of specific machinery.** An example of this is direct seeding, where the initial investment may be between €18,000 and €50,000. In any case, farmers have the option of outsourcing operations to an external company. This would facilitate the process, particularly for small farmers who cannot afford the initial investment in machinery.

A second issue is the **learning curve for the optimal use of Conservation Agriculture techniques**. As a new technique for the farmer, there must be an initial training process to learn proper applications, advantages, etc. To facilitate this phase and make it less costly, it is important to develop farmer training policies, particularly in the early years of transition to this farming practice.

Thirdly, there may be **uncertainty in the face of change** on the part of farmers due to being a practice that is scarcely implemented in some areas of Spain. In this regard, it is essential to **develop public policies** to build awareness of the benefits of Conservation Agriculture and incentivise its use, particularly in the early years.



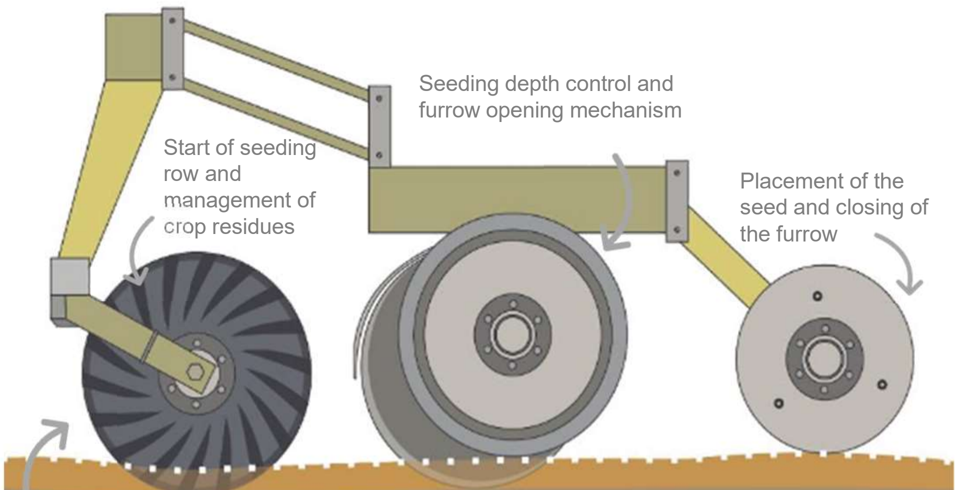
Source: PwC analysis and AEAC.SV

The essential tools needed to implement Conservation Agriculture include direct seeding machines…

Essential tools for CA: Direct seeding machines

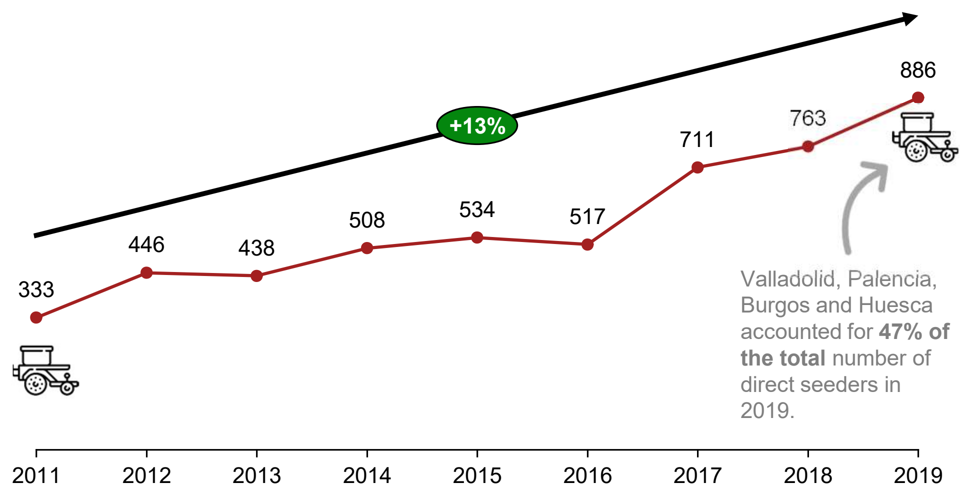
Direct seeders may be distinguished from conventional seeders by the **sowing trailer**, which is more solid and must put high pressure on the soil to assure a correct cut and seed positioning. This means that the machines tend to be heavier than those used in the conventional seeding system.

Example of a direct disk seeder sowing trailer



In **Spain**, the number of direct seeders rose from 333 in 2011 to over **880 in 2019**, entailing **13% average annual growth**. This has allowed an increase in the area cultivated under CA. To reach maximum adoption levels, greater **economic and training support** will be needed from public institutions.

Number of direct seeders in Spain (2011-2019)[1]



1) Official Register of Farm Machinery (ROMA) and ANSEMAT. Direct seeders can be adapted to different farming practices, so these figures might not accurately reflect all the machines that are in use in Conservation Agriculture.
Source: PwC analysis, ANSEMAT, MAPA and AEAC.SV

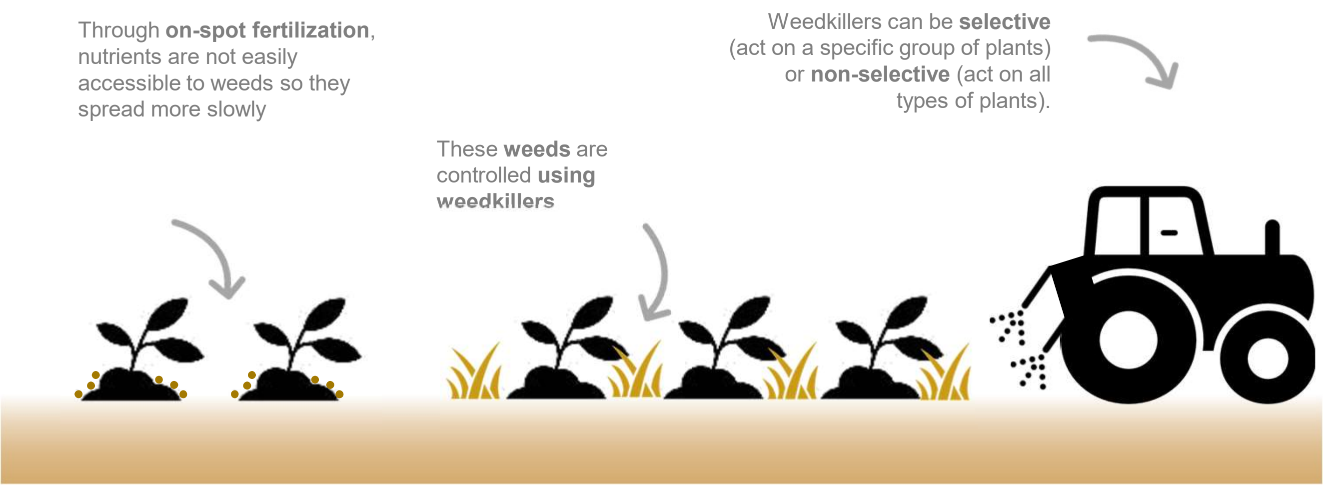
…and weedkillers, glyphosate being the most common weedkiller used to control weeds and protect soil nutrients

Essential tools for CA: Weedkillers

Conservation Agriculture improves the physical and chemical aspects of soil thanks partly to the use of **phytosanitary products such as weedkillers**. The elimination of weeds using herbicides during fallow and pre-seeding periods is essential for the soil to **make the most efficient possible use of water and nutrients**. The active substance **glyphosate** is one of the **most common herbicides** for most weed species.

Depending on when it is applied, there are pre-seeding, pre-emergent and post-emergent weedkillers, the latter being used when the plants are perfectly visible.

Although glyphosate is an essential tool for CA, this farming technique is not associated with increased use of this active substance. **CA optimises the use of herbicides** compared with tillage-based systems. In fact, according to some scientific studies, over the years it is possible to reduce doses and the number of applications.[1]



(1) AEAC.SV: Conservation Agriculture weed control synergies.
Source: PwC analysis and AEAC.SV

Glyphosate is a broad spectrum herbicide used widely in farming. It allows weeds to be controlled more effectively and efficiently than with alternative methods

Uses of glyphosate

Glyphosate is an active substance forming part of a large group of herbicide formulations and a **fundamental weed control tool**.

Since it was introduced, glyphosate-based products have become the most widely used weedkillers.

Agricultural uses

Glyphosate is widely used in the farming industry, mainly in pre-seeding and pre-harvesting weed control tasks. It is employed in humid areas as a drying agent at harvest time, although not in Spain.

Non-agricultural uses

Glyphosate is also used to control weeds in transport infrastructures such as railways and roads. It is used in towns to control weeds in public spaces such as streets, parks and gardens.

The analyses carried out focus on the use of this substance for **agricultural purposes.**

Benefits of glyphosate for agriculture

The three principles on which Conservation Agriculture is based (no tillage, crop coverage and crop rotation) perform a weed control function. However, it is essential to manage the crop cover and undesired vegetation well, which is primarily achieved using herbicides, particularly glyphosate.

Besides being especially useful for CA, in more general terms this herbicide is a core instrument for controlling weeds because it **simplifies and brings down the cost of the process** compared with other alternative products or mechanical or manual techniques.

For example, glyphosate is commonly used for **fruit trees**, favouring **correct soil maintenance** and preventing weeds from affecting the productivity and health of crops (since uncontrolled weeds compete with crops -nutrients, water, light- and may be hosts to plagues and disease).

Use of glyphosate in different stages of the cultivation process

Pre-seeding treatment

Glyphosate is applied from pre-seeding to a few days after seeding to prepare the seed bed and avoid early competition from weeds.

Post-emergence treatment

Glyphosate is used for specific treatments between rows also when the crop has been planted (before weeds appear).

Pre-harvesting

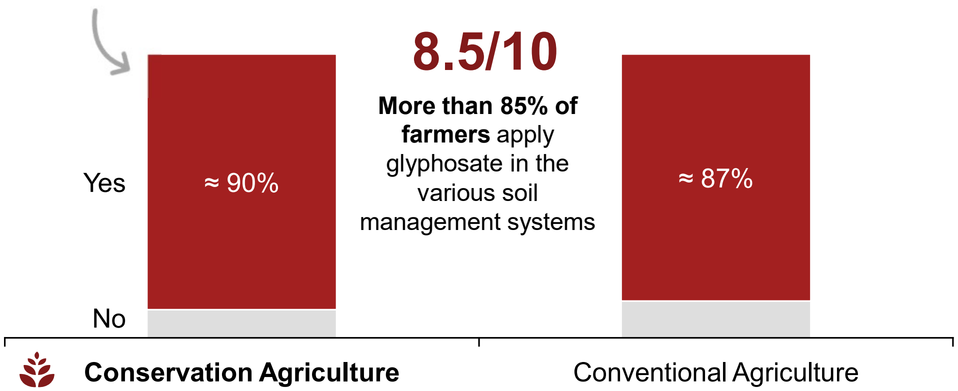
Before harvesting, glyphosate is used to control the late appearance of weeds.

Glyphosate is a key tool for CA, since 43% of farmers consider that there is no alternative in direct seeding and 32% state that they would abandon Conservation Agriculture and return to conventional farming were it not for glyphosate

Alternatives to the use of glyphosate

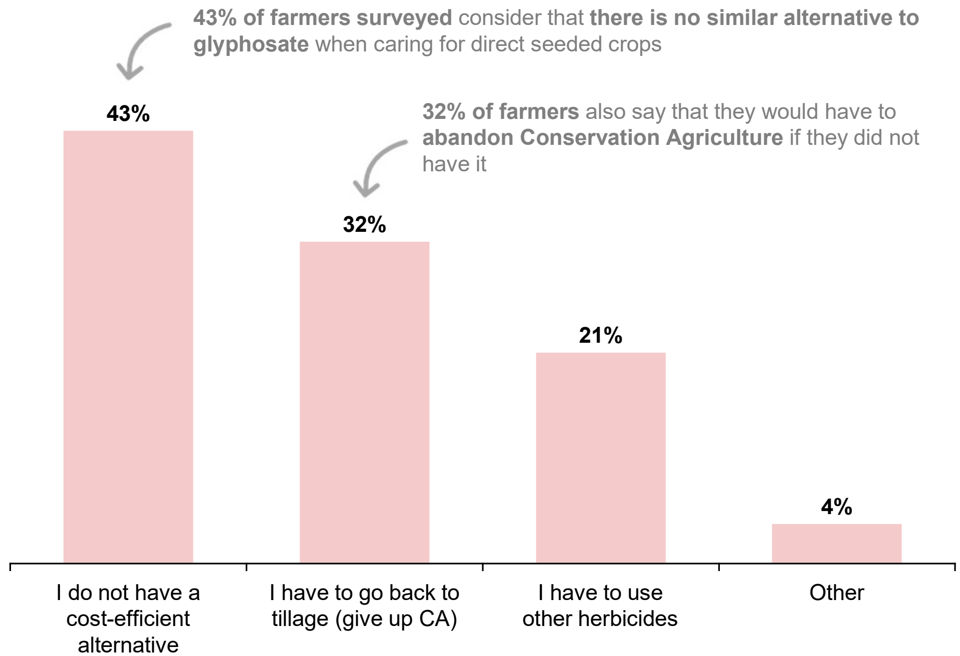
Percentage of farmers that apply glyphosate by soil management system (2020)[1]

Although glyphosate is used in all soil management systems, it is **particularly relevant** in **Conservation Agriculture**.



