Boosting the European Green Deal in the crop production sector:

Conservation Agriculture and the tools for its implementation in Denmark, France, Germany, Italy, Poland and Spain

Report prepared by:

ECAF
European Conservation Agriculture Federation

Collaborating entities:

FRDK SUND JORD

Université de Toulouse

Fachhochschule Südwestfalen
University of Applied Sciences

UNITE
UNIVERSITÀ DEGLI STUDI DI TERAMO

UNIVERSIDAD D CÓRDOBA

ETSIAM

April 2023

Regarding this study

This report has been prepared by ECAF and the collaborating entities highlighted below for each country, with the sponsorship of Bayer Crop Science and the technical support of PwC, and is intended to analyse and quantify the impact of Conservation Agriculture (CA) as a useful production system to contribute to national and European environmental, socioeconomic and food security goals, as well as the role of essential CA tools such as direct seeders, for no-till crop establishment for regenerating soil health, and integrated weed management, for an optimal herbicide use.

Collaborating entities in Denmark:

FRDK SUND JORD

Collaborating entity in France:

Université de Toulouse

Collaborating entity in Germany:

Fachhochschule Südwestfalen University of Applied Sciences

Collaborating entity in Italy:

UNITE UNIVERSITÀ DEGLI STUDI DI TERAMO

Collaborating entity in Spain:

UNIVERSIDAD D CÓRDOBA

ETSIAM

Authors:

ECAF: Antonio Holgado Cabrera, Julio Román Vázquez, Gottlieb Basch, Amir Kassam, Elizabeth Moreno Blanco, Beatriz Agüera de Pablo Blanco and Miguel Ángel Repullo Ruibérriz de Torres.

Denmark: Annette Vibeke Vestergaard (SEGES Innovation) and Hans Henrik Pedersen (FRDK).

France: Jean-Pierre Sarthou (Université Fédérale Toulouse Midi-Pyrénées).

Germany: Thomas Weyer, Simon Aue, Lars Nolting, Maximilian Cordt, Philipp Ruck, Roman Engemann, Soltan Paprotny and Jonas Splietker (Fachhochschule Südwestfalen).

Italy: Michele Pisante (Università degli Studi di Teramo) and Silvia Cantalamessa (Università degli Studi di Padova).

Spain: Emilio J. González Sánchez (Universidad de Córdoba).

Table of contents

In the context of the European Green Deal and the future CAP, this report aims to analyse the benefits of Conservation Agriculture (CA) and its contribution to European targets

Objectives

- Describe the **relevance of CA** and detail the benefits and characteristics of the **two essential tools** to practice Conservation Agriculture: **no-till seeders** and an **integrated weed management** (IWM)
- Quantify the **benefits of CA implementation for farmers**
- Measure CA's contribution to European **environmental, socioeconomic and food security targets**, in the framework of the **European Green Deal,** the new **Common Agricultural Policy (CAP) 2023-27** and the recent **Food Security** policies implemented by the European Commission

Framework for analysis

The relevant areas of CA studied are subject to the themes considered under European strategies:

Soil quality | Climate | Biodiversity | Farmers | Economy & rural dev.

Methodology

- The quantification of benefits for farmers and CA contribution to environmental and food security targets have been carried out with specific models comparing conventional agriculture with Conservation Agriculture based on an extensive literature review
- For CA socioeconomic contribution we have used an input-output methodology that enables us to estimate the direct, indirect and induced impacts on GDP and employment

Note: CA is the acronym for Conservation Agriculture.

CA, encouraging the use of minimum soil disturbance, soil cover and crop diversification, has as its main objective to conserve, improve and make a more efficient use of natural resources

Principles of CA

→ **Minimum soil disturbance →** No tillage

→ **Permanent soil coverage →** Cover crops, crop biomass, stubble and/or live mulches

→ **Crop rotation →** Crop rotation or associations (e.g. intercropping)

Source: ECAF and FAO.

Essential CA techniques

1. No-tillage

This technique is essentially used for herbaceous crops. It consists of sowing directly on the remains of the previous crop, without using mechanical seedbed preparation or soil disturbance prior to sowing.

2. Groundcovers

This technique is used in annual crops and woody crops with he aim of protecting the soil between the two crops or between crop rows. The cover can be vegetal, sown or spontaneous, or inert (i.e. pruning residues).

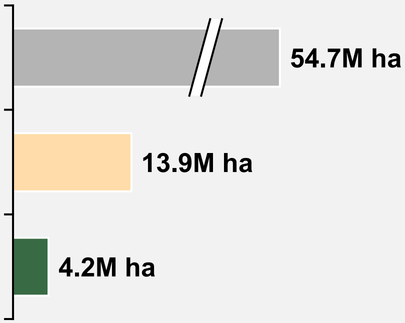
3. Species diversification

Crop rotation permits the planting and harvesting of multiple types of crops. This enables the farmer to harvest larger varieties of plants, and benefit from increased production, soil quality and income.

For the six countries analysed, CA represents, on average, 6.9% of cropland, but could increase rapidly due to the 23% of cropland already under reduced tillage techniques and if more policies were in place to support CA

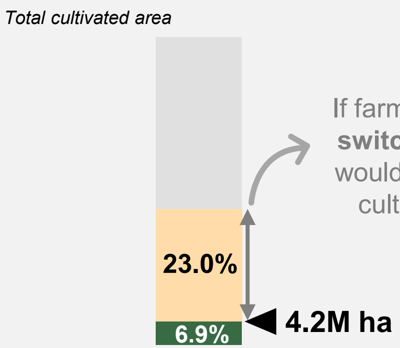
Key figures of CA (six countries)

Conventional agriculture	Involves the inversion of the soil by a mouldboard plough severely disturbing the soil	54.7M ha
Reduced tillage	Non inversion and less intrusive tillage methods are used leaving some crop residues on the topsoil	13.9M ha
Conservation Agriculture	The crop is sown directly into the soil avoiding any tillage and leaving the previous crop residues	4.2M ha



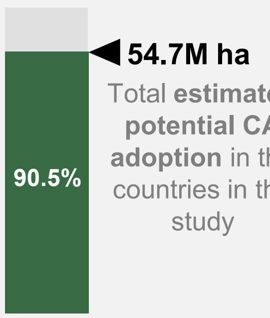
CA implementation scenarios

Current scenario



If farms under **reduced tillage switch to CA** techniques, CA would **represent 29.9%** of the cultivated land (**18.1M ha**)

Potential scenario



Total **estimated potential CA adoption** in the countries in the study

4.2M ha
of CA in total in Denmark, France, Germany, Italy, Poland and Spain

6.9%
of the total cultivated land in the countries analysed is dedicated to CA

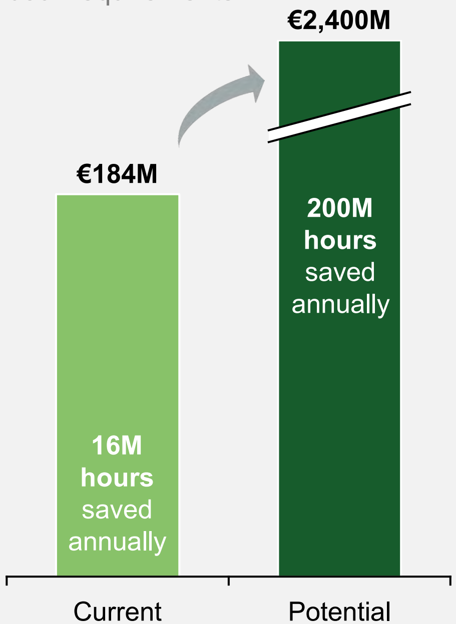
13.9M ha
are under reduced-tillage practices, an intermediate step towards CA implementation

Note: Please refer to “Section 2: Relevance of Conservation Agriculture” of the report (page 23) for more details on the analyses and results obtained.
Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, Destatis, INRAe, and Danmarks Statistik.

Farmer's benefits from the use of CA are valued at €391 million in the current scenario and up to €5,473 million in the maximum potential adoption scenario, compared to conventional tillage

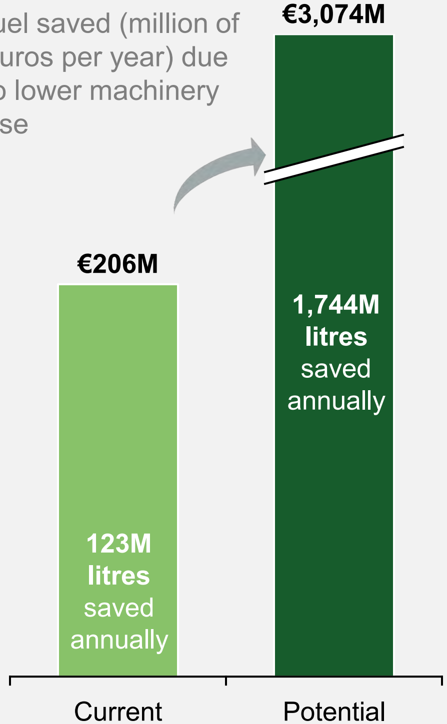
Time savings from CA

Economic value associated to hours saved (million of euros per year) due to lower labour requirements



Fuel savings from CA

Economic value associated to litres of fuel saved (million of euros per year) due to lower machinery use



€44/ha

Each additional hectare under CA brings an average economic benefit of €44 from time savings

1-4.2 h/ha

Each additional hectare under CA allows from 1 to 4.2 work hours to be saved

€49/ha

Each additional hectare under CA brings an average economic benefit of €49 from fuel savings

29 l/ha

On average, each additional hectare under CA decreases diesel use by 29 litres

Note: Please refer to "Section 3: Benefits of Conservation Agriculture for farmers" of the report (page 30) for more details on the analyses and results obtained.
Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on European Commission, Economic Research Institute, Danmarks Statistik, Arnal Atares, P. (2014), Centre d'études et de prospective (2013), Schmitz, Mal and W. Hesse (2015), Bialczyk, W., et al. (2012) and technical support from PwC.

The essential tools for the adoption of CA are no-till seeders, able to place the seeds in untilled soils, and integrated weed management, to prevent severe weed infestations

No-till seeders

- No-till seeders are essential to prevent soil organic carbon losses that arise from tillage.
- **No-till seeders** are specifically designed for **opening the seed slot, placing the seed** and **guaranteeing good seed cover**.
- **The machinery** is more robust and heavier to provide enough pressure to cut crop residues and **ensure soil penetration and correct seed placement**.

Example of a no-till disc seeder

Integrated weed management with herbicides

- The implementation of **CA improves soils biologically, physically and chemically**. The integrated weed management (IWM) practice in CA **optimizes** the use of **plant protection methods and products**, including herbicides.
- In CA, the active substance **glyphosate** is one of the **commonly used herbicides in IWM** for the majority of weeds.

Barriers to the adoption of CA → Access to machinery | Lack of guidance | Uncertainty | Policies

CA has been identified as a "Carbon farming" solution by the European Commission in the list of potential practices for eco-schemes.