Despite the elimination of tillage tasks in direct seeding, **doses of herbicide used do not increase under Conservation Agriculture**, so a migration from a conventional tillage system to no-till farming (Conservation Agriculture) **does not mean using more weedkiller.[1]**

Alternatives that farmers would choose were glyphosate not available (2020)[1]



(1) ECAF (2020).

Treatment with glyphosate is common practice when growing cereals, industrial crops, fruit trees, olive trees and grapevines

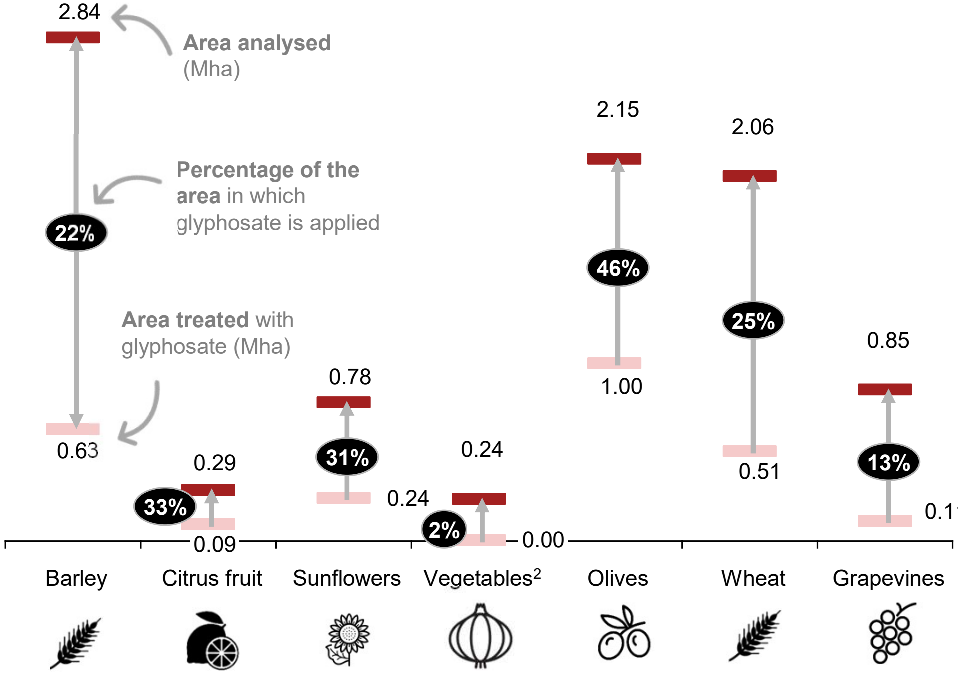
Use of glyphosate by crop type

According to the latest Survey on the Use of Phytosanitary Products conducted by the Ministry of Agriculture, Fisheries and Food (MAPA)[1], **2.9 thousand tonnes of glyphosate** were applied to the crops analysed in an area of **2.6 million hectares**.

Glyphosate use on **citrus fruit and olive trees**, on 94 thousand and 1 million hectares, respectively, accounts for **33% and 47%** of the total area of each crop.

It is also used when growing sunflowers, wheat, barley and grapevines. Conservation Agriculture is employed for only 2% of vegetables produced.

Use of glyphosate for Spanish crops[1]



1) Data for 2013, the latest information available.
2) Garlic, onions, cauliflower, broccoli, lettuce, melons and tomatoes.
Source: MAPA (2013). Survey on the Use of Phytosanitary Products. Spain. The "Statistics on the Use of Phytosanitary Products" indicate the use of phytosanitary products for certain crops that are socially or economically important in Spain's agricultural industry.

In aggregate terms, the estimated area treated with glyphosate in 2019 amounts to 3.9 million hectares or approximately 8% of the total cultivated area

Estimated use of glyphosate in 2019

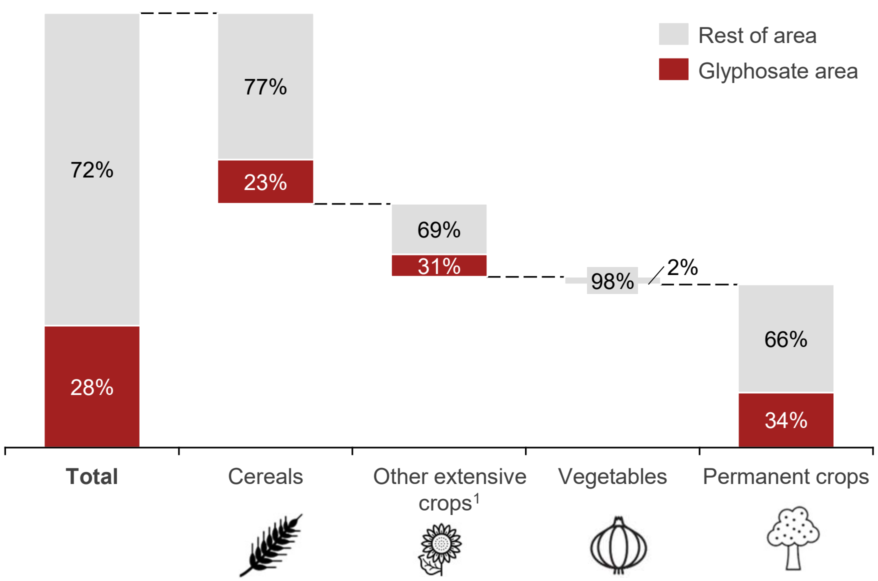
Based on the data on the use of glyphosate for specific crops, we have extrapolated the figures for 2019 for four major crop types: (i) cereals; (ii) other extensive crops*; (iii) vegetables; and (iv) permanent crops, for which disaggregated results are provided.

Specifically, the crop group for which most **glyphosate** is used are **permanent crops**, due largely to citrus fruit trees, olive trees and grapevines. In 2019 values, the area on which glyphosate was used amounts to **1.8 million hectares** of these crops.

The **cereals** and **other extensive crops**[1] treated with this product amount to **1.4 and 0.7 million hectares**, representing 23% and 31% of the total land devoted to these crops, respectively.

In the case of **vegetables**, glyphosate is not widely used and is applied only to 2% of the area.

Estimated proportion of cultivated areas treated with glyphosate (2019)[2]



1) Includes legume, root and tuber, industrial and fodder crops.
2) Estimated using MAPA data on the proportion of the cultivated area treated with glyphosate for different crops (2013). Survey on the Use of Phytosanitary Products. MAPA. The proportions obtained from the above information relate to the cultivated areas in 2019 according to the MAPA (2019). Survey of Areas and Crop Yields. MAPA. Spain.

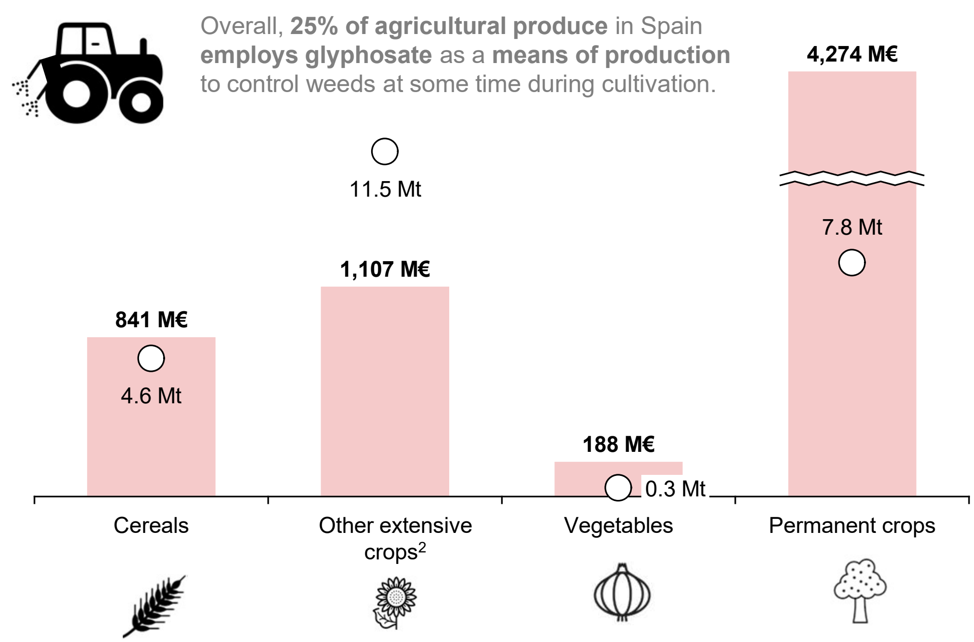
Production of crops using glyphosate amounts to nearly 24 M tonnes and 6,410 M€, representing 25% and 21% of agricultural produce in Spain in tonnes and monetary units, respectively

Value of produce associated with the use of glyphosate

Production using glyphosate of the four major crop groups analysed is shown below:

- **Production of permanent crops** using this weedkiller amounts to 7.8 million tonnes and an economic value of €4,274 million.
- **Cereal** output totals approximately 4.6 million tonnes or €841 million in economic terms.
- For **other extensive crops**[1], output in the area treated with glyphosate amounts to 11.5 million tonnes or €1,107 million in monetary terms.
- Glyphosate is not widely used to produce **vegetables**. In this case, output amounts to 293 thousand tonnes and €188 million.

Estimated produce treated with glyphosate in Spain (2019)[1]



1) Estimated using MAPA data on the proportion of the cultivated area treated with glyphosate for different crops (2013). Survey on the Use of Phytosanitary Products. The proportions obtained from the above information relates to the produce in 2019 according to the MAPA (2019). Survey of Areas and Crop Yields. Spain.

2) Includes legume, root and tuber, industrial and fodder crops.

Glyphosate-based herbicides are associated with greater productivity and lower costs, as reflected in studies of the effects of doing without this active substance

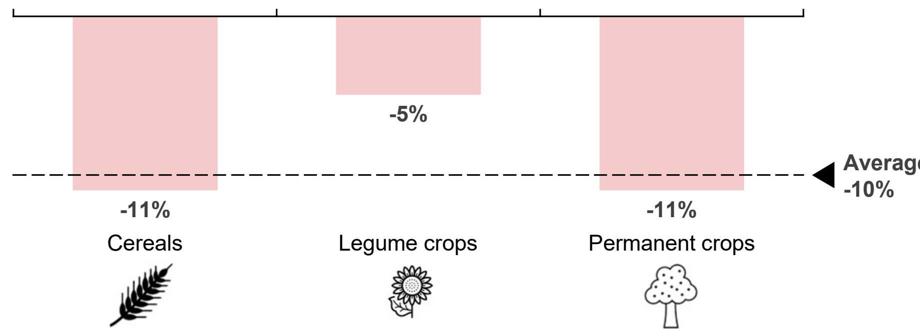
Increase in farm produce and reduction in production costs associated with the use of glyphosate

Evidence of the effects of **doing without glyphosate** shows an **average reduction of 10% in output** and an **average increase of 9% in variable costs.**

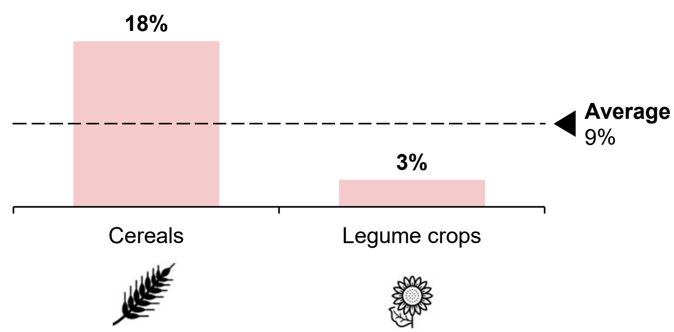
Cereal and permanent crops benefit most from the use of glyphosate and output falls by around **11%** in the affected area if use of this product is discontinued. Other extensive crops are also affected, though to a lesser extent, with falls of around 5%.

In the absence of glyphosate, farmers have to seek alternative ways to control weeds, which may consist of mechanical means or other chemical products. These alternative weed control methods require a **larger amount of weedkillers** and **more intensive use of mechanical and human resources**. For this reason, in the absence of glyphosate, **variable costs** could **rise by up to 18%** in the case of **cereals** and **3%** for **legume crops**.[1]

Production changes that would take place were glyphosate not used (%/ha)



Variable cost changes that would take place were glyphosate not used (%/ha)



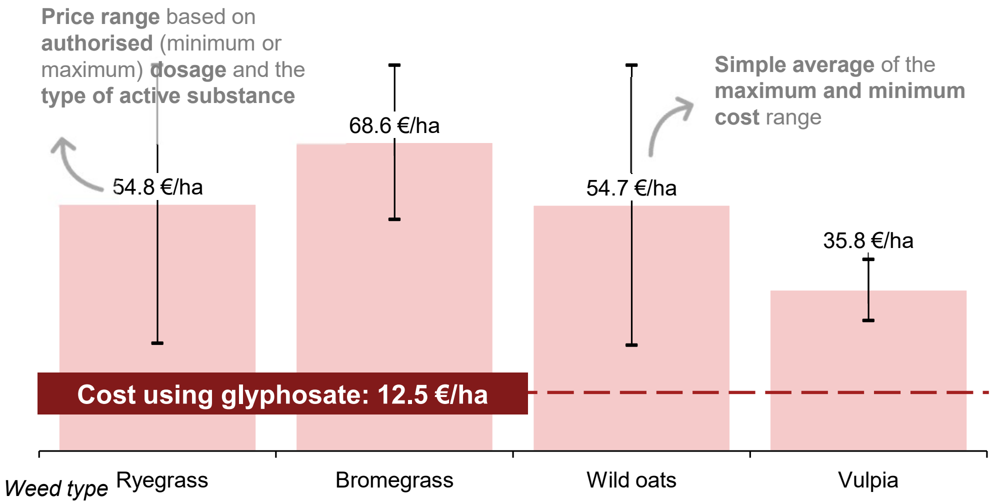
1) *European Crop Protection (2016). Low Yield Cumulative impact of hazard-based legislation on crop protection products in Europe. Final report July 2016.*

In particular, the possible chemical alternatives to glyphosate, which vary depending on the type of weed, cover crop, active substance used or dosage applied, are associated with much higher costs than glyphosate

Cost difference using glyphosate and other alternatives

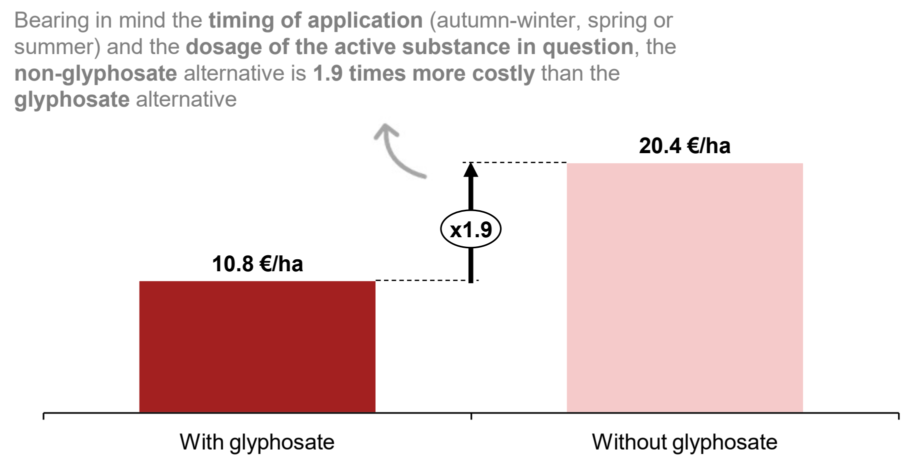
Herbaceous crops: Wheat

Comparison of the cost of applying different substances to control weeds (€/ha)[1]



Permanent crops: Olive trees

Comparison of the cost of applying different substances to control cover crops (€/ha)[1]



Doing without glyphosate causes an **increase in costs** for the farmer of around **€41 per hectare** in the case of **herbaceous crops** and **€9.6 per hectare** for **permanent crops**.

Some active substances that could be an alternative to glyphosate (though more expensive) cannot be used in all cases due to not being authorised for use with certain crops. In practice, there are no chemical alternatives to glyphosate for some crops.

(1) Figures estimated by AEAC.SV.

Given its relevance to the agricultural industry and related sectors, glyphosate makes a considerable macroeconomic contribution amounting to over 2,431 M€ in produce, 1,087 M€ in GDP and more than 23,000 jobs

Macroeconomic contribution from the use of glyphosate in Spain

The use of glyphosate has a **direct impact** on the farming industry itself. The increase in output and reduction in costs per crop type has an impact of **893 M€** on output, **485 M€** on **GDP** and nearly **11,600 jobs**.

If, besides the direct impact, the related sectors and increase in household consumption are considered, the use of glyphosate has an associated total impact of **2,431 M€ on output** (0.11% of domestic output) and **1,087 M€ on GDP** (0.09% of Spain's GDP). As regards employment, the impact on output in both the farming industry and other sectors has an associated impact of **over 23,000 jobs** (0.12% of employment in Spain).

Glyphosate allows the farming industry to contribute **a positive balance of over 750 M€ to Spain's foreign trade balance**.

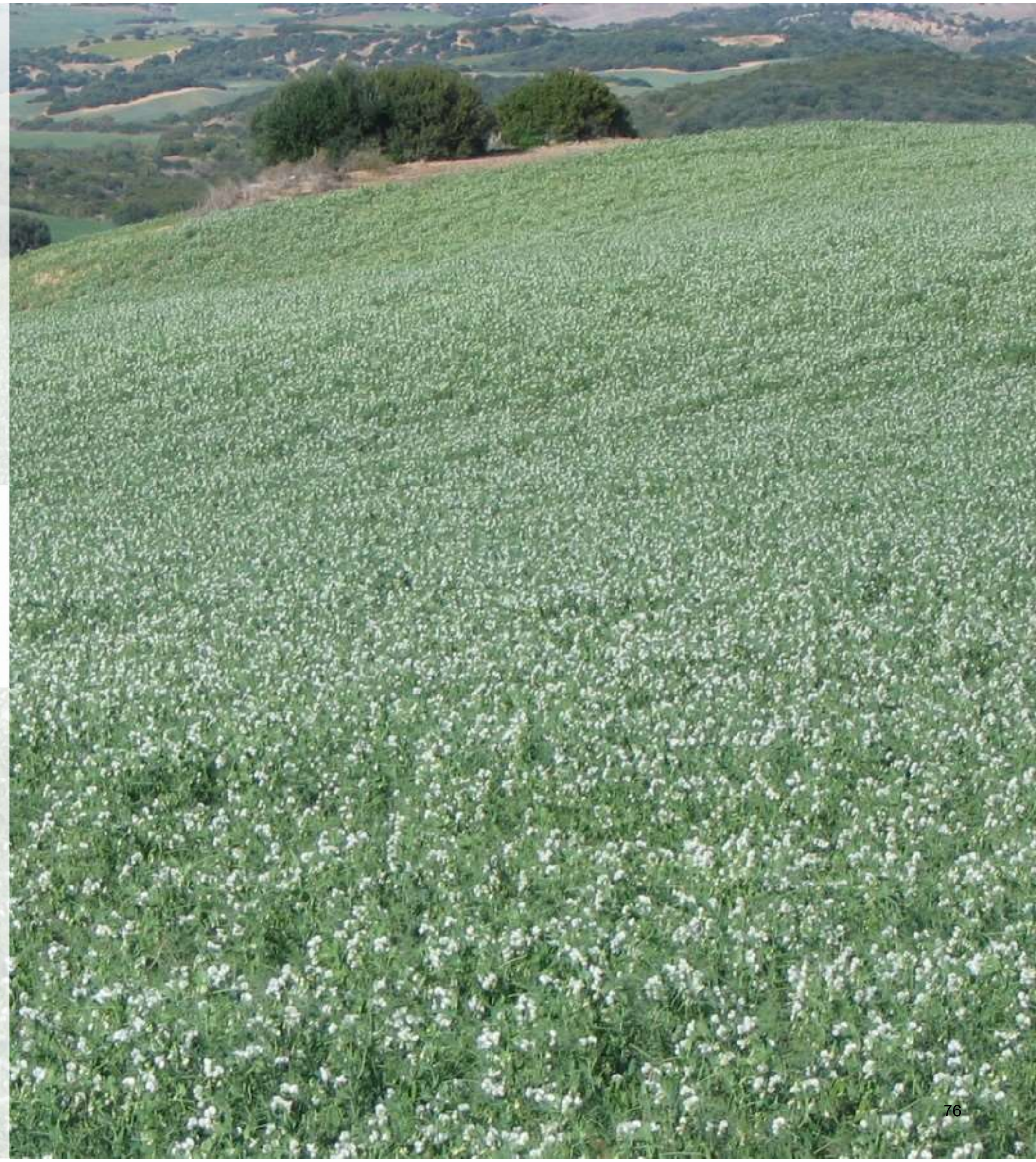
Summary of the estimated impacts of using glyphosate in agriculture (2019)

	Impact on the farming industry	Impact on related sectors	Impact on households	Total impact
Output	893 M€	914 M€	624 M€	**2,431 M€** (0.11% of domestic output)
GDP	485 M€	280 M€	322 M€	**1,087 M€** (0.09% of Spain's GDP)
Employment	11,598 jobs	5,497 jobs	5,987 jobs	**23,082 jobs** (0.12% of total employment)
Balance of trade	754 M€			

Note: Appendix A.1 contains a breakdown of the impacts on the farming industry, related sectors, households and tax revenue. Appendix A.3 describes the method used to calculate the impacts associated with the use of glyphosate.
Source: PwC analysis

Appendices

A.1 Socio-economic contribution from glyphosate



The purpose of this section is to estimate the impacts on Spain's economy of the use of glyphosate in agriculture

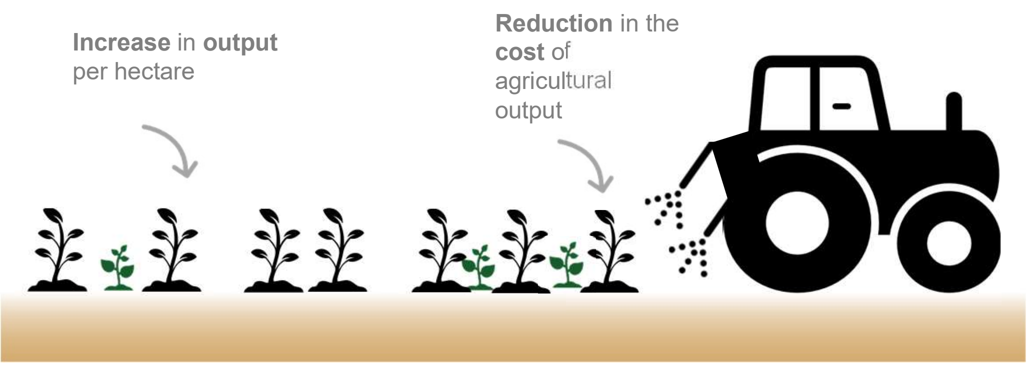
Effects of the use of glyphosate

This section quantifies the contribution made by glyphosate to the Spanish economy as a whole. It begins with the area currently treated with glyphosate in order to estimate the herbicide's contribution to agriculture and, in general, to the rest of the economy.