45%
Chemical alternatives to glyphosate have, on average, a 45% cost increase for farmers

38%
of farmers in the EU would abandon CA techniques if it were not for glyphosate, and adopt intensive tillage for weed management

€827 M
Due to higher crop yields, the IWM with glyphosate contribution to CA production amounts to €827 million[1]

Note: Please refer to "Section 4: Essential Conservation Agriculture tools" of the report (page 35) for more details on the analyses and results obtained. 1) Impact of Glyphosate in IWM on CA production for France, Germany, Italy, Poland and Spain. Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Keynetec, Agreste, Eurostat, González-Sánchez, E. J., & Basch, G. (2017), ECAF European Survey on alternatives to glyphosate (2020) and technical support from PwC.

Regarding sustainability, CA is a compelling solution to reduce soil erosion and CO_2 emissions, and to increase biodiversity and water infiltration rates, making it a key technique for achieving the European Green Deal targets

CA contribution to environmental goals

Tonnes of soil saved due to lower land erosion[1]

€58/ha

On average, CA adoption would enable an annual soil loss reduction valued at €58/ha

CO_2 savings due to lower fuel consumption and soil carbon emissions

€269/ha

On average, CA adoption would enable an annual CO_2 reduction valued at €269/ha

Current	**34M tonnes** soil saved annually	**€238M**	**€1,128M**	**11M** CO_2 tonnes saved annually	Current
Potential	**219M tonnes** soil saved annually	**€1,811M**	**€10,049M**	**110M** CO_2 tonnes saved annually	Potential

The **total economic savings** from the lower land erosion and CO_2 savings could amount to **€11,860 million** in the maximum potential adoption scenario

-90%

The soil erosion is reduced by up to 90% using Conservation Agriculture techniques

x3

Conservation Agriculture improves water infiltration around 3 times compared to conventional agriculture

x2-9

Increase between 2 and 9 times in the density of worms, arthropods and birds, and in the number of species

24%

Under the potential adoption of CA, current agricultural GHG emissions would be reduced by 24%

Note: Please refer to "Section 5.1: Conservation Agriculture contribution to European targets – Environmental targets" of the report (page 44) for more details on the analyses and results obtained. 1) Economic losses from soil erosion in Denmark are not significant (not included), as low soil erosion is balanced by the creation of new fertile soils through plant growth, and the presence of deeper soils. Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on European Parliament, Sendeco2, Natural Resources Canada, APAD (2021), Centre d'études et de prospective (2013), Søby, Julie Marie (2020), Schmitz, Mal and W. Hesse (2015), Axelsen, J. (2019), Hundebøl, NRG & Axelsen, JA (2022), Vestergaard, A.V. et al, (2020) and technical support from PwC.

In addition, the increased savings to farmers from the use of CA contributes to improving the agricultural trade balance and the affordability of food among households achieving a reduction in food insecurity

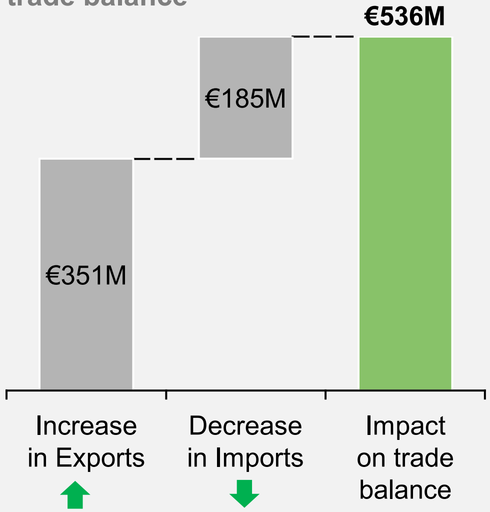
CA contribution to food security goals

Improvements in agriculture trade balance due to higher farmer savings

€536 million

€6,871 million (potential scenario)

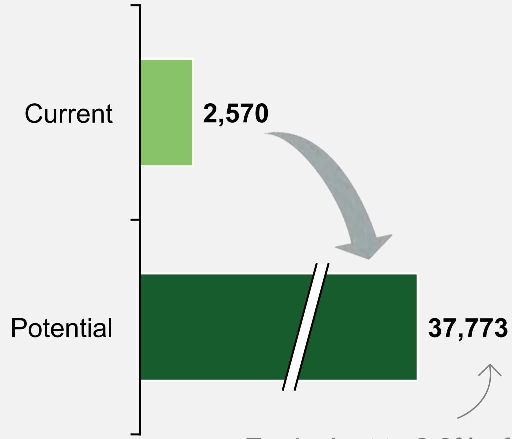
Equivalent to **3%** of the current **agricultural crop trade balance**



Reduction of severely food insecure households through more affordable products

2,570 households

The reduction in food prices from the use of CA can be associated to a reduction of about 2,570 households that live under severe food insecurity in the 6 countries analysed



Equivalent to **2.8%** of current households under severe food insecurity

x1.6

From 2020 to 2022 the price of cereals and food increased by up to 1.6 times

50%

of EU27 agricultural crop trade is accounted for by the 6 countries analysed

16.9%

On average, over the six countries studied, a low-income household spends 16.9% of its expenditure on food and non-alcoholic beverages

1%

of the population, on average, has prevalence of severe food insecurity

Note: Please refer to "Section 5.2: Conservation Agriculture contribution to European targets – Food security targets" of the report (page 54) for more details on the analyses and results obtained.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on FAO, Eurostat ,The Economist Group, Schmitz, Mal and W. Hesse (2015), Ghodsi et al (2016) and technical support from PwC.

More than €13 billion and over 408,000 jobs are directly and indirectly associated to CA in the six countries analysed

GDP contribution

CA direct GDP contribution

€6,760 million
€71,099 million (potential scenario)

Total contribution of CA to GDP, including impact on value chain and households

€13,821 million
€163,501 million (potential scenario)

Employment contribution

CA direct employment contribution

281,064 jobs
3,703,828 jobs (potential scenario)

Total contribution of CA to employment, including impact on value chain and households

408,764 jobs
5,565,972 jobs (potential scenario)

Promotion of rural development & poverty reduction in rural areas

Rural abandonment

3,525,000 ha
are at risk of rural abandonment by 2030, over the six studied countries

Risk of social exclusion in rural areas

23%
of households in rural areas are at risk of poverty and/or social exclusion, on average

11%
CA total GDP contribution, including impact on value chain and households, is equivalent to 11% of agricultural GDP of the six countries

x2
For each €1 of GDP arising directly from CA, €2 are contributed in total to GDP including the indirect and induced impact

10%
CA total employment contribution, including impact on value chain and households, is equivalent to 10% of agricultural employment of the six countries

x33
For every million euros of output under CA, on average, a total of 33 jobs are created in the economy as a whole

Note: Please refer to "Section 5.3: Conservation Agriculture contribution to European targets – Socioeconomic targets" of the report (page 62) for more details on the analyses and results obtained.
Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, OECD, LUISA Territorial Modelling Platform, Destatis and technical support from PwC.

1. Introduction and scope

The EU has one of the largest agricultural sectors in the world, with cultivated land covering about a 23% of the territory and achieving over €240,000 million of crop output in 2021

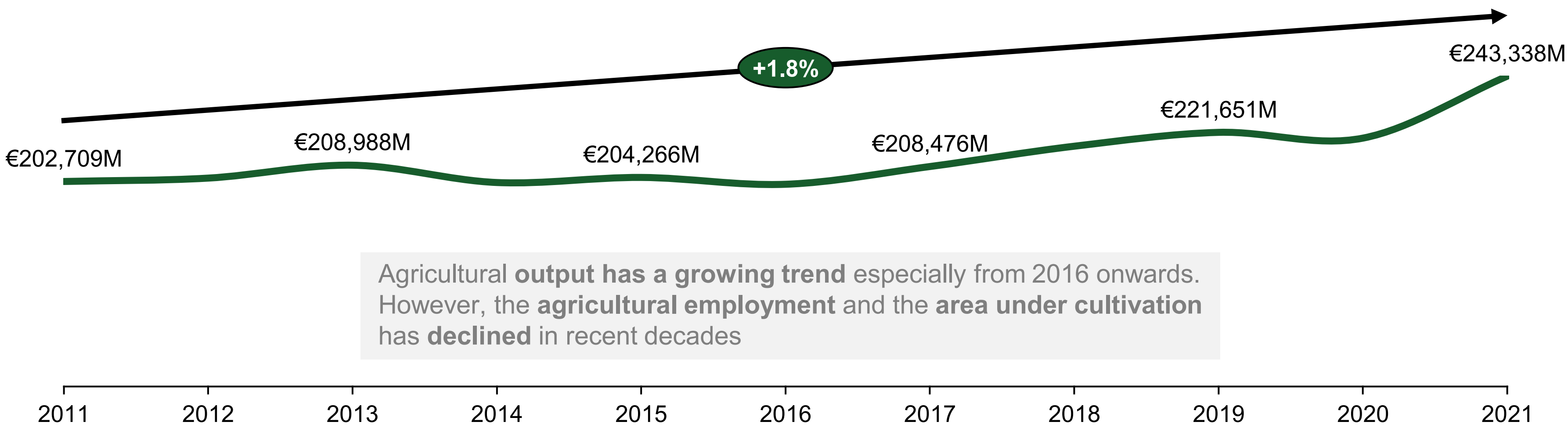
23%

The cultivated area in the EU covers 23% of the territory, 60% of the total utilised agricultural area, employs almost 7 million people and accounts for about 105 billion euros of the EU GDP

EU's key agricultural indicators (2021)

Agricultural GDP	€104,891 million
Crop output	€243,338 million
Cropland area	98,349,080 ha
Agricultural employment	6,857,400
Share of population in rural areas	27%

Crop output (M€)



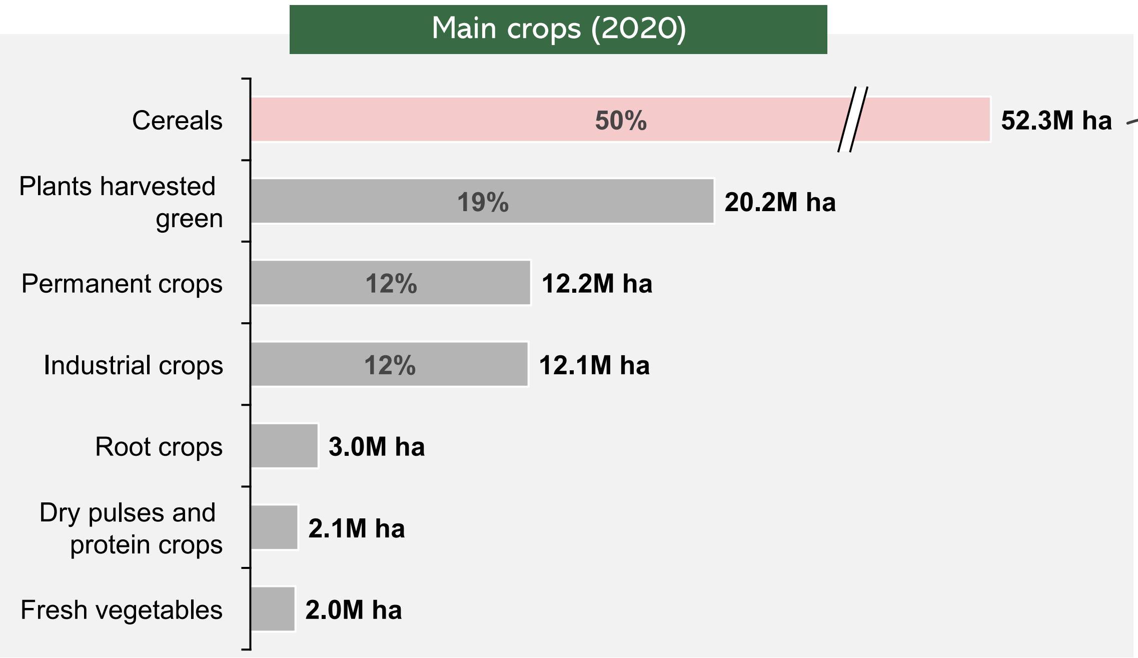
Agricultural **output has a growing trend** especially from 2016 onwards. However, the **agricultural employment** and the **area under cultivation** has **declined** in recent decades

Source: Eurostat, Agreste, Destatis, Danmarks Statistik and MAPAMA 2022.