The use of this weedkiller has two main direct benefits for farming:

- **Increase** in **output** per hectare
- **Reduction** in the **cost** of agricultural output

These effects, arising in the farming industry, trigger a series of impacts that make a significant positive contribution to the economy as a whole.



Summary of estimated impacts

The impact of these two benefits of the use of glyphosate on the domestic economy are analysed below. The effects are estimated in the following areas:

- Impact on the **farming industry itself** (direct impact).
- Impact on the **other industries** that are related to the farming industry. This includes both suppliers and customers (indirect impact on the value chain of suppliers and of customers).
- Impact on **households** (induced impact).
- Impact on **State tax revenue**.

Glyphosate-based herbicides are associated with an increase of up to 11% in the production of crops such as cereals and permanent crops, and around 5% in legume crops, as reflected in the various studies conducted on the effects of doing without this substance

Increase in agricultural output associated with the use of glyphosate

Based on the evidence of the effects **on production were glyphosate not used**, we have estimated **output** of the four main crop categories analysed.

Cereal and permanent crops benefit most from the use of glyphosate and output falls by around **11%** in the affected area if use of this product is discontinued. Other extensive crops are also affected, though to a lesser extent, with falls of around 5%.

Evidence for the Spanish case

The study carried out by the European Crop Protection Association ("Low Yield Cumulative impact of hazard-based legislation on crop protection products in Europe"[1]) addresses the fall in output that would arise from the potential elimination of glyphosate for two permanent crops in Spain, olive and citrus trees:

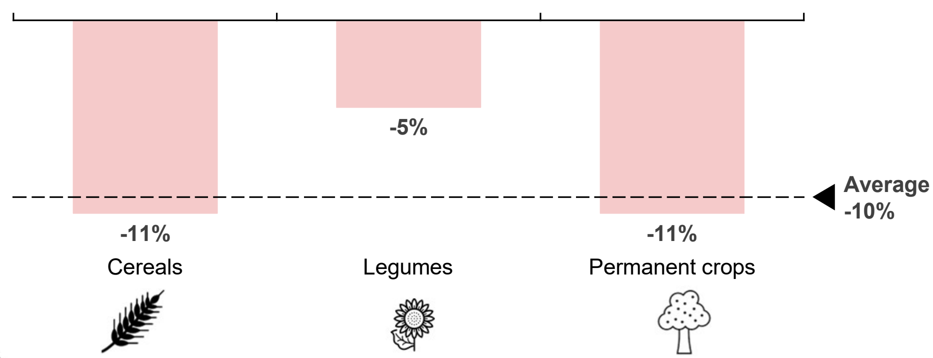
Olive trees

The study estimates a reduction of 7.8 million tonnes of produce, entailing a fall of 20%.

Citrus trees

The study estimates a reduction of 5.9 million tonnes, entailing a fall of 10%.

Changes that would take place in production by doing without glyphosate (%/ha)



We have estimated the impact based on specific crop variations at the European level, according to the data provided by AEPLA from the Red Queen Low Yield[1] study (using data provided by agrarian research institutes and agrarian organisations):

- **Cereals:** estimated using data on cereal variations in Mediterranean countries (barley in France [12%], wheat in France [11%] and corn in Italy [11%]).
- **Other extensive crops:** estimated using rapeseed data for the EU as a whole [15%], for potatoes in France [6%] and for sugar beet in Italy [2%].
- **Permanent crops:** estimated using data on variations in olive and citrus trees in Spain (20% and 10%, respectively) and in grapevines for the EU as a whole (2%).
- **Vegetables:** there is considered to be no effect.

1) European Crop Protection (2016). Low Yield Cumulative impact of hazard-based legislation on crop protection products in Europe. Final report July 2016.

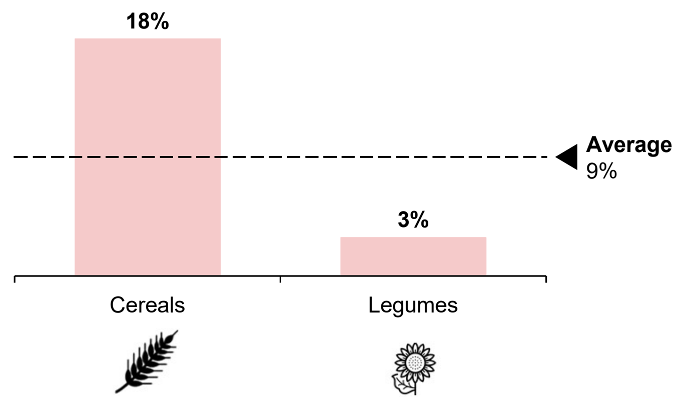
Besides the increase in output, the use of glyphosate is also associated with a reduction of around 9% in production costs

Reduction in production costs associated with the use of glyphosate

As in the case of production, we have used the evidence provided by the literature, which mostly calculates the effects on variable costs of doing without glyphosate.

The use of other alternative weed control methods require a **larger amount of weedkillers** and **more intensive use of mechanical and human resources**. For this reason, in the absence of glyphosate, **variable costs could rise by 9%**, on average.[1]

Variable cost changes were glyphosate not used (%/ha)



Estimate made using data on variations in specific crops provided by AEPLA based on studies at the European level:

- **Cereals:** estimated using data on cereal variations in Mediterranean countries (barley in France [19%], wheat in France [18%] and corn in Italy [13%]).
- **Other extensive crops:** estimated using rapeseed data for the EU as a whole [3%], for potatoes in France [4%] and for sugar beet in Italy [1%].
- **Vegetables:** there is considered to be no effect.

1) European Crop Protection (2016). Low Yield Cumulative impact of hazard-based legislation on crop protection products in Europe. Final report July 2016
Source: PwC analysis and AEPLA

Bearing in mind these two effects, the estimated macroeconomic contribution from the use of glyphosate in the farming industry, related industries, households and tax revenues is shown below

Macroeconomic impact of the use of glyphosate

B Indirect impact on the supplier value chain

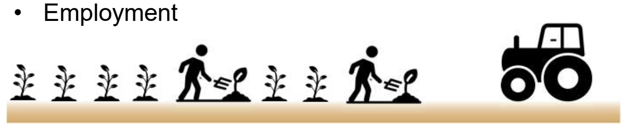
The increase in domestic agricultural output thanks to glyphosate also has an impact on the farming industry's demand for goods and services from **its suppliers**, which is referred to as **intermediate consumption** in the National Accounts.

As a result of the impact on agricultural output, the demand from and production by suppliers in this industry would increase.

A Direct impact on the agricultural industry

The use of glyphosate has a direct impact on the farming industry itself. The increase in output and reduction in costs per crop type have an impact on the following variables:

- National output
- Gross Value Added (GVA)
- Imports and exports
- Employment



C Indirect impact on the customer value chain

The impact on agricultural output affects not only the industry's suppliers but also its customers. This is because an increase in farm output does not only **improve primary output** (fresh farm produce) but also all **processed products made from farm produce and derivative products**.

Indicators employed to calculate macroeconomic impacts

Output	GDP	Employment	Tax revenue	Disposable income

Source: PwC analysis

The use of glyphosate has an immediate direct impact on the farming industry itself

Sequence of impacts generated

Increase in output and cutting of costs
The use of glyphosate increases productivity and production levels while cutting production costs.

Increase in consumption
The reduction in production costs causes prices to fall and therefore an increase in consumption by both end consumers and the businesses that use farm produce in their production processes.

Substitution of imports by domestic produce
The fall in the price of domestic products makes them more competitive in relation to foreign substitutes. The relative price improvement leads to the substitution of imports by domestic produce. This has a positive impact on the farming industry's balance of trade.

Increase in exports
The fall in relative prices also enhances the competitiveness of domestic produce abroad. This leads to growth in domestic exports and also drives the industry's balance of trade.

Source: PwC analysis

Overall, the two effects in which output grows and costs are cut have been used to estimate the overall direct economic impact of the use of glyphosate

Calculation method for estimating direct impacts

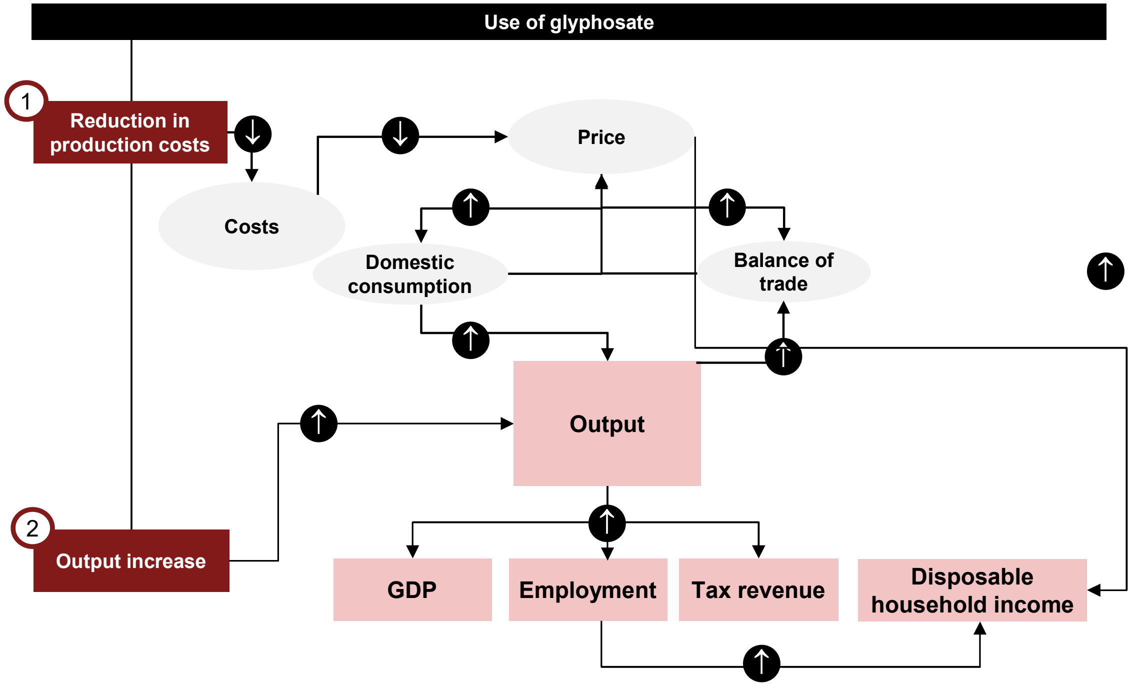
Starting with an initial situation of equilibrium, the model employed recreates the functioning of the domestic farming industry and simulates the new equilibrium resulting from the inclusion of a shock, in this case a dual shock: increase in agricultural output and fall in costs due to the use of glyphosate.

The effects of this shock are modelled using the **demand price elasticity** concept, from the viewpoint of both imports and exports.

A new equilibrium is also calculated in which the volume of domestic output rises in relation to the reference scenario. This increase in economic activity will have a **positive impact** on employment, tax revenue and business margins, which will **increase GDP**.

The model was built using the latest data available on the main macroeconomic variables: GDP, output, employment, etc., extracted from Spain's 2019 National Accounts.

Summary of the direct impact on the agricultural industry



Source: PwC analysis

The effects on foreign trade have been calculated based on the important contribution made by the farming industry to improve Spain's trade deficit, the positive contribution having totalled €5,861 million in 2019

Spain's balance of trade

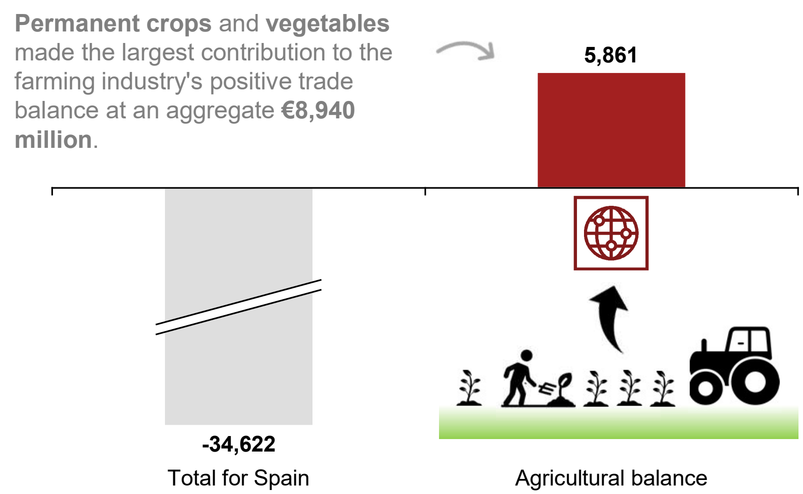
The Spanish economy is characterised by a large trade deficit, which amounted to €34,622 million in 2019[1]. In this context, the farming industry[2] helps to reduce the domestic deficit, having contributed a **positive balance** of **€5,861 million** in 2019.

In general, the agricultural industry is closely involved in trade relations abroad. Specifically, the industry's **exports** totalled **€12,129 million** or over 4% of Spain's total exports. The value of **imports** amounted to **€6,268 million** or over **2%** of Spain's imports.

By crop group, **permanent crops** and **vegetables** stand out due to having **made the largest contribution** to the farming industry's trade surplus.

Conversely, cereals and oilseeds show the highest import balance.

Total balance of trade and farming industry's balance of trade in Spain (2019, M€)

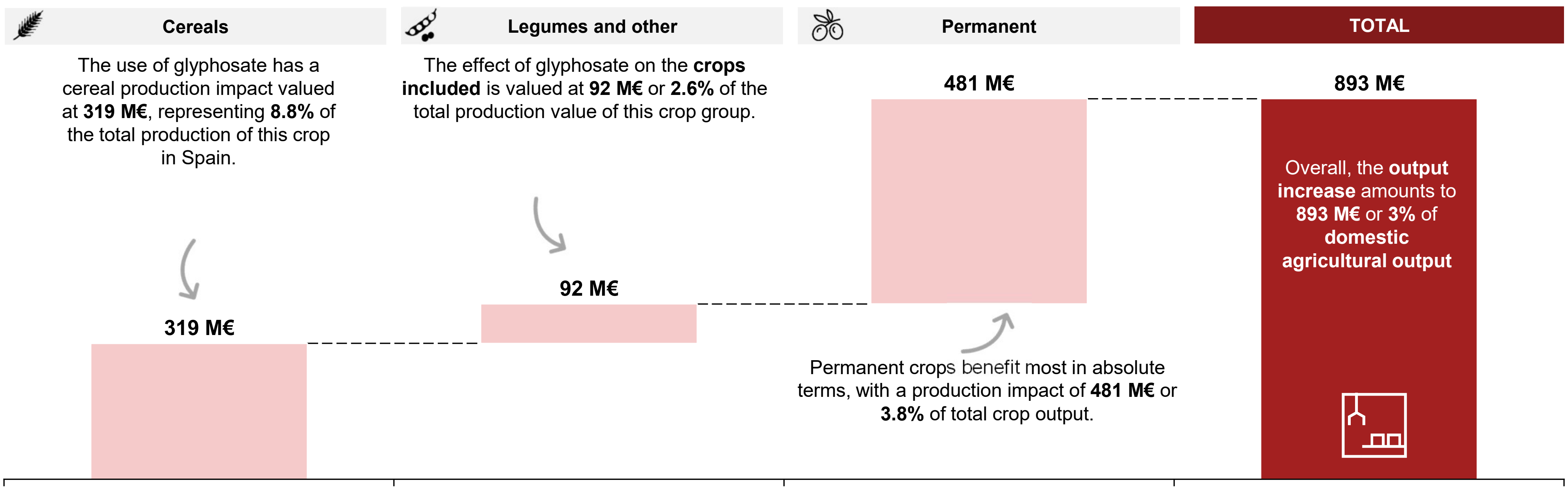


Domestic import and export elasticities were used to calculate the effects on exports and imports.

1) The balance of trade is calculated using the product total per TARIC code and includes exports and imports of merchandise, i.e. it does not take account of services, investments or movements of capital between countries. 2) Includes only the TARIC categories of farm produce comprising cereals, legumes, vegetables and permanent crops.
Source: PwC analysis, DataComex and MAPA (2019).

The use of glyphosate is associated with a direct impact on production of 893 M€ or 3% of Spain's agricultural output

Direct impact of the use of glyphosate in production terms



Relative impact on the production levels of each crop (%)

Cereals	Legumes and other	Permanent	TOTAL
8.8%	2.6%	3.8%	3.0%

Note: It is assumed that production costs are cut by using glyphosate, which leads to price cuts that are transferred along the production chain, through the intermediaries that use farm produce in their production processes, to end consumers (Bukeviciute, L., et al. (2009) and Djuric, I., et al. (2016)). The use of glyphosate to grow vegetables is limited, so this crop would not be significantly affected.
Source: PwC analysis

In GDP terms, the use of glyphosate is associated with an impact of 485 M€ on agricultural GDP, mostly due to the effect on business profits

Direct impact of the use of glyphosate in GDP terms

The impact on production entails a contribution to agricultural GDP of **€485 million**.

This GDP breaks down into **wages and salaries** received by agricultural workers amounting to **€20 million**, social security contributions totalling **€3 million** and **business profits** (gross operating surplus in the National Accounting terms) of **€463 million**.

Direct impact of the use of glyphosate in Spain in GDP (M€ in 2019)

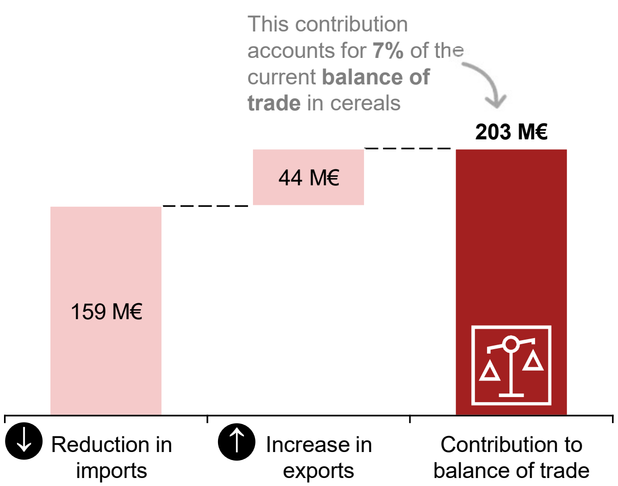
Source: PwC analysis

Production generated thanks to the use of glyphosate is associated with a reduction in prices giving rise to an increase of 280 M€ in exports and a reduction of 474 M€ in imports, improving the balance of trade by 754 M€

Direct impact of the use of glyphosate on the balance of trade

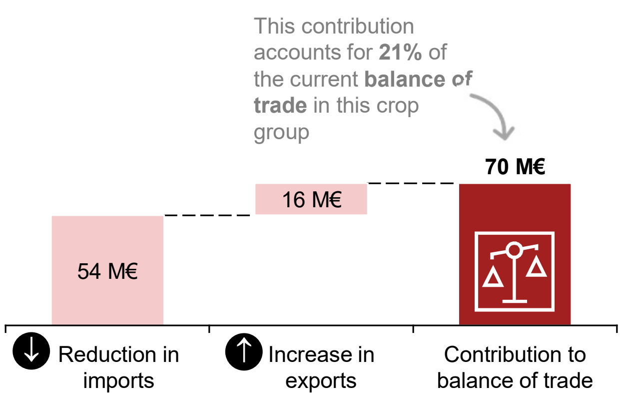
Cereals

Approximately half of the cereals consumed in Spain are obtained abroad. With the effects described above, the **balance of trade** in these products **improves** by **203 M€**, 159 M€ due to the decline in imports and 44 M€ thanks to the growth in exports.



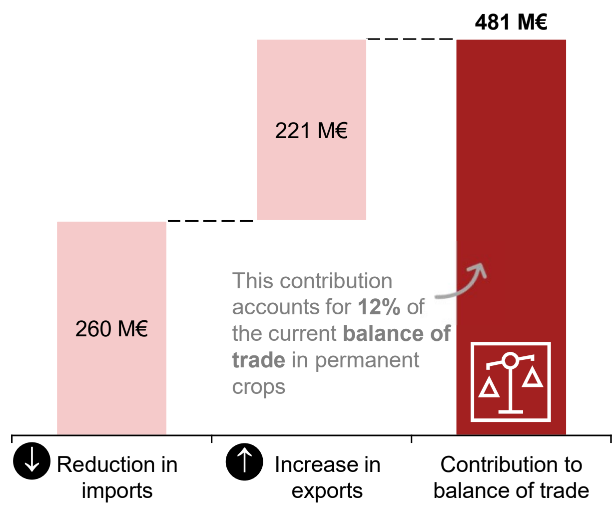
Legumes and other

Spain also has an overall foreign trade deficit in the crops included in this category. The use of glyphosate allows the negative balance to be improved by **70 M€**. This figure is the sum of an increase of 16 M€ in exports and a fall of 54 M€ in imports.



Permanent crops

As regards permanent crops, the effects analysed increase exports by 221 M€ and cut imports by 260 M€, entailing an overall improvement of **481 M€** in the balance of trade.



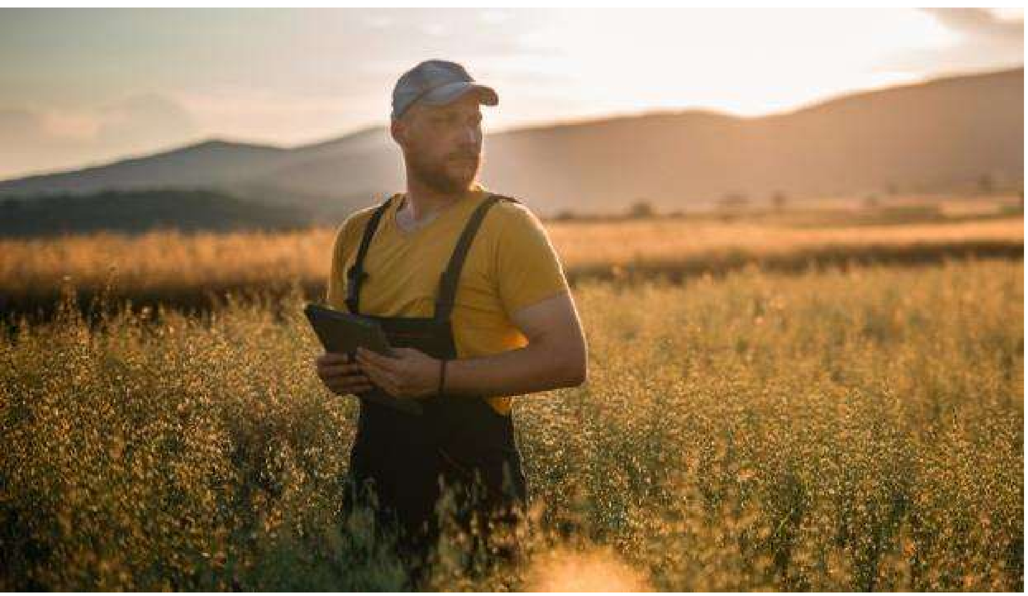
1) Includes legume, root and tuber, industrial and fodder crops.
Note: As there are no changes to the total quantity produced or to the production cost, the vegetable balance of trade would not be affected.
Source: PwC analysis

The economic activity generated thanks to the use of glyphosate is also associated with a contribution to employment of 11,598 jobs, which is equivalent to 3% of the total number of people employed in agriculture

Direct impact on employment of the use of glyphosate

The farming industry creates an average of **13 jobs** per **million euros invoiced**.

For this reason, the impact on production of the use of glyphosate is associated with a contribution of **11,598 jobs**.