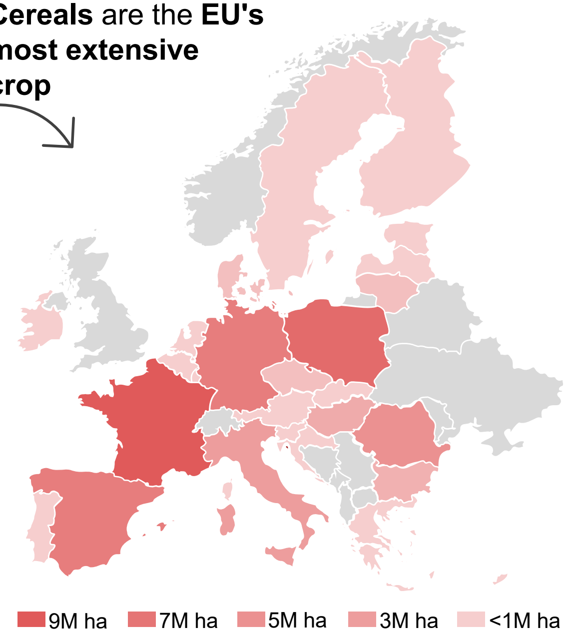
Cereals are grown on ½ of the cropland area of EU, with a total of 52 million hectares in 2020

50%

Cereals are the most cultivated crop accounting for 50% of the cropland, followed by plants harvested green and permanent crops



Cereals are the **EU's most extensive crop**



Source: Eurostat 2022.

The EU agricultural sector plays an important role in international trade, exporting almost €40 billion in 2021, 27% of which is accounted for by cereals

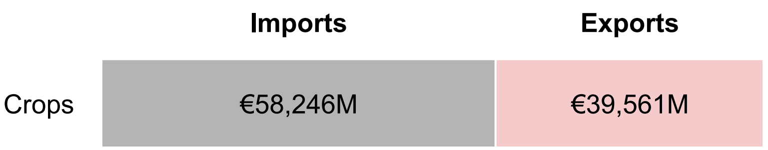
+76%

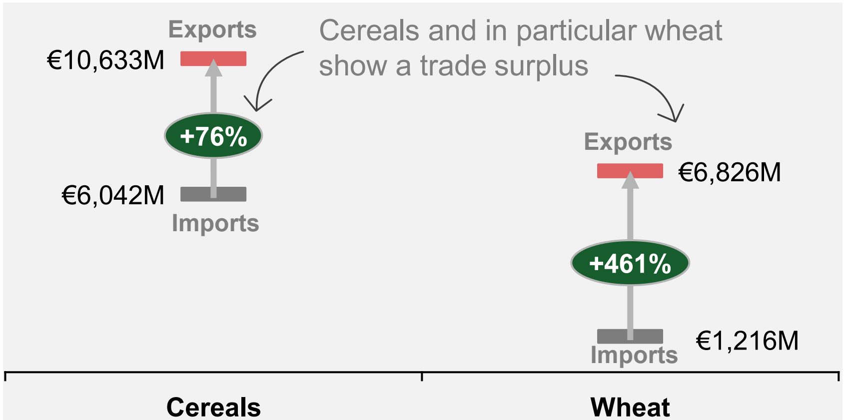
Exports of cereals are 76% higher than imports. For wheat, exports are 5.6 times greater than imports

37%

of the agricultural exports go to the United Kingdom, Switzerland and the United States

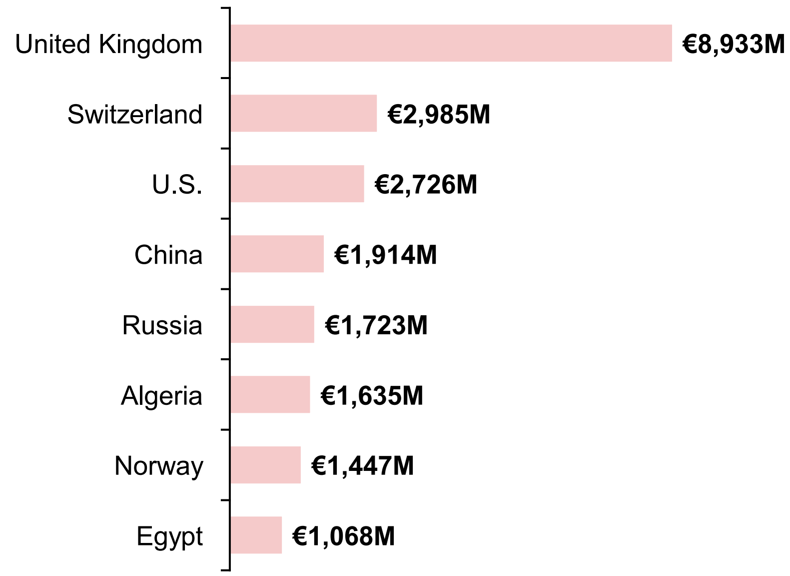
Agricultural crops trade balance (2021)





Source: Eurostat and European Commission 2022.

Main agricultural goods export countries (2021)



The European Union has recently adopted ambitious environmental objectives in which the primary sector is a key player

Why take action?

The global average **temperature increases** at a rate of **0.18°C per decade**

Each degree increase in temperature **decreases** the **yield of rice, corn and wheat** by **3% to 10%**

1 million species are at risk of extinction

More than **75% of global food crop** types rely on animal pollination

Source: European Commission (2019,2020 and 2021) and European Parliament.

Main milestones in agriculture and sustainability in the past few years

11 December 2019
Presentation of the **European Green Deal**

20 May 2020
Presentation of the **EU Biodiversity Strategy 2030** to protect natural resources, and of the **"Farm to Fork Strategy"** to make food systems more sustainable

14 December 2020
The **EU Next Gen** recovery and resilience plan was adopted to fund EU partner countries to boost the green, digital and healthy transition

9 July 2021
The **European Climate Law** is published, setting the objective of climate neutrality by 2050 and reducing GHG emissions by at least 55% by 2030

17 November 2021
Commission adopts **EU Soil Strategy for 2030** aims to promote sustainable soil management practices to protect soil health, preserve biodiversity and reduce carbon emissions from soils

2 December 2021
A new and more ambitious **CAP** was formally adopted setting out the path for agricultural policies for 2023 and onwards

31 August 2022
CAP Strategic Plans of EU countries are formally approved by the Commission. These Plans will shape how the new CAP, set to begin in 2023, will be implemented by each EU country at a national level

Planned for 2Q 2023
The initiative for a **soil health law** intends to grant soils the same level of legal protection as for air and water

Central to the European Green Deal is the need to shift to a more sustainable agriculture that minimises the environmental footprint and does more to protect and sustain nature

6/8

among the 8 main initiatives, 6 are directly or indirectly related to agriculture

-55%

Cut greenhouse gas emissions by at least 55% by 2030 and become climate neutral by 2050

Initiatives under the European Green Deal

- **Clean energy +**
  Prioritize energy efficiency, renewable resources, affordable energy supply and an integrated energy market in the EU
- **Sustainable industry +**
  Push industry to explore and create "climate neutral" circular economy-friendly goods markets
- **Building and renovation**
  Increase the use of renewable resources and the renovation rate of buildings
- **Farm to Fork ++**
  Ensure a more sustainable food chain
- **Eliminating pollution +**
  Aims to achieve cleaner air, water, and soil
- **Sustainable mobility**
  Encourage more sustainable, efficient and smart means of transport
- **Biodiversity ++**
  Restore ecosystems and their biological levels
- **Climate action +**
  Reduce EU greenhouse gas emissions

(++) Initiatives directly related to agriculture *(+) Initiatives closely related to agriculture*

Source: European Commission (2019).

The new CAP 2023-27 is certainly introducing more ambitious environmental targets, with significant changes towards a greener, fairer and more competitive economy

10 key objectives

The CAP 2023-27 presents 10 Key Objectives (KOs) that address economic, environmental and social sustainability, as well as knowledge and innovation within the industry

The 10 Key Objectives (KO) of the new CAP 2023-27

Economic sustainability	Supporting viable farm income	Increasing competitiveness	Improving farmers' position in the value chain
Environmental sustainability	Contributing to climate change mitigation	Efficient natural resource management	Halting and reversing biodiversity loss
Social sustainability	Generational renewal	Jobs, growth and equality in rural areas	Responding to societal demands on food & health
Knowledge & innovation		Fostering knowledge & innovation	

Source: European Commission (2021).

At the same time that environmental targets keep raising, food security is a growing concern, increasing the need to promote a more stable food market and less dependent on external supply

European Food Security

- **Food affordability** is the main concern of European countries because of the access of low-income people's access to food that can guarantee adequate nutrition. **Price shocks from third-country** agricultural crops or input supplies can **inflate the agricultural basket prices**, compromising lower-income households' access to healthy and nutritious food, and forcing them to switch to other caloric and nutrient-poor food.
- In this context, the EU has taken a step forward to **safeguard food security and support EU farmers and consumers**, and adopt the REPowerEU strategy to ensure the affordability and accessibility of energy and fuels. The latter has a significant stake in the path towards stable food markets due to agriculture's high dependence on energy inputs.

Risks: Global Warming, Pandemics, Wars, etc.

Crops: Wheat, Sunflower, Maize, Barley, etc.

Inputs: Fuel, Fertilizers, Seeds, Water, Plant Protection Products, etc.

Consequences

- **Food shortages**
- **Inputs availability**
- **Food affordability**

The Path for Food Security

1. **Education and awareness-raising**
2. **Farmers and Agricultural labour**
3. **Farms, efficiency and sustainability**
4. **Agricultural Machinery and energy**
5. **Economy and market for agricultural products**
6. National Food Security

Source: European commission (2022).

At the Paris Climate Conference in 2015, the 4 per 1000 initiative was launched to show that agriculture, and in particular agricultural soils, can play a crucial role in food security and climate change

Agricultural soils are carbon sinks when they are managed properly. Good agricultural practices based on **CA principles can increase soil organic carbon up to 1.7 tC/ha** per year[1].

The International "4 per 1000" initiative seeks to achieve **0.4% growth rate per year in soil carbon stocks**. If the level of carbon stored by soils in the top 30 to 40 centimetres of soil increased this amount, the annual increase of carbon dioxide (CO_2) in the atmosphere would be significantly reduced.