Direct impact on employment of the increase in output associated with the use of glyphosate (2019)

The **impact on production** entails a contribution to employment of **11,589 jobs**

11,598 jobs created in total

Similarly, those 11,598 jobs represent **10,705 full-time-equivalent employees**

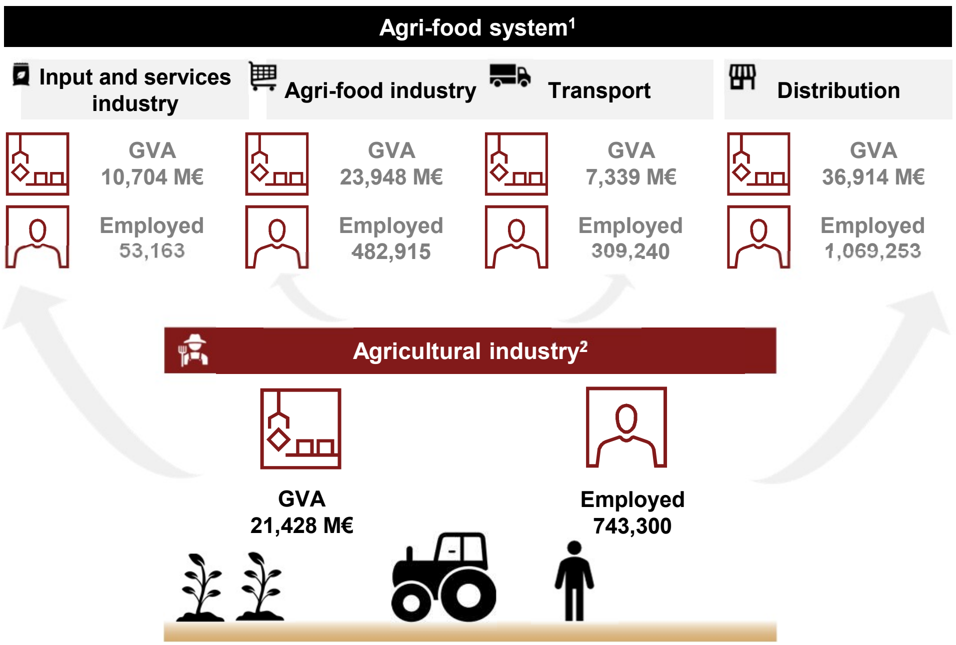
10,705 full-time-equivalent employees (FTE)

x13 **For every million euros of output** in the farming industry, **13 jobs are created in Spain**

Source: PwC analysis and INE

The farming industry and agricultural output in the broader sense are closely related to other economic activities, so the effects on the industry extend to the rest of the economy through both suppliers and customers.

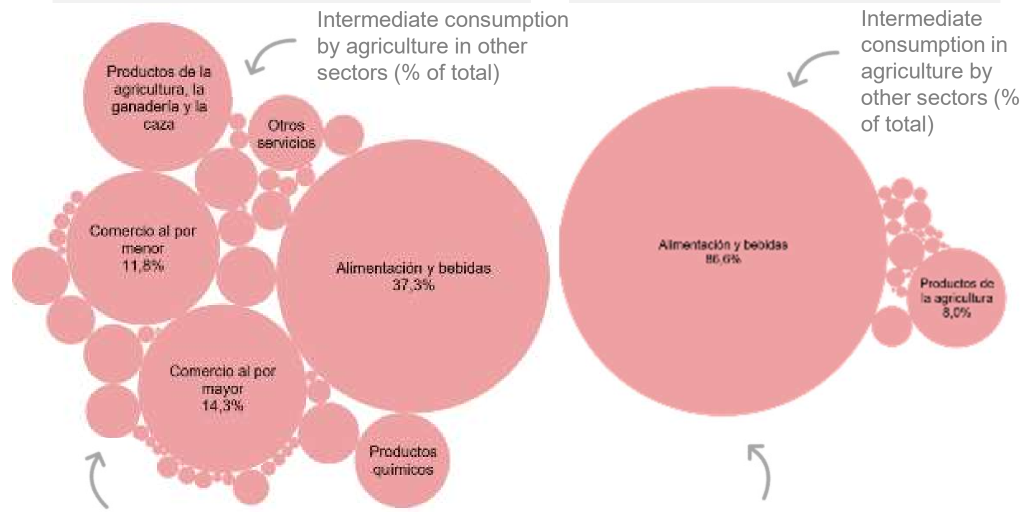
Interrelationship between the agricultural industry and the rest of the economy



The **agri-food system as a whole** accounts for **9.9% of Spanish GVA** and **13.8% of total employment**

Besides the interrelationship with the other agri-food system activities, the farming industry has **suppliers and customers** in a large number of economic sectors.

The farming industry's relationship with the supply chain | **The farming industry's relationship with the customer chain**

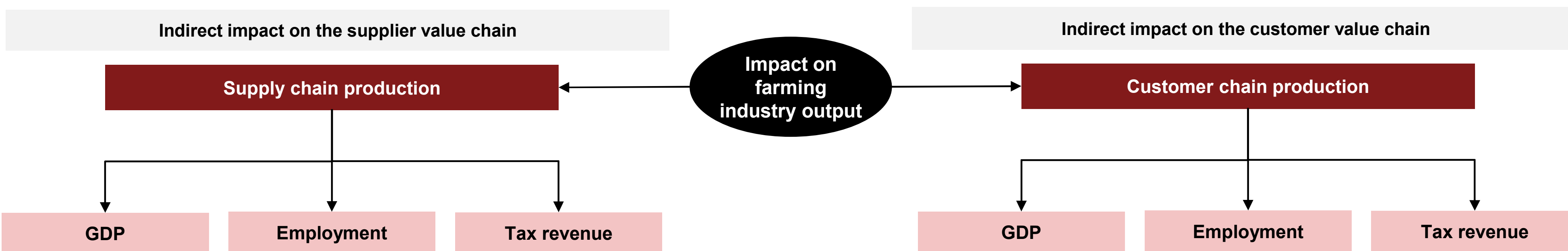


The **food industry** has the **closest relationship** with the farming industry as its **main supplier** and, in particular, its **main customer.**

1) Statistics prepared by the National Institute of Statistics in October 2020 using data for 2018 AgrInfo Series no. 30. "The agri-food system's contribution to the Spanish economy." 2) Includes vegetable and animal produce.
Source: PwC analysis and INE

The indirect impacts of the use of glyphosate have been estimated using the input-output method

Summary of estimated indirect impacts



The estimated indirect impacts are based on information on **costs incurred by the agricultural industry**. The cost allocation is obtained from the input-output (IO) tables of Spain's National Accounts for the agriculture, livestock farming and silviculture industry. In addition, and also using the IO for 2015 from the National Accounts published by the National institute of Statistics (INE), the industry multipliers have been calculated, which indicate the economic impact in terms of output and employment of each euro disbursed in the various sectors. The impacts are calculated using multipliers estimated for each business sector of the Spanish economy, as well as the amount of costs associated with production improvements in the farming industry due to the effect analysed.

The estimated indirect impact on the customer value chain is based on information on the **destination of agricultural output in Spain**, also obtained from the IO of the National Accounts. These tables are also used to obtain forward-looking industry multipliers that indicate the economic impact in terms of output and employment of each euro produced in the production chain of the various sectors. The impacts are calculated using multipliers estimated for each business sector and the increase in agricultural produce thanks to the effect analysed.

Source: PwC analysis

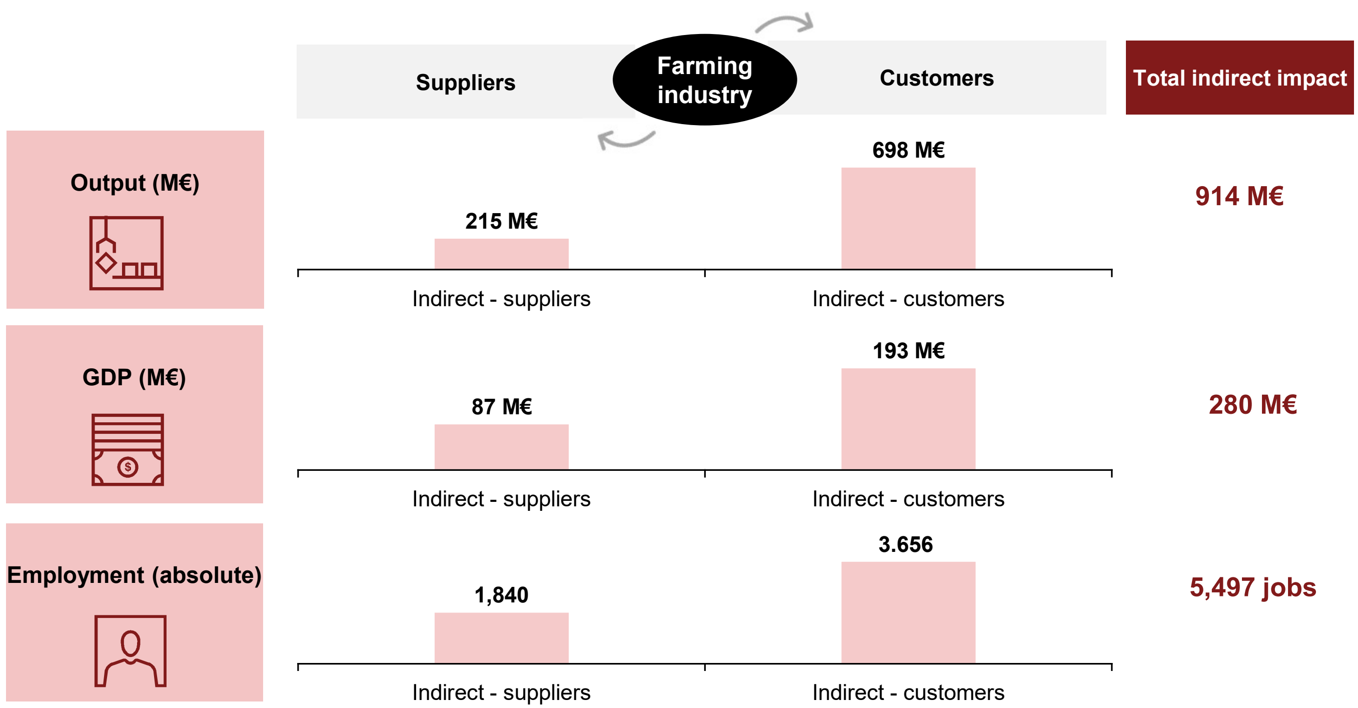
The impact on farming industry output thanks to the use of glyphosate has an indirect positive effect of 914 M€ on production, 280 M€ on GVA and 5,497 jobs

Indirect impact of the use of glyphosate

The impact of agricultural output has the following effects on the activities of related industries:

- **On suppliers**: intermediate consumption generated thanks to the use of glyphosate is associated with an impact on production in the supply chain (suppliers, their suppliers, etc.) of 215 M€, 87 M€ in GDP terms and 1,840 jobs.
- **On customers**: the output generated also has a positive impact on farming industry customers of 698 M€ in production terms, 193 M€ in GDP and 3,656 jobs.
- In the aggregate, the **main sectors benefited** by the impact on output are food, agriculture, hotels and restaurants, retail and wholesale.

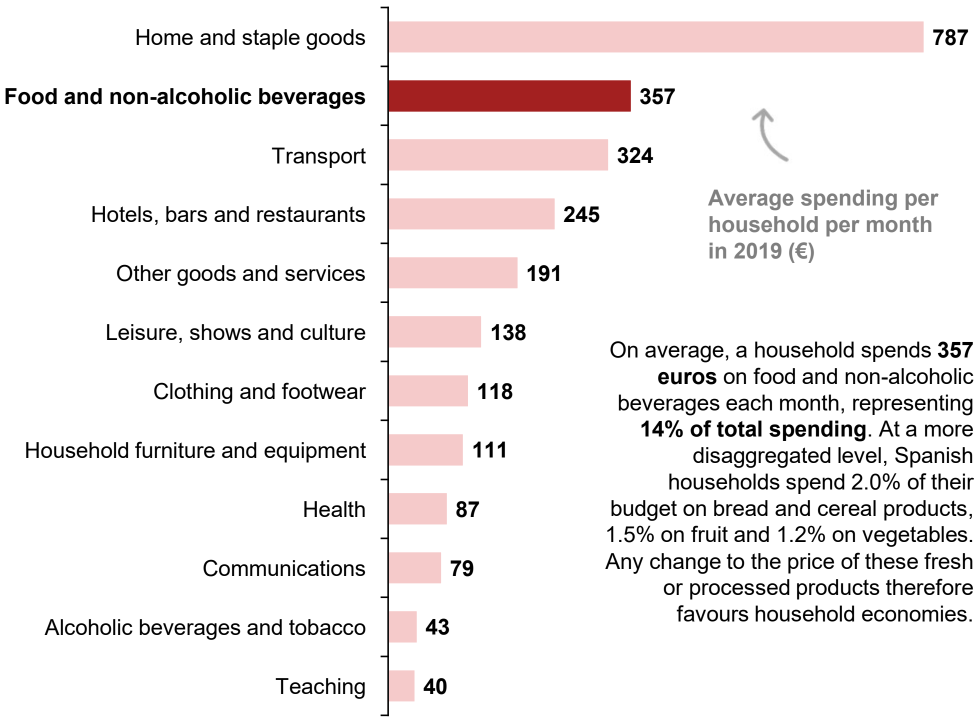
Indirect impact of the use of glyphosate in terms of output, GDP and employment (2019)



Source: PwC analysis

Any effect on the price of agricultural and food products has a relevant impact on household economies, since these products account for one sixth of the family budget

Household spending on farm products



On average, a household spends **357 euros** on food and non-alcoholic beverages each month, representing **14% of total spending**. At a more disaggregated level, Spanish households spend 2.0% of their budget on bread and cereal products, 1.5% on fruit and 1.2% on vegetables. Any change to the price of these fresh or processed products therefore favours household economies.