30%

30% of carbon dioxide is recovered by plants through photosynthesis

x2-3

The world's soils contain 2 to 3 times more carbon than the atmosphere

How can soils store more carbon?

- Never leave soil bare and disturb it minimally, for example **using CA methods** of no-till, soil mulch cover and diversified cropping
- Introduce more **intermediate crops**, more **row intercropping, cover crops** and more **grass strips**
- Planting of **hedges** and development of CA-based **agroforestry**
- Optimise **pasture management** with adapted grazing periods and rotations
- **Restore land** in poor condition e.g. the world's arid and semi-arid regions, and degraded lands
- **Improve water and fertilisers management** and use organic fertilisers and compost

Source: The international "4 per 1000" Initiative: Soils for Food Security and Climate and Lal et al., 2015.
(1) Based on Lal et al., 2015.

In the context of the European Green Deal and the future CAP, this report aims to analyse the benefits of Conservation Agriculture (CA) and its contribution to European targets

Objectives

- Describe the **relevance of CA** and detail the benefits and characteristics of the **two essential tools** to practice Conservation Agriculture: **no-till seeders** and an **integrated weed management** (IWM)
- Quantify the **benefits of CA implementation for farmers**
- Measure CA's contribution to European **environmental, socioeconomic and food security targets**, in the framework of the **European Green Deal,** the new **Common Agricultural Policy (CAP) 2023-27** and the recent **Food Security** policies implemented by the European Commission

Framework for analysis

The relevant areas of CA studied are subject to the themes considered under European strategies:

Soil quality | Climate | Biodiversity | Farmers | Economy & rural dev.

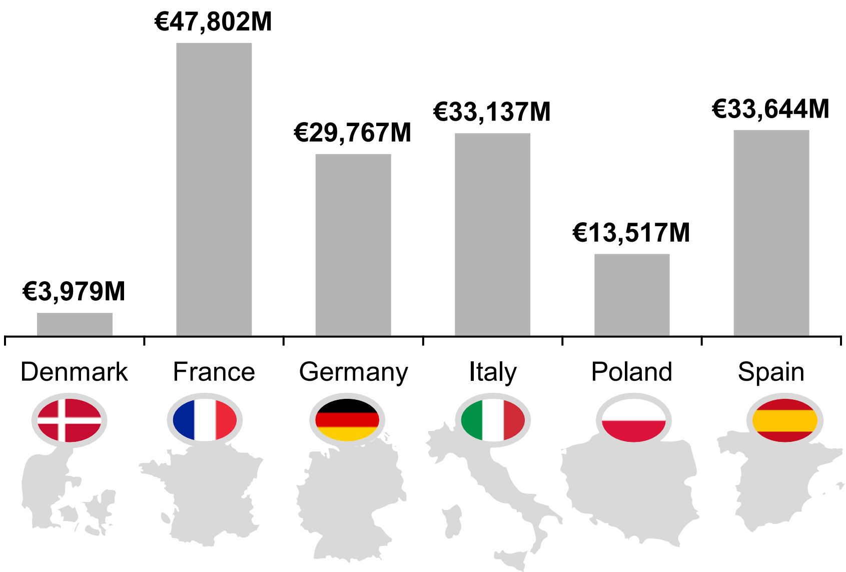
Methodology

- The quantification of benefits for farmers and CA contribution to environmental and food security targets have been carried out with specific models comparing conventional agriculture with Conservation Agriculture based on an extensive literature review
- For CA socioeconomic contribution we have used an input-output methodology that enables us to estimate the direct, indirect and induced impacts on GDP and employment

To this end, the study is carried out by combining the results of six countries with strong agricultural systems that represent the agricultural diversity of the EU: Denmark, France, Germany, Italy, Poland and Spain

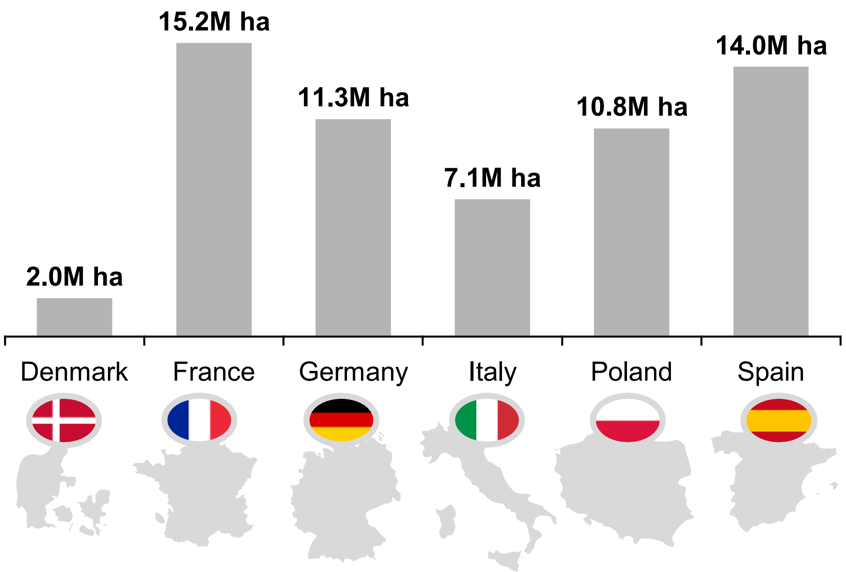
66%
of EU-27 agricultural production

Crop output in the six countries analysed (2021)



60.4M
hectares of cropland

Cultivated land in the six countries analysed (2021)



Source: Eurostat, Destatis, Agreste, Danmarks Statistik and MAPA: ESYRCE 2021.

2. Relevance of Conservation Agriculture

The main objective of CA is to conserve, improve and make more efficient use of natural resources. To this end, this technique is based on the use of direct sowing, soil coverage and crop diversification

Principles of CA

- **Minimum soil disturbance →** No tillage
- **Permanent soil coverage →** Cover crops, crop biomass, stubble and/or live mulches
- **Crop rotation →** Crop rotation or associations (e.g. intercropping)

Source: *ECAF and FAO.*

Essential CA techniques

1. No-tillage

This technique is essentially used for herbaceous crops. It consists of sowing directly on the remains of the previous crop, without using mechanical seedbed preparation or soil disturbance prior to sowing.

2. Cover crops and groundcovers

This technique is used in annual crops and woody crops with the aim of protecting the soil between the two crops or between crop rows. The cover can be vegetal, sown or spontaneous, or inert (i.e. pruning residues).

3. Species diversification

Crop rotation permits the planting and harvesting of multiple types of crops. This enables the farmer to harvest larger varieties of plants, and benefit from increased production, soil quality and income.

CA brings direct benefits at the individual and country level, contributing to national and European strategies on environment, food security and socio-economic objectives

Benefits resulting from the adoption of CA

Benefits for farmers

Time savings for farmers

Lower labour time needed in farm operations

- Lower **labour costs**
- Time to devote to other **activities**

Energy savings

Reduction on the time need of **machinery**

- Lower tractor **fuel costs**

Improvement in the profitability of operations

The implementation of CA results in a decline in operating costs for farmers (energy, maintenance, etc.) what leads to **greater benefits per hectare**

Contribution to national and European strategic goals

Soil erosion reduction

CA **prevents** tillage, water and wind **erosion**

Better water management

CA **achieves** both greater **water infiltration** and lower **evaporation**

Resilience to climate change effects

CA enhances soil capacity to **withstand torrential rains and droughts**

Biodiversity enhancement

CA favours the presence of **worms, arthropods and birds**

Improvement in soil quality

CA **improves soil structure** and leads to an increase in **organic matter**, providing more nutrients and enhancing fertility

Greater carbon sequestration and lower CO_2 emissions

From no-till techniques

Increased **carbon sequestration** in the soil

Reduction in CO_2 atmospheric **emissions**

From lower need of fuel

Reduced **CO_2 emissions** from tractors

Socioeconomic impact & rural development

CA contributes to **GDP, employment** and **rural development,** reducing the risk of rural abandonment and poverty

Food security

CA is associated to a **reduction in farmers' production costs**, which makes food products cheaper in the country and, therefore, improves the trade balance of agricultural crops

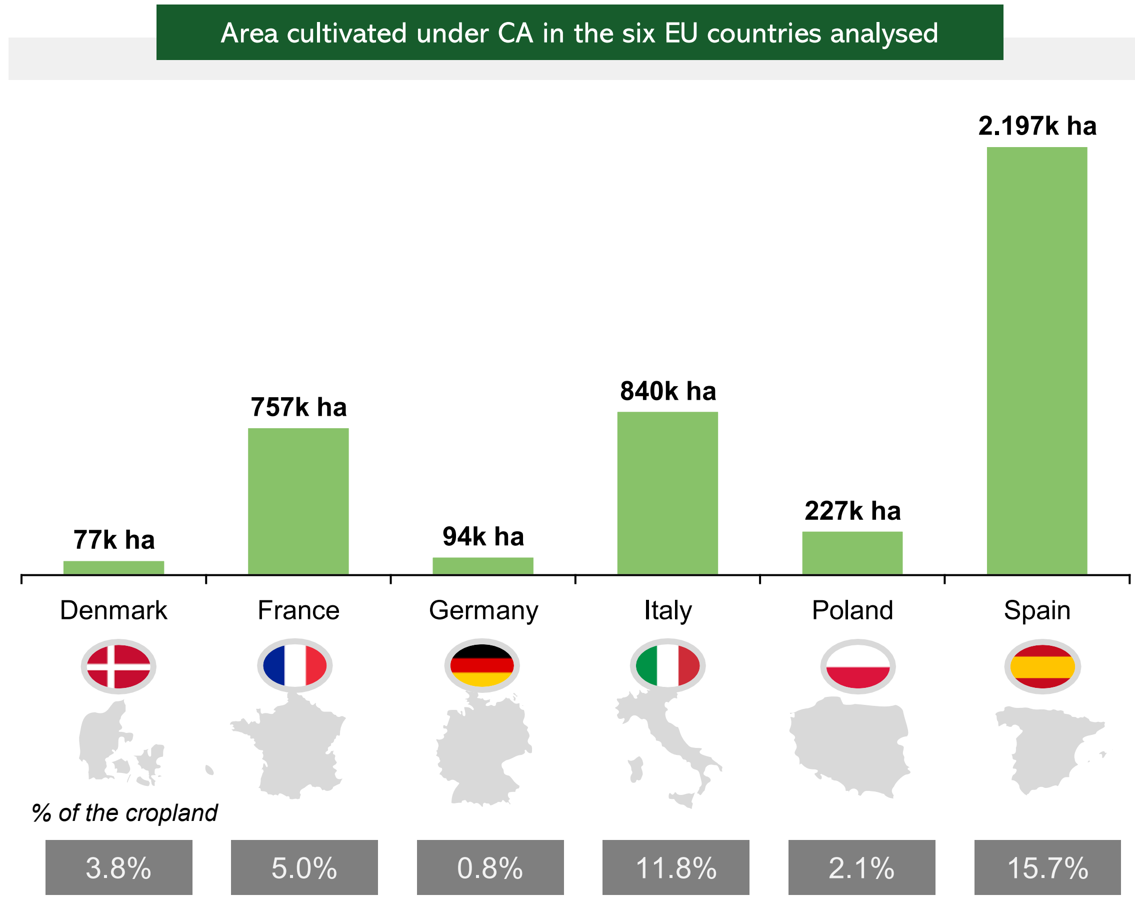
Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba.

In the six countries analysed, the CA is practised on a cultivated area of 4.2 million hectares, which represents the 65.6% of the Conservation Agriculture land in the EU

4.2M ha
of CA in the six countries analysed

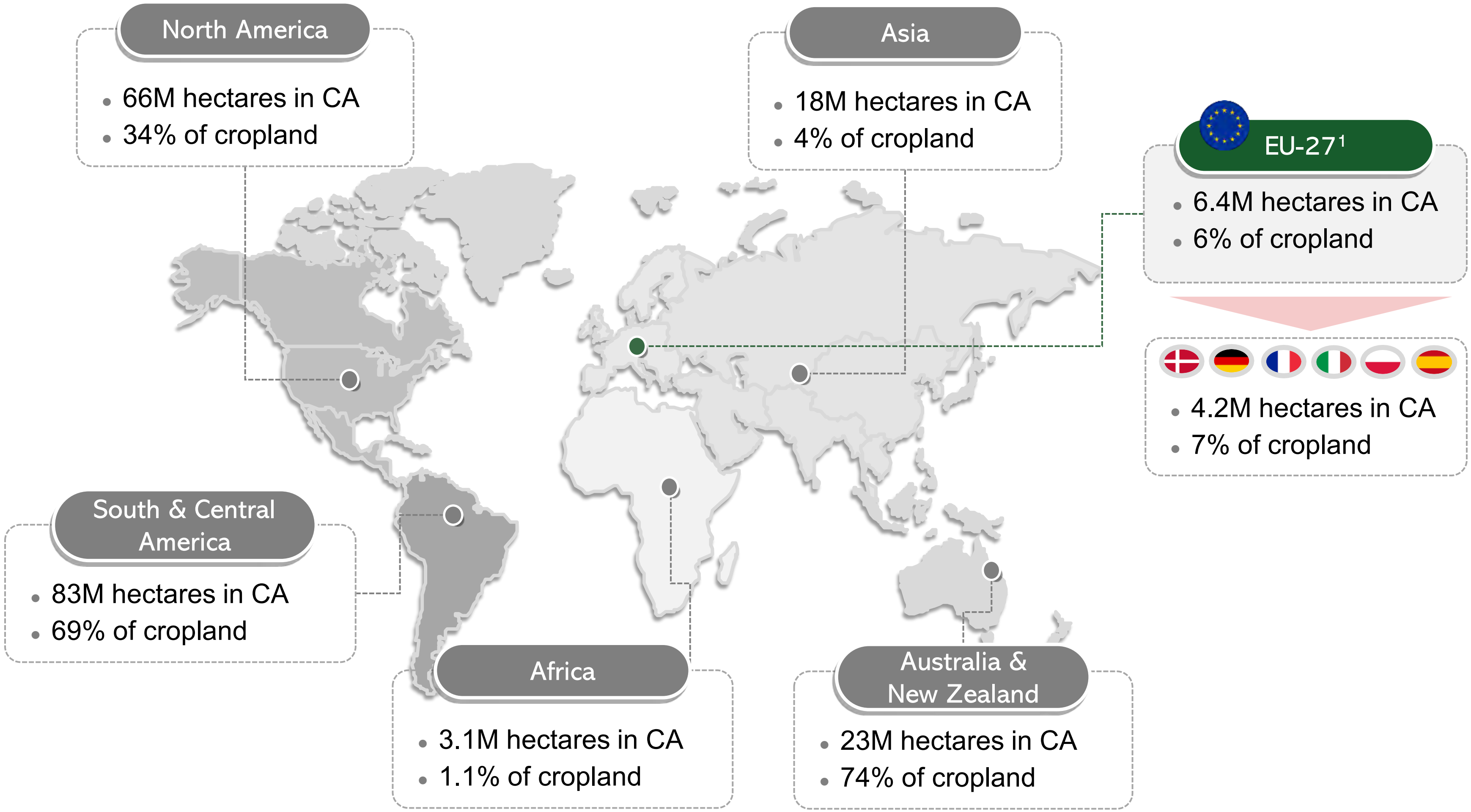
6.9%
CA penetration reaches, on average, 6.9%

65.6%
of CA crop production in the EU



Note: Annual and permanent crops under Conservation Agriculture are considered
Source: ECAF, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, INRAe, Danmarks Statistik, Destatis and MAPA: ESYRCE 2021.

Compared to other regions, the EU currently lags behind with a relatively low adoption of CA. In this context, a rapid growth of this technique can close the gap with the leading countries



1) Estimate for EU-27 based on ECAF data with updates from this report for Denmark, France, Germany, Italy, Poland and Spain.

Source: ECAF, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, INRAe, Danmarks Statistik, Destatis, MAPA: ESYRCE 2021, and Kassam et. al. (2022).

These countries could experience a rapid transition to CA given the fact that almost 14 million ha are already under reduced tillage techniques, an intermediate step towards full CA implementation

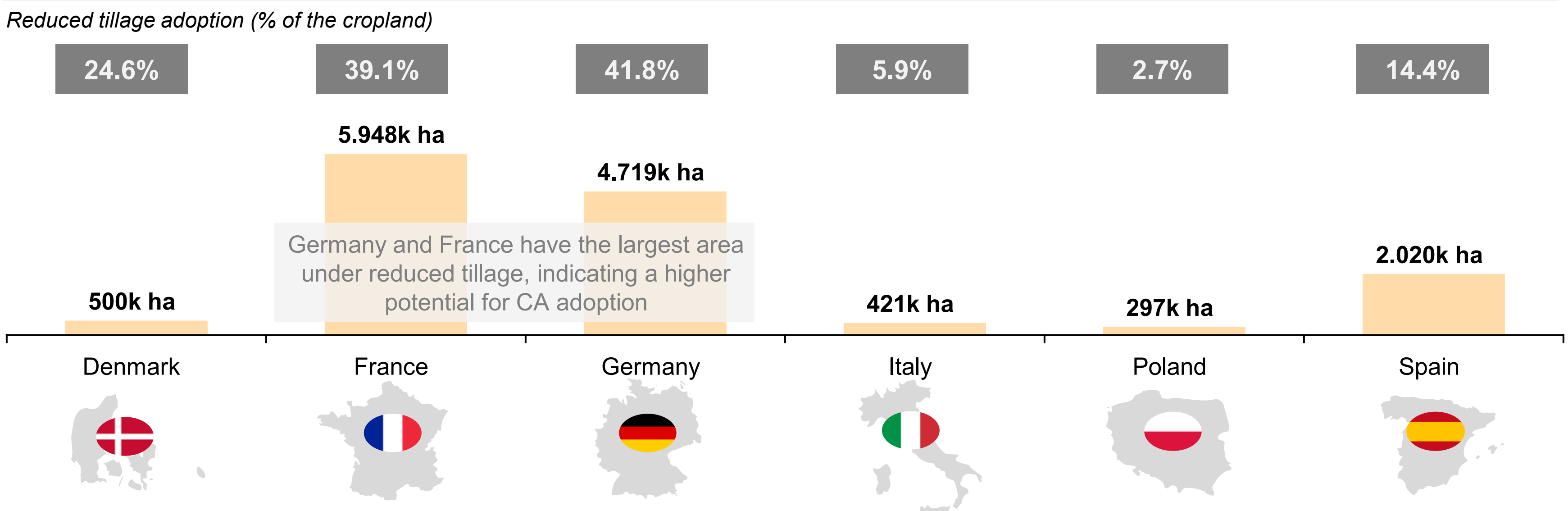
23%

of cropland is currently under reduced tillage in the six countries analysed, which represent 13.9M ha

Conventional agriculture → **Reduced tillage** → **No-tillage (CA)**

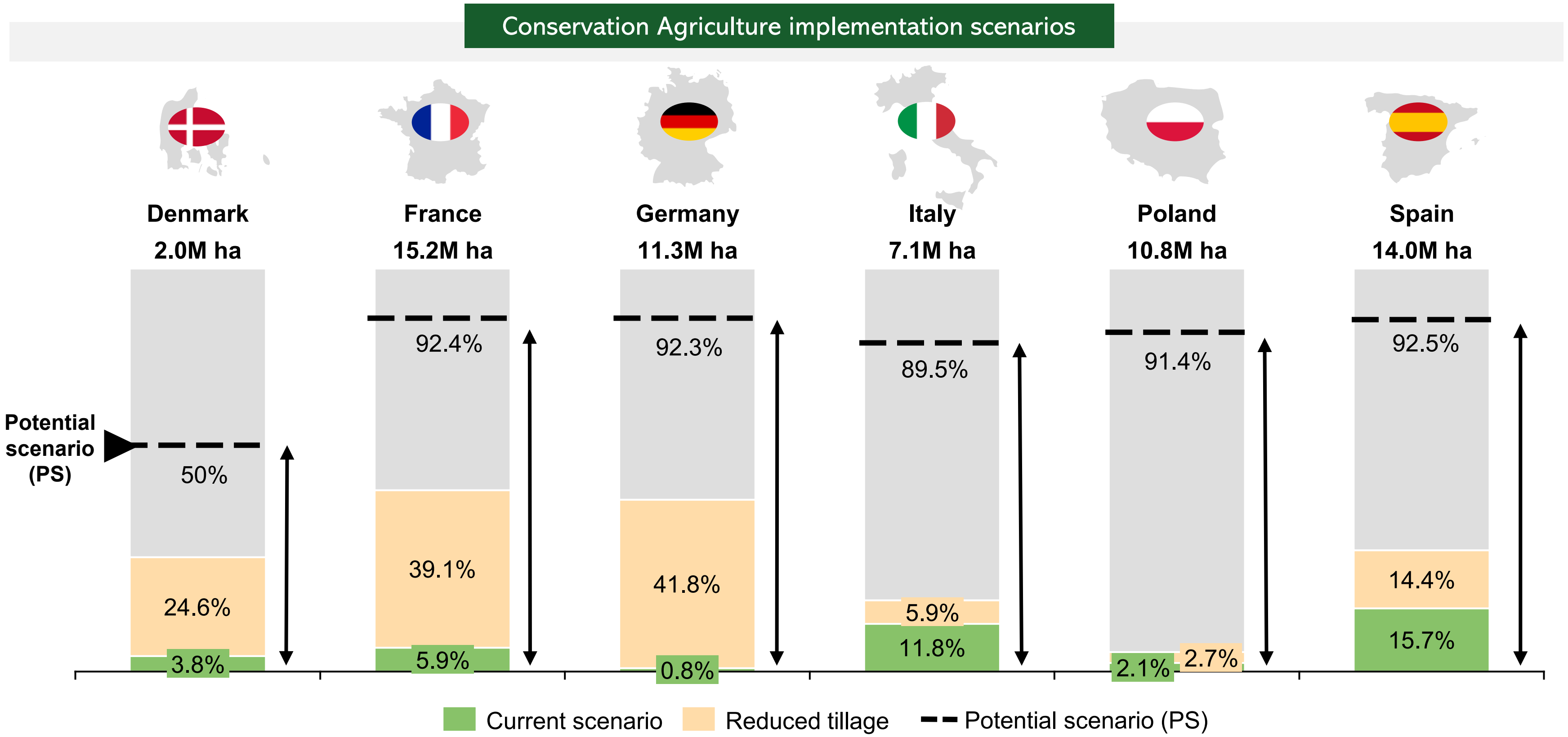
- **Conventional agriculture:** Involves the inversion of the soil by a mouldboard plough severely disturbing the soil
- **Reduced tillage:** Non inversion and less intrusive tillage methods are used leaving some crop residues on the top soil
- **No-tillage (CA):** The crop is sown directly into the soil avoiding any tillage and leaving the previous crop residues

Reduced tillage implementation (hectares)



Source: ECAF, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, INRAe, Danmarks Statistik, Destatis, and MAPA: ESYRCE 2021.