The use of glyphosate has two effects that have a positive impact on disposable income in households:

- The lower price of farming products reduces household spending, which increases disposable income. To calculate this effect, the model reflects the consumption structure of Spanish households, identifying the specific relative significance of farming products consumed. Starting with current prices, the model allows the estimation of the effect of lower agricultural product prices on demand for these goods and on disposable income.
- Secondly, the rise in the number of employed persons and thus in the volume of wages and salaries increases the overall income of Spanish households, which have more disposable income.

As the disposable income of households grows, they have several alternatives: spend all the increase, add to their savings or both.

The average behaviour of households in this situation was determined using an estimate of their marginal propensity to consume, which measures how much household consumption rises or falls for every € of increase or reduction in disposable income.

Finally, the input-output model was used to include all the economic impacts of this increase in domestic consumption, allowing the total effect on economic activity to be estimated.

Source: PwC analysis and INE (2019) Survey of family budgets. National Institute of Statistics. Spain

The impact on production generated by the use of glyphosate has an impact of €624 million on household consumption in production terms and €322 million in GDP terms

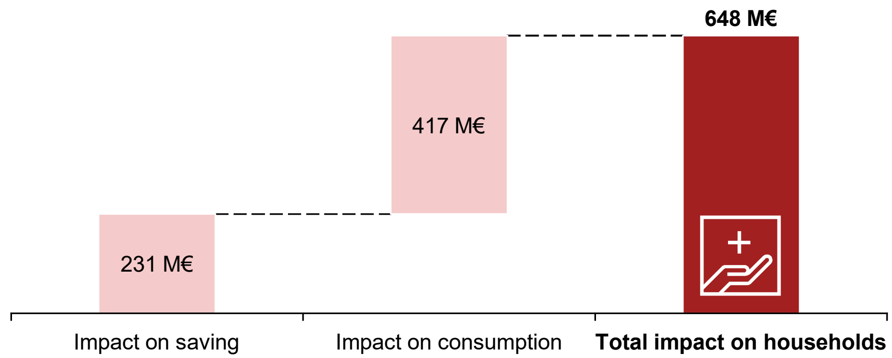
Impact of the use of glyphosate on households and disposable income

The positive impact on output associated with the use of glyphosate has implications for the price level of agricultural products.[1] In view of household spending on this type of products in Spain, this effect reduces household spending by **528 M€**.

The impact on economic activity both in the farming industry and in other related sectors has an associated effect on employment and, in a derivative manner, on wages and salaries, of **120 M€**.

Overall, the **impact on household consumption** has an economic and social effect on the economy as a whole of **624 M€** in **production** terms, **322 M€** in **GVA** and **5,987 jobs.**

Impact on households in terms of saving and consumption (2019)



Induced impact on households per indicator (2019)

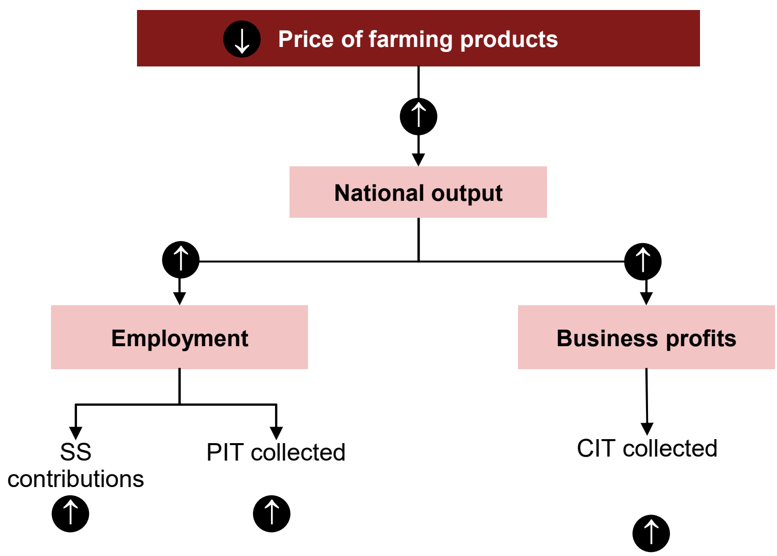
Output	GDP	Jobs
624 M€	322 M€	5,987

1) The reduction in the price of agricultural products has been estimated at around 0.7%.
Source: PwC analysis

As regards taxes, the economic activity generated by using glyphosate results in total tax revenue of €196 million

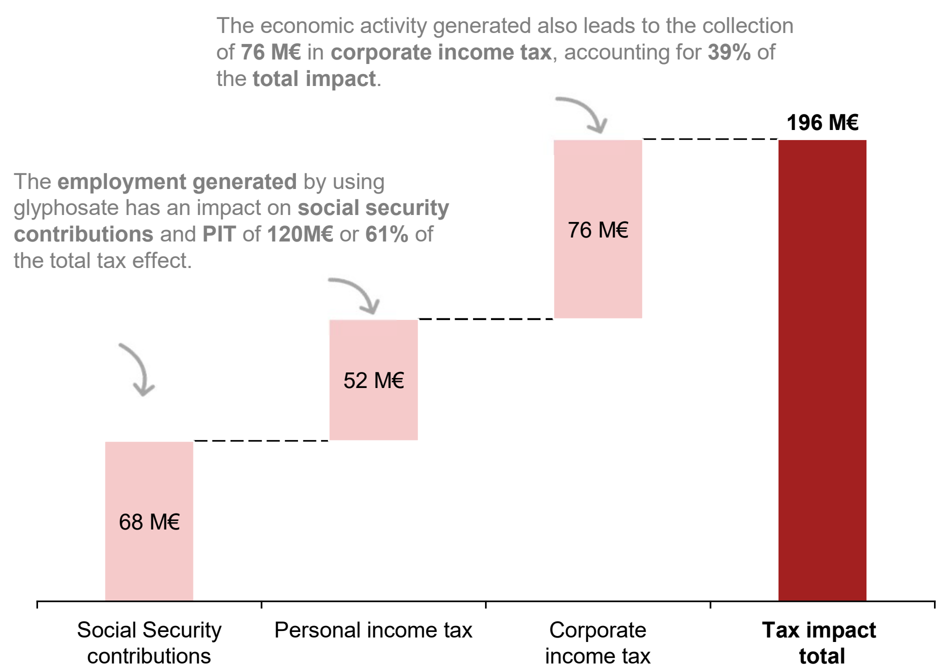
Impact of the use of glyphosate on tax revenue

The economic activity stimulated by the use of glyphosate has a significant impact on government revenue, mainly through taxes. Specifically, the impact of the reduction in the price of agricultural products and the resulting production effect has been estimated at **196 M€**. The following breakdown shows the effects of a cut in the price of farming products:



Source: PwC analysis

Tax impact and distribution by type of tax (2019)



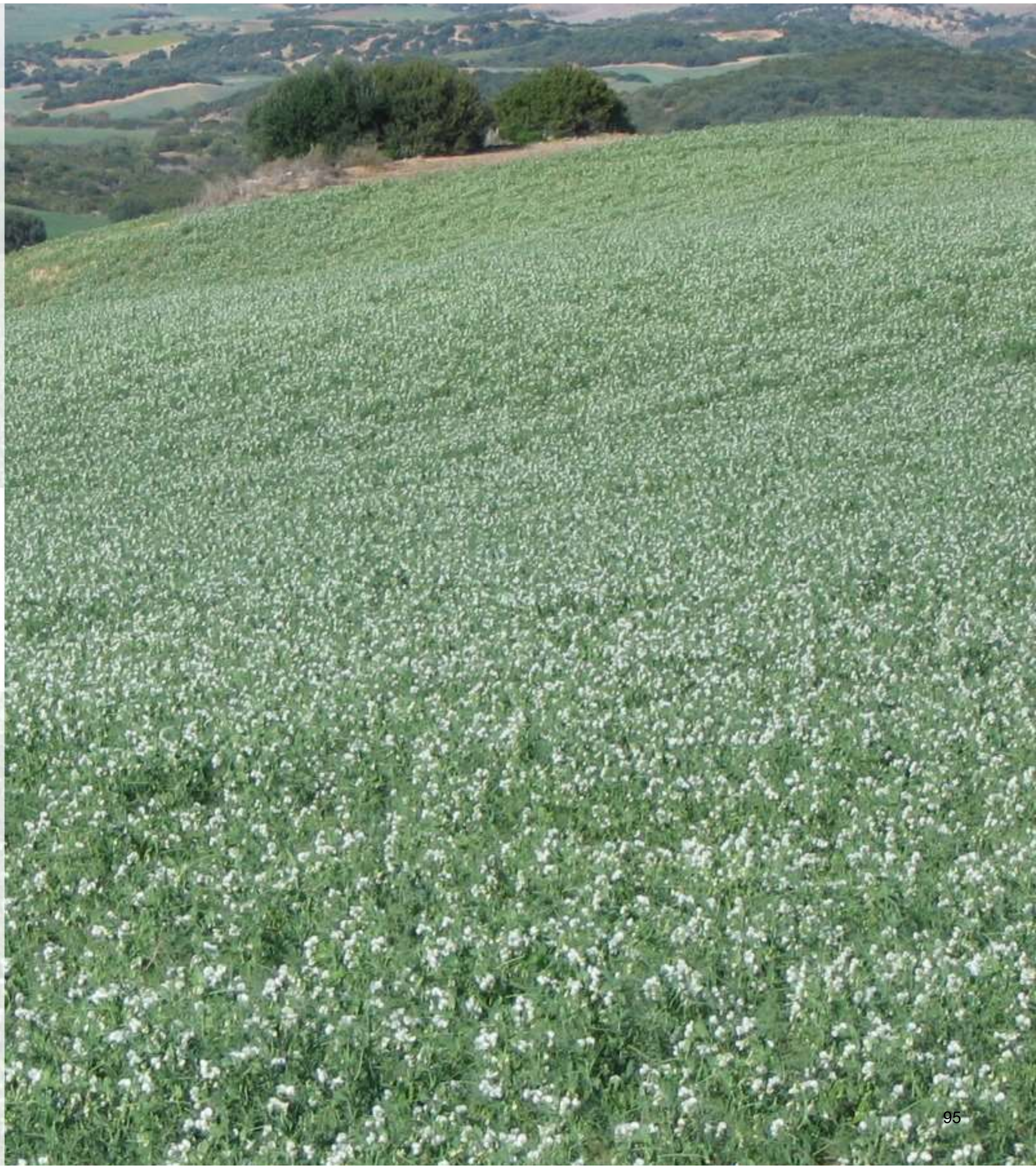
Overall, the estimated total impact arising from the use of glyphosate in agriculture amounts to over 2,431 M€ in production terms, 1,087 M€ in GDP terms and more than 23,000 jobs

Summary of the estimated impacts of using glyphosate in agriculture (2019)

	Impact on the farming industry	Impact on related sectors	Impact on households	Total impact
Output	**893 M€**	**914 M€**	**624 M€**	**2,431 M€** (0.11% of domestic output)
GDP	**485 M€**	**280 M€**	**322 M€**	**1,087 M€** (0.09% of Spain's GDP)
Employment	**11,598 jobs**	**5,497 jobs**	**5,987 jobs**	**23,082 jobs** (0.12% of total employment)
Balance of trade	**754 M€**			

Appendices

A.2 Methodology for estimating impacts



Method for estimating the contribution made by Conservation Agriculture to the economy - Input-output model (1/3)

Input-output method

The socio-economic contribution made by Conservation Agriculture is calculated using the input-output model, built on data from Spain's National Accounts.