Given its growth, CA techniques could be applied, on average, to 90.5% of the total cultivated area, meaning that CA adoption could reach over 54.7 million ha in the six countries analysed



Current and **Potential** adoption scenarios will be used to estimate the benefits that CA brings (current) and would bring (potential) to farmers and to national and European strategies

Note: FRDK and SEGES consider that the potential scenario for Denmark should be around 50% given the agricultural and soil conditions in the country. In this sense, the maximum adoption scenario for Denmark differs from the one considered for the other five countries, where CA potential adoption is calculated as the total cultivated land excluding vegetables and root-crops for which CA in the strict sense cannot be applied. Source: ECAF, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Eurostat, INRAe, Danmarks Statistik, Destatis and MAPA: ESYRCE 2021.

3.

Benefits of Conservation Agriculture for farmers

By adopting CA practices, farmers benefit through time savings, energy savings, cuts in machinery costs and input optimization

Benefits for farmers from CA

Time savings

- **Time saving for farmers.** By not tilling the soil in CA, farmers can devote more time to other productive activities on the farm.

Lower costs

- **Energy savings.** The reduction in the use of machinery to prepare the soil brings fuel savings and cuts machinery maintenance costs.
- **Agricultural input savings.** CA helps to improve soil health and prevent soil erosion, resulting in a reduced incidence of pests and diseases and improved soil fertility leading to a lower need for phytosanitary inputs and fertilizers in the long term.
- **Operating cost savings.** 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 CA, the later brings greater benefits per hectare in comparison with tillage-based techniques.

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba.

With time savings of between 1 and 4.2 hours per hectare, the use of CA brings a reduction of 16 million hours compared with conventional tillage, resulting on an economic saving of almost €184 million

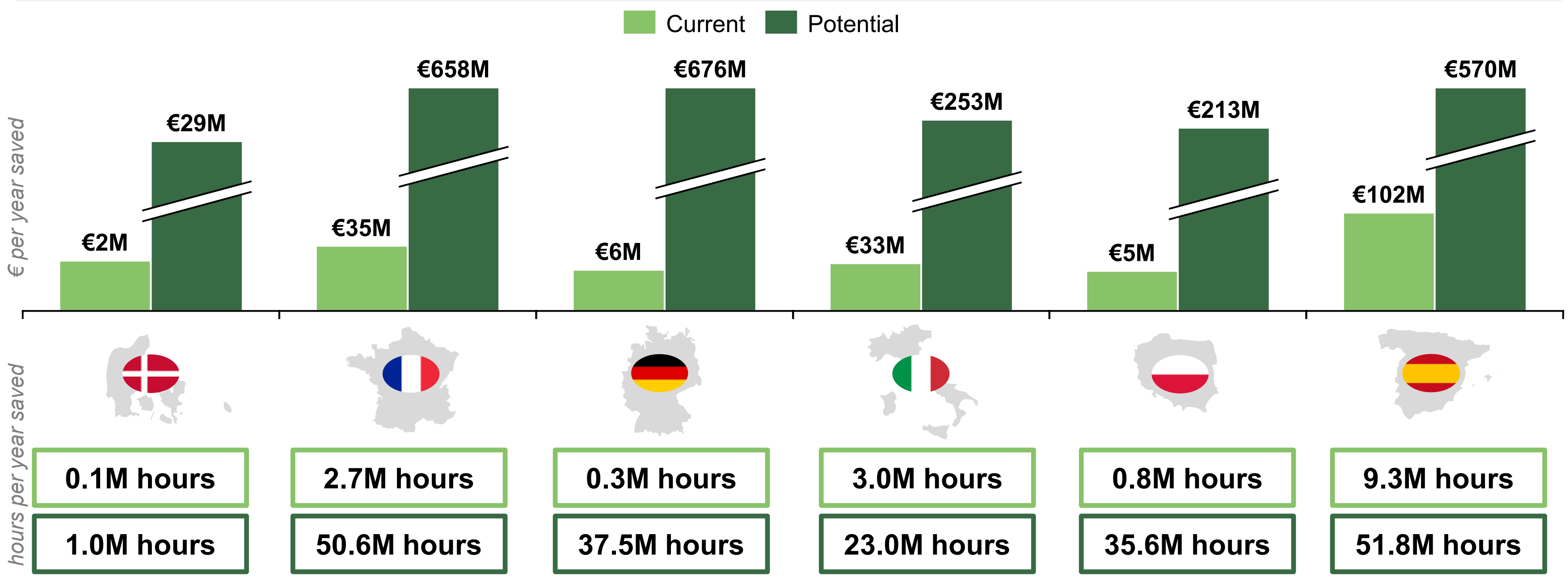
1-4.2 hours/ha

Each additional hectare under CA allows from 1 to 4.2 work hours to be saved

€44/ha

On average, each additional hectare under CA brings time savings valued at €44

Conservation Agriculture savings in labour costs



Note: The average salary of tractor operator considered: Denmark €28.5, France €13, Germany €18, Italy €11, Poland €6, and Spain €11.
Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba, based on Economic Research Institute, Farmtal, Arnal Atares, P. (2014), and technical support from PwC.

In addition, CA contributes to fuel savings of, on average, 29 litres per hectare, which in economic terms translates to farmers saving €49 per hectare or €206M per year in the current adoption scenario

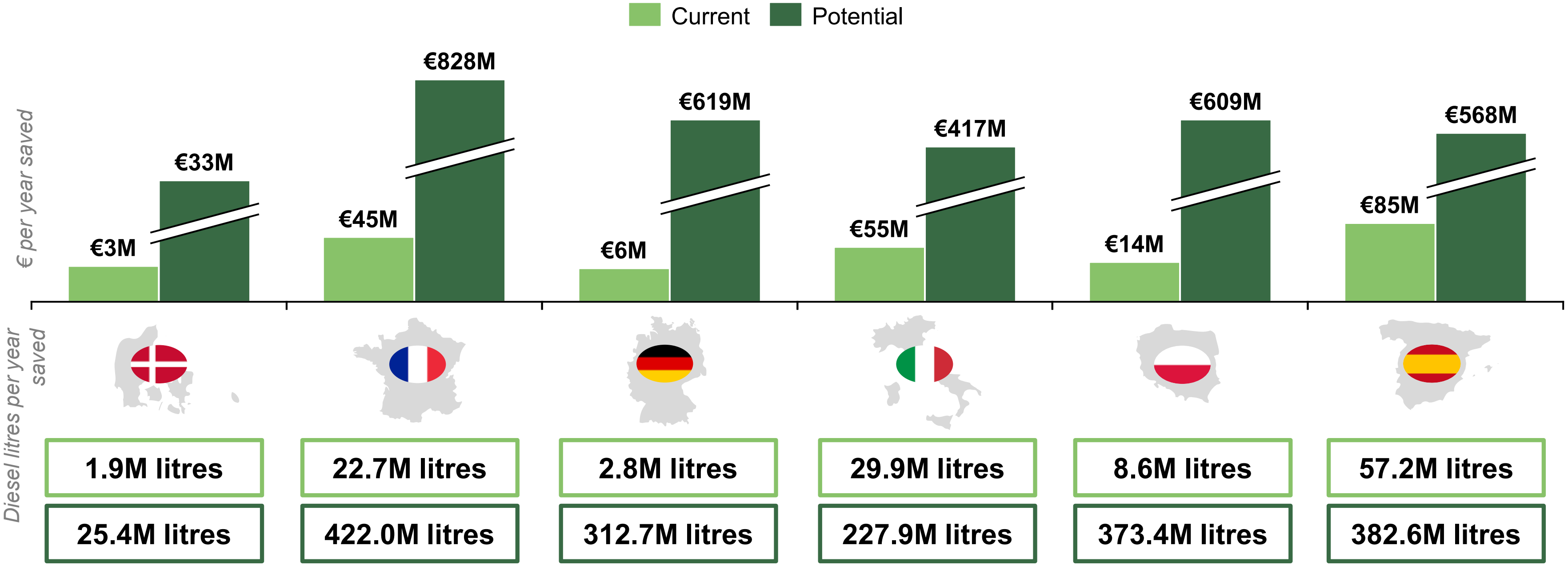
29 litres/ha

On average, each additional hectare under CA decreases diesel use by 29 litres

€49/ha

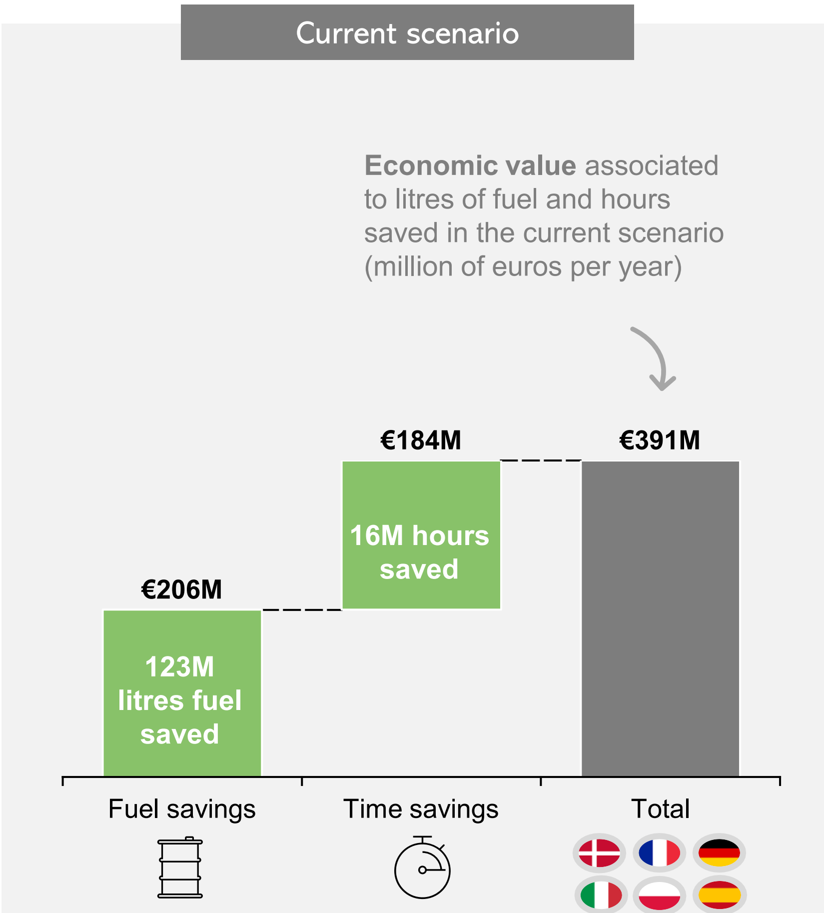
On average, each additional hectare under CA brings fuel savings valued at €49