Input-output models are a standard, widely-used technique for quantifying the economic impact of economic activities, investments, or events, among other aspects. They are based on the *Leontief* production model in which an economy's output requirements are equivalent to the intermediate demand for goods and services in production industries plus final demand, as may be observed in the following expression:

$$X = AX + y$$

where X is a column vector representing the production needs of each sector of the economy (a total of 63 in Spain's National Accounts), y is a column vector representing final demand in each sector, and A is a matrix (63 rows x 63 columns) of technical coefficients; the rows refer to each specific sector and the percentage of output destined for each of the other economic sectors, and the columns refer to each specific sector and the relative significance of the goods and services demanded from each of the other economic sectors for production purposes. The above expression may also be presented as follows:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \dots \\ X_{63} \end{bmatrix} \quad \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{163} \\ a_{21} & a_{22} & a_{23} & \dots & a_{263} \\ a_{31} & a_{32} & a_{33} & \dots & a_{363} \\ & & \dots & & \\ a_{661} & a_{662} & a_{663} & \dots & a_{6663} \end{bmatrix} \quad \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \dots \\ X_{63} \end{bmatrix} \quad \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \dots \\ y_{63} \end{bmatrix}$$

where, for example, X_1 are the production needs of sector 1, y_1 is the final demand in this sector, and a_{11}, a_{12}, a_{13}, …, a_{163} are the percentages of production of sector 1 that are destined for, respectively, sectors 1, 2, 3, …, 63, while a_{11}, a_{21}, a_{31}, …, a_{63} are the weights of the output of sector 1 goods and services demanded, respectively, from sectors 1, 2, 3, …, 63.

Method for estimating the contribution made by Conservation Agriculture to the economy - Input-output model (2/3)

Input-output method

By reorganising the above expression, the production needs of an economy (X) may be calculated using the economy's final demand (y) as follows:

$$X = (I-A)^{-1} y$$

where (I-A)-1 is the Leontief inverse matrix or matrix of output multipliers used to calculate the impacts.

The output multiplier matrix used in our analysis was calculated using data published by the National Institute of Statistics. This matrix allows us to determine, for each euro disbursed or invested in the different sectors of the National Accounts (that is each euro of final demand), the impact in terms of gross output (that is production needs).

The output multiplier matrix is used to calculate employment multipliers. This means using data from the National Institute of Statistics to calculate the direct employment coefficients for each sector (ratio of the number of employees to output). The employment multipliers are then obtained by multiplying the output multiplier matrix by a column vector of the direct employment coefficients calculated for each sector.

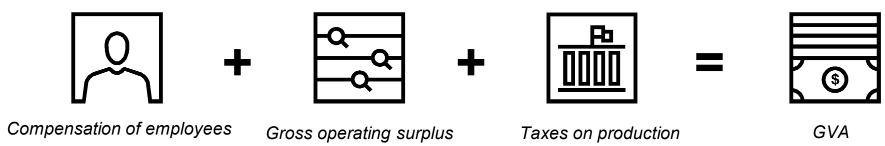
The multipliers used to calculate the induced effects are obtained based on information on: (i) the relative significance of household income (compensation of employees) on output in each of the sectors affected, (ii) the distribution of household consumption by sector, and (iii) the marginal propensity to consume estimated for the Spanish economy.

Method for estimating the contribution made by Conservation Agriculture to the economy - Input-output model (3/3)

Input-output method

Estimation of the direct contribution

The direct contribution made by Conservation Agriculture to Spain's **GDP** was estimated using the “**income method**”, in which GDP is the result of adding together compensation of employees, the gross operating surplus and net taxes on production.[1]



Estimation of the indirect and induced contribution

The indirect and induced contributions were estimated using information on costs incurred and investments made by this type of agriculture in 2019. These costs and investments were estimated using information extracted from the input-output tables in Spain's National Accounts for the agriculture, livestock farming, hunting and related services sector. In turn, and also based on the 2015 Input-Output tables in the National Accounts published by the National Institute of Statistics,[2] the industry multiples were calculated. These multiples indicate the impact in terms of output and employment in the Spanish economy of each euro invested or disbursed in the various sectors. The impacts on GDP and employment are calculated using multipliers estimated for each business sector of the Spanish economy, as well as the amount of costs incurred and investments made in each of these sectors by the farming industry.

1) GDP impacts are approximate, based on Gross Value Added (GVA) at basic prices.
2) INE, Input-Output Framework 2015.

Method for estimating the socio-economic impact of the use of glyphosate in agriculture (1/5)

Direct impact

We have developed a model to estimate the impact of glyphosate that recreates the functioning of Spain's farming industry. This model begins with an initial equilibrium and simulates a new equilibrium resulting from the inclusion of a dual shock: an increase in agricultural output and a reduction in production costs. The effects triggered by this shock are modelled using demand price elasticity for farming products from an internal and external viewpoint (through imports and exports).

A new equilibrium is then calculated in which the volume of domestic output rises in relation to the reference scenario. This increase in economic activity has a positive impact on employment, on wage income and on business profits, reducing the agricultural industry's Gross Value Added.

The model was built using the latest data available on the industry's main economic variables: output, GVA, employment, etc. extracted from Spain's 2019 National Accounts. The effects of each variable were estimated in the form of percentage variations on the actual situation in 2019.

The characteristics of the model and the estimation process are further explained below.

Output

The use of glyphosate boosts output thanks to improving soil yields and cutting production costs, which stimulates internal demand and exports, impacting domestic output.

Our model assumes that supply (output) and demand variations are equal, so the increase in the level of final output is calculated as the sum of the variations in internal consumption and in exports.

Gross Domestic Product

Gross Domestic Product (GDP) is the indicator most commonly used to measure economic activity. The GDP impact is calculated as the sum of the impacts of the indicators included in GDP, as defined in the National Accounts from the viewpoint of income. The indicators that make up GDP are as follows:

- Compensation of employees
- Gross operating surplus (business profits) and gross mixed income (profits obtained by self-employed workers)
- Net production taxes

Method for estimating the socio-economic impact of the use of glyphosate in agriculture (2/5)

Indirect effect

Prices

The reduction in production costs thanks to glyphosate is considered to be passed on in the final price of agricultural products for output associated with the area treated with glyphosate. In other words, the price increase is calculated by multiplying the percentage variation in product cost per hectare by the proportion of the farmland treated with glyphosate. In addition, it is assumed that international agricultural product prices do not vary.

Changes in consumption are calculated by multiplying the price variation by demand elasticity in the farming industry.

Similarly, the effects on imports and exports are calculated by multiplying the variations in the industry's relative prices by the respective elasticities.

Imports

The improvement in domestic agricultural output reduces demand for imports to cover domestic consumption needs. Low farming costs mean that foreign farming products are more affordable.

The percentage reduction in imports is calculated by multiplying the variation in the ratio of the price of imports over the price of domestic output by the elasticity of imports.

Exports

The enhanced competitiveness of Spain's economy leads to a rise in demand for exports. This increase was calculated by multiplying the variation in the ratio of the price of exports over the price of imports by the elasticity of imports.

Method for estimating the socio-economic impact of the use of glyphosate in agriculture (3/5)

Direct impact

The process followed to calculate the elasticities employed in the models is explained below.

Demand elasticity

The demand elasticity of Ho, M.S., Morgenstern, R. and Shih, J.S. (2008)[1] for the economy of the United States in the agricultural industry, -0.812, was used.

This value is in line with the values of specific product categories in the Spanish case. For example, the report on the fruit and vegetable sector (supply, distribution and demand) issued by the Ministry of Agriculture, Fisheries, Food and Environment (2004) includes the price elasticity of fresh fruit, -0,80, and fresh vegetables, -0.77.

Export and import elasticity

The elasticities of the Spanish economy's exports and imports were calculated as the average of the elasticities estimated in a number of studies. In these studies, estimated elasticities are defined in terms of relative prices. Specifically, they are defined as follows:

$$\varepsilon_{\text{exp}} = \frac{\Delta\% Exp}{\Delta\%\left(P_{nac.} / P_{\text{internac.}}\right)}$$

$$\varepsilon_{\text{imp.}} = \frac{\Delta\%\text{Imp.}}{\Delta\%\left(P_{\text{internac.}} / P_{\text{nac.}}\right)}$$

According to these expressions, the elasticity of exports is defined as the percentage variation of exports as a result of a 1% variation in the ratio of domestic prices over international prices. The elasticity of imports is equal to the percentage variation of imports as a result of a 1% variation in the ratio of international prices over domestic prices. In both cases, exports and imports relate to physical units, i.e. to volumes exported and imported, respectively.

For export elasticity, the Bank of Spain study "An update of Export and Import Functions in the Spanish Economy, 2009"[2] was used as a reference as it provides elasticities of both goods and services. Based on these figures, the industry's export elasticity was calculated as -1.603, taking account of the extent to which the various economic sectors are open to exports.

For import elasticity, the recent study by The Vienna Institute for International Economic Studies, *Import Demand Elasticities Revisited, November 2016*[3] was used, indicating an import elasticity for Spain's agricultural industry of -0.96.

1) *Ho, M.S., Morguenstern, R., Shih, J,S. (2008). Impact of Carbon Price Policies on U.S. Industry. Resources for the future.*
2) *García, C., et al. (2009). An update of Export and Import Functions in the Spanish Economy. Bank of Spain.*
3) *Ghodsi, M., et al. (2016). Imported Demand Elasticities Revisited. The Vienna Institute for International Economic Studies.*

Method for estimating the socio-economic impact of the use of glyphosate in agriculture (4/5)

Indirect effect

Indirect impact on the supplier value chain

The indirect impact through the supplier value chain is estimated using the input-output method. The estimate is based on information on costs incurred by the agricultural industry, obtained from the input-output tables of Spain's National Accounts for the agriculture, livestock farming and silviculture industry.

Using the input-output tables for 2015, the industry multipliers were calculated, which indicate the economic impact in terms of output and employment of each euro disbursed in the various sectors. The impacts are calculated using multipliers estimated for each business sector of the Spanish economy, as well as the amount of costs associated with production improvements in the farming industry due to the use of glyphosate.

Indirect impact on the customer value chain

The estimated indirect impact on the customer value chain is based on information on the destination of agricultural output in Spain, also obtained from the input-output tables of the National Accounts.

Unlike the estimation of the indirect impact on the chain of suppliers, for which the Leontief demand approach was used, this estimation uses the Ghosh supply model.

We began with the Ghosh distribution coefficient matrix, where each component is generically shown as bij and is calculated as bij=xij/xi. Each coefficient reflects the output of the line or sector of the row i-ésima, in monetary terms, that is destined for each of the other lines of the economy.

In a manner similar to the Leontief model, the inverse matrix coefficients are obtained and used to calculate the supply multipliers. In this case, the multipliers are the sum of the inverse matrix coefficients on each row. These multipliers indicate the contribution made by each activity line so that the primary inputs increase by one unit.

The impact on employment is calculated in a similar way to the supply chain model, using the multipliers and the sales destined for each of the sectors.

Method for estimating the socio-economic impact of the use of glyphosate in agriculture (5/5)

Impact on households and tax revenue

Consumption and saving

The approach applied estimates the positive impact on households, which occurs through two channels.

Lower product prices mean that end consumers spend less and have more disposable income. The direct and indirect impact on employees' wages and salaries also entails an increase in income for these end consumers.

A part of the increase in income through these two channels is saved, while the rest leads to an increase in consumption. The portion used to increase consumption is calculated by multiplying the increase in disposable income by the marginal propensity to consume. In turn, the marginal propensity to consume was estimated using an econometric model and data on the Spanish economy. The coefficient derived from this estimate is 0.6428, meaning that each euro of increase in income causes an increase of 0.6428 euros in consumption.

Subsequently, the input-output model was used to include all the economic impacts of this increase in domestic consumption.

The model estimates the effect on output, GDP and employment of the improved economic activity associated with the rise in consumption.

Tax revenue

The positive impact on the economy of cutting agricultural costs also leads to an increase in tax revenue. In this study, the effects on the public coffers through the following taxes are calculated:

- Corporate income tax.
- Social security contributions.
- Personal Income Tax (PIT).

The findings of the previous sections are used to estimate the effect on each of the taxes specified, taking into account the characteristics of the tax and the rates applicable in Spain.

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