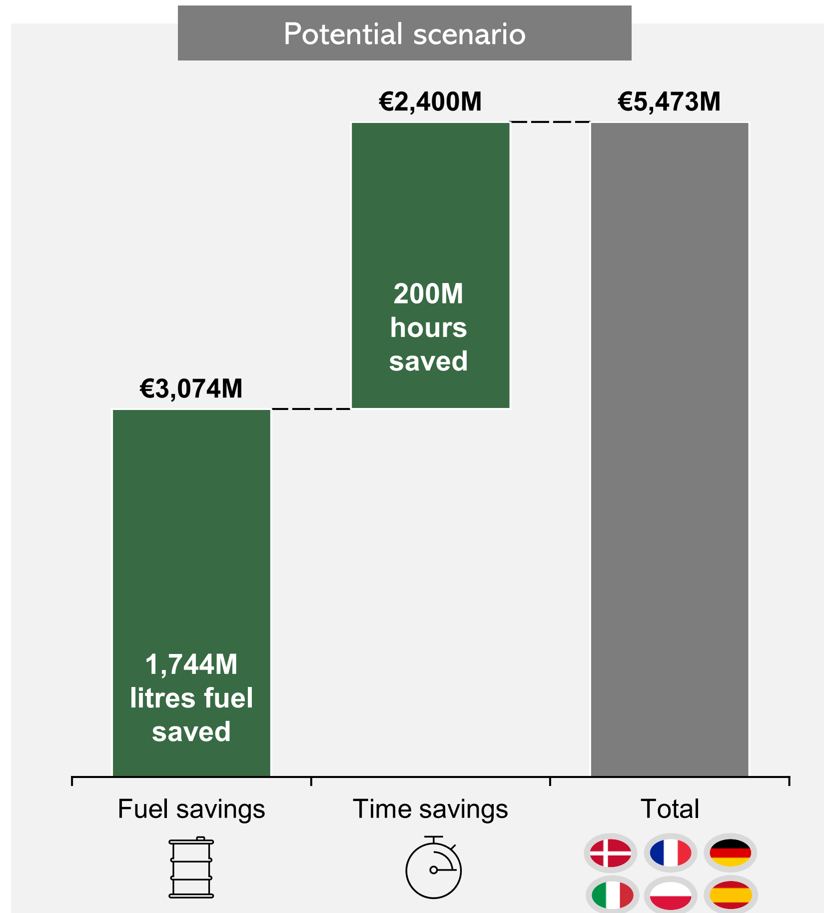
Fuel savings for farmers adopting Conservation Agriculture



Note: Price of fuel based on European Commission Weekly Oil Bulletin for 6 of June 2022. Data for Spain from CNMC and for Denmark from OK.
Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on European Commission, CNMC, Krogh, P.H. and Qin, J., (2018), Munkholm, L.J. et al, (2020), Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015), Bialczyk, W . et al.(2012), Agricare (2017), Arnal Atares, P. (2014), and technical support from PwC.

To sum up, farmers economic benefits from the use of CA are valued at €391 million per year in the current scenario and up to €5,473 million in the maximum potential adoption scenario





Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on European Commission, CNMC, Economic research Institute,, A.V. et al, (2020), Krogh, P.H. and Qin, J., (2018) and Munkholm, L.J. et al, (2020), Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015), Bialczyk, W . et al.(2012), Agricare (2017), Arnal Atares, P. (2014), and technical support from PwC.

4.

Essential Conservation Agriculture tools

The essential tools needed to implement CA include no-till seeders and IWM with optimised herbicide use

No-till seeders

Given that CA avoids tillage, it is necessary to have proper equipment to establish the crops in conditions with abundant plant residues. In this sense, and to successfully implement CA, there has been an important development of specific machinery. One of the key machines are **no-till drills (direct seeders)**. The no-till seeders are distinguished from conventional seeders by the **sowing line**, which is more solid and must put high pressure on the soil to assure a correct cut and seed positioning.

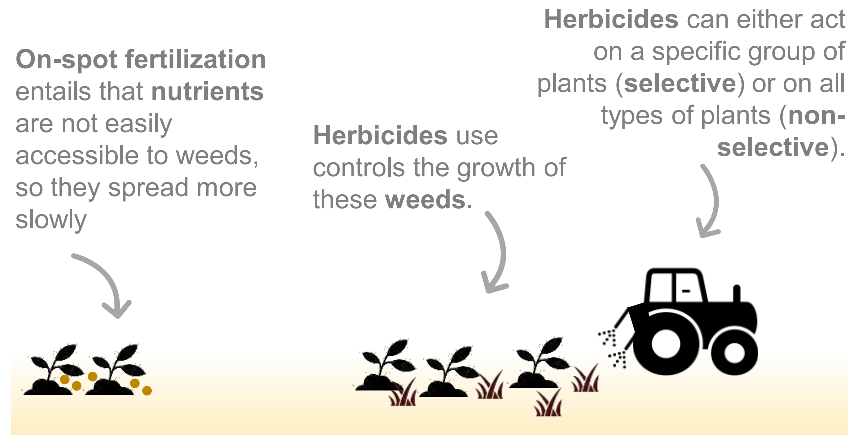
In general, no-till drills must have the following characteristics:

- Enough **weight to penetrate** under compact soil conditions and groundcovers
- Ability to **open a groove wide and deep** enough to place the seed at the correct depth (small seeds - 3 cm - or large seeds - 5 cm)
- Possibility to **regulate the rate and spacing** of seeds of different size and ensure their adequate covering
- Possibility to easily **modify its settings** to adapt to different crops and to apply fertilisers and plant protection products simultaneously
- **Resistance of its elements** to withstand heavy duty conditions

Herbicides in IWM

CA principles lead to the application of optimised amounts of **herbicides** whilst minimizing the risk of downstream contamination. A judicious use of crop protection products is in many cases essential to control weed growth. Glyphosate is one of the most widely used herbicide due to its **appropriate characteristics**: effective one-pass weed control on a broad spectrum of weeds and cover-crops, environmental profile, non-selectivity, cost-effectiveness, etc.

Some tips about control of weeds



In addition, for the implementation of CA, **harvesters** must also be **equipped with well adjusted equipment for chopping and spreading of straw** so that, after the harvester has passed through, the residue is spread and covers the ground evenly, rather than being left for later baling.

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on González-Sánchez, E. J., & Basch, G. (2017).

No-till seeders are specific machines to perform direct sowing on untilled soils with a mulch of residues and stubble

With no-till seeders, the only mechanical disturbance of the soil is performed in the seed furrow to place the seed in optimal conditions for germination. **Some added <u>elements</u> in the machinery improve the capacity to sow on residues** differing from the conventional ones.

Pre-openers tools

Tools that allow to remove or cut through the residues. Different type of discs are normally employed. To manage high amount of residues row cleaners are attached in front of the furrow openers.

Seed furrow Openers

They are tool to open the seed furrow and place the seed Depending on residue and soil, a pre-opener tool might not be needed. There are two types of openers:

- **<u>Discs</u>**: single or double, the outer edge can be smooth or grooved to cut the straw better. A lateral tube guides the seed to the furrow. In case of V-shape double disc opener the drop tube is located between them. Discs openers are recommended for high amount of residues, especially when not chopped.
- **<u>Tine coulters</u>**: Exert on the ground the vertical cut upwards. They reduce the necessary pressure to reach the desired depth. This type of openers adapts better to stony terrains.

Row closure wheel

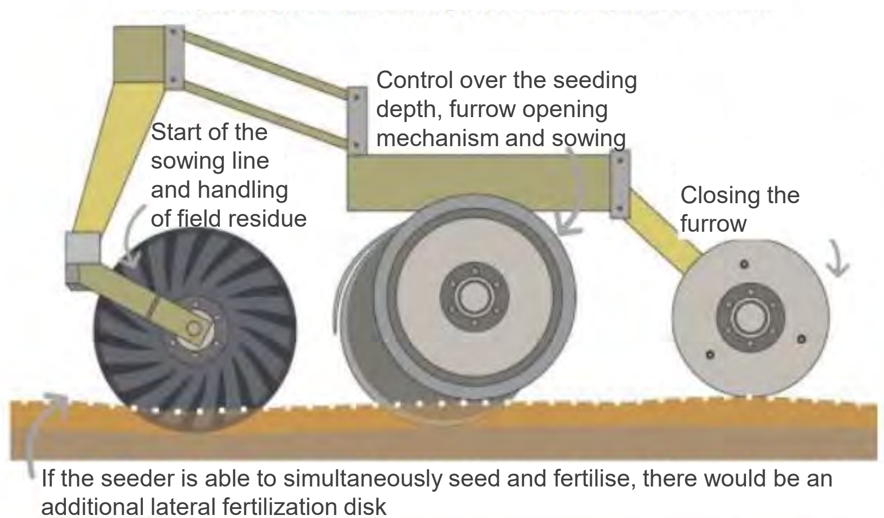
A press wheel (single or double) is needed to press in the base of the slot after the seed placing. It should be tight enough to absorb the soil moisture. Rakes after the press wheels are sometimes mounted to smoothen the surface.

No-till seeders have important functions as **creating the correct microenvironment** for the seeds within the soil.

The openers of no-tillage drills must follow ground surface variations and **move through significant surface residues without blockage**. Different drill openers differ markedly in their abilities to do this.

With appropriate equipment, no-till has no more, and often less, crop failure risk than tillage, even in the short term.

Example of the direct seeding mechanism on a disc no-till seeder



Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on González-Sánchez, E. J., & Basch, G. (2017) and Baker et al. (2007).

Glyphosate is one of the commonly used herbicide due to its appropriate characteristics for weed control and to prepare the crop seedbed

Common uses of Glyphosate in CA[1]

Glyphosate can be applied on agricultural soils in the **intercrop period** (weed control, cover crops & ground cover management), in **pre-sowing** or just **after sowing** before crop emergence.

- **Inter-crop period**

Glyphosate is used to get rid of weeds that emerge in the inter-cropping period and are difficult to get rid of at other times (e.g. perennials in summer). Also, it is used to manage cover crops and groundcovers.

- **Pre-sowing period**

Glyphosate is used to get rid of weeds present before sowing and to prepare the seedbed for the upcoming crop.

- **After sowing, before crop emergence**

Glyphosate can be used at this time in case it was not possible to control weeds before sowing (e.g. because of weather conditions), or to maintain a living cover crop until the emergence of the new crop (e.g. "sown under cover" crops).

Benefits of glyphosate in CA

The three core **principles** of Conservation Agriculture (minimum soil disturbance, permanent soil cover and crop rotation / diversification) already play, by themselves, a functional role in weeds control. However, a careful **management of cover crops, groundcovers and unwanted vegetation** is needed, which is mainly achieved through the use of herbicides, in particular glyphosate.

Besides the particular value of glyphosate in the practice of CA, in more general terms this herbicide is an essential tool for weeds control, as it **simplifies** by reducing the number of passes **and makes the process cheaper** than alternative products or mechanical or manual techniques.

As an example, glyphosate is commonly used in permanent crops, promoting proper **soil maintenance and preventing weeds** from affecting crop productivity and health. This is because uncontrolled weeds compete with crops - nutrients, water, light - and may be hosts to pests and diseases.

1) Farmer generally implements one of these 3 uses in a year depending on weed problems.
Note: The improper use of glyphosate or any other herbicide (management of these products without observing the directions included in their labels, e.g.: incorrect or lack of use of personal protective equipment, exceeded frequency of use, or application of inappropriate doses) can potentially lead to environmental, health or agronomic risk, such as the appearance of resistance to the active substance applied. Therefore, a judicious use of these products, like for any other plant protection product from chemical origin (through synthesis or not), or biological origin, is necessary, following the label recommendations and implementing the appropriate stewardship measures.
Source: ECAF.

In particular, data from Denmark, Germany, France and Spain show that chemical alternatives to glyphosate have, on average, 45% higher costs, making IWM with glyphosate effective for the adoption of CA

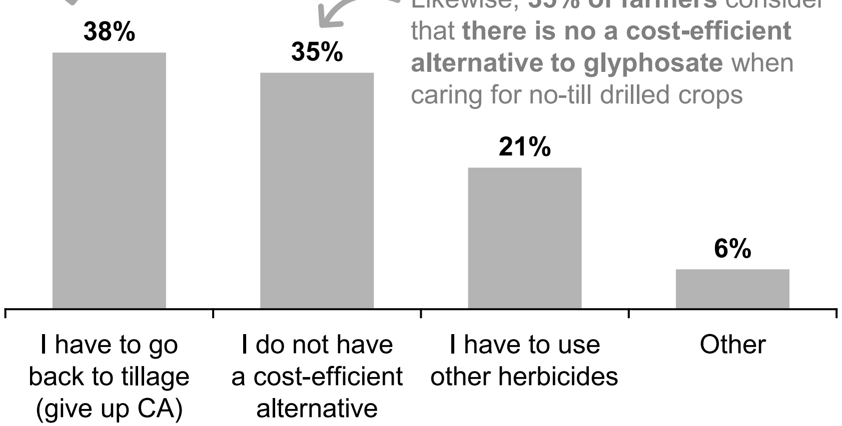
38%

of farmers in the EU consider that they would abandon no-tillage soil management systems (CA) if it were not for glyphosate

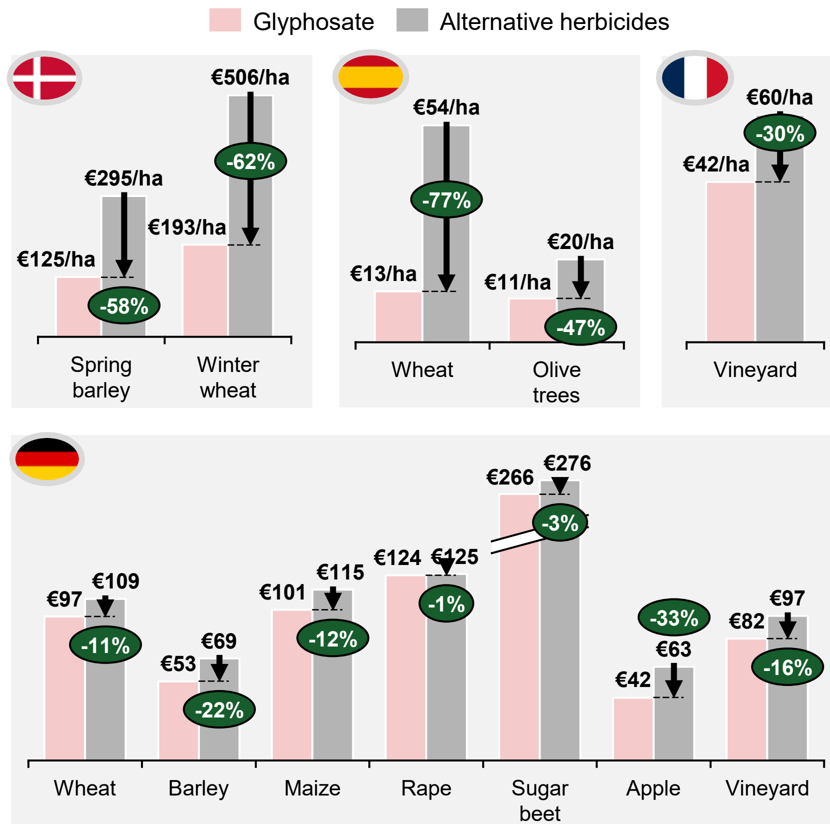
European Survey on alternatives to glyphosate (2020)[1]

A majority of farmers (38%) say that they would **abandon no-tillage soil management systems** (CA) if it were not for glyphosate

Likewise, **35% of farmers** consider that **there is no a cost-efficient alternative to glyphosate** when caring for no-till drilled crops



Cost difference using glyphosate and other alternatives[2]

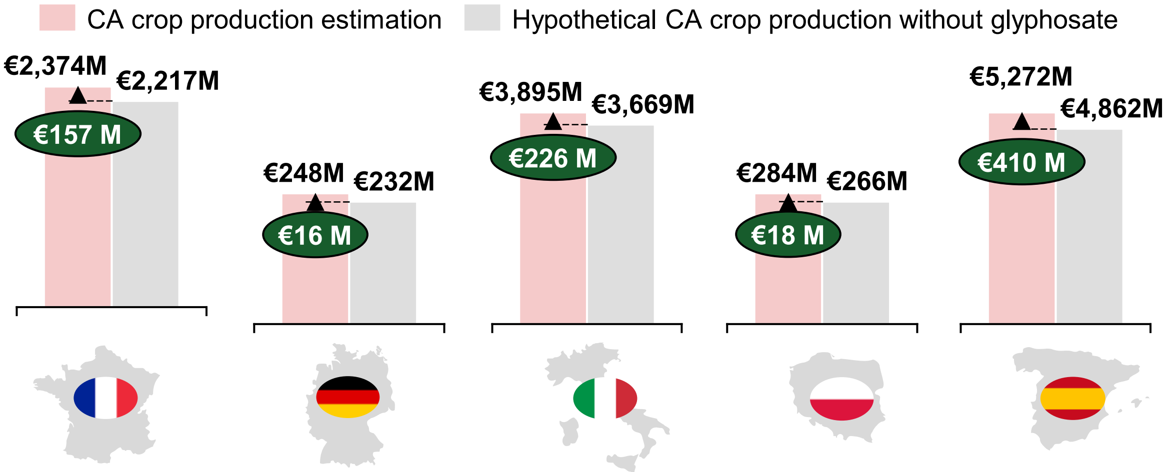


1) ECAF European Survey on alternatives to glyphosate (2020) for many different types of crop. 2) Data for Denmark from Petersen, PH & Krong, J (2021); Germany from Fairclough B., Mal P. & Kersting S. (2017); France from Adquation and in line with the INRAe (2019a) study, which found that chemical weed control is 35% more cost-effective than mechanical methods in viticulture; and Spain from AEAC.SV. France and Spain analyze the difference in costs solely for glyphosate, while Denmark accounts for all weed control expenses in CA. In Germany, the cost of glyphosate includes any additional substances used in conjunction with it.

In addition to lower costs, glyphosate use in IWM leads to higher crop yields. Thus, around €827M of the current CA crop production can be associated to IWM with glyphosate's boost to productivity

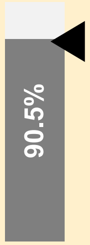
€827M **The use of glyphosate can be associated with €827M of the current CA crop production on the studied countries**

Increase in CA crop production associated to glyphosate use



Potential

CA adoption



In the **maximum potential adoption scenario** of CA, the increase in crop production associated to IWM with glyphosate use could reach **€9,625M** annually

In addition to its relevance for CA, the **use of glyphosate in agriculture** has an important socioeconomic contribution to agriculture as a whole, representing a total annual contribution of **€2,799M in terms of GDP** and **63,262 jobs in terms of employment**.[1]

Note: Impact on Denmark not included.

1) For further information on glyphosate socioeconomic contribution in the analysed countries please refer to Appendix A: Glyphosate socioeconomic contribution.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on European Crop Protection (2020), Steward Redqueen (2017), Luchia Garcia-Perez & Harriet Illman (2020), and the technical support from PwC.

For the wide adoption of CA three potential barriers should be considered: access and use of machinery, lack of learning and uncertainty related to regulatory changes at national and European level

Barriers to the adoption of Conservation Agriculture

Use of machinery

CA is a common practice that requires the **use of specific machinery**. For example, the purchase of a no-till seeder requires an initial investment of between **€50,000 and €150,000** depending on the width of the machine. Given the current early stage of CA implementation in the EU, the second-hand market for no-till seeders plays a crucial role in the sector, as it allows farmers to start applying CA techniques by reducing the initial investment. Another option is to rent the machinery or outsource the operation to an external company. Both options would be of particular interest to small farmers who cannot afford the initial investment in machinery.

Learning of techniques

A second issue is the **learning curve for the optimal implementation of CA techniques**. As a new system, in the early years of transition, farmers need an initial training process to learn about tools, applications, social, economic and environmental benefits, etc. Developing policies to promote and create farmer training programmes is important to overcome this early stage and make it more cost-efficient.

Uncertainty

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 the EU. 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.

Regulatory system

Regulatory systems should **support science-backed** criteria to foster sustainable agriculture. The adoption of best management practices must be facilitated. However, decision-making does **not always follow science's recommendations but is sometimes influenced by market and political criteria.**

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba.

5. Conservation Agriculture contribution to European targets

CA can play an essential role in the environmental, socioeconomic and food security targets set by the European Union

- ✓ Lower land erosion
- ✓ Higher water infiltration rate
- ✓ Higher biodiversity
- ✓ Reduction of CO_2 emissions and increase of carbon sequestration

- ✓ Improvements in agricultural trade balance
- ✓ Reduction in the number of severely food insecure households

- ✓ Total contribution to GDP (direct, indirect and induced impact)
- ✓ Total contribution to employment
- ✓ Lower risk of rural abandonment and poverty or social exclusion

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba.

5. Conservation Agriculture (CA) contribution to European targets:

5.1 Environmental targets

The use of CA can be linked to an overall improvement of the soil in terms of erosion, biodiversity, infiltration rate, carbon sequestration and CO_2 savings

Environmental benefits of CA

Lower soil erosion

- **Reduction in erosion.** The soil 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 groundcover 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.

Higher water infiltration rate

- **Reduction in surface run-off and increase in infiltration.** Crop residues on the surface of the soil limit surface run-off, reducing the soil degradation and desertification process, in four ways:
  - i. lower surface water speed
  - ii. increased soil protection against the impact of raindrops, thus decreasing soil sealing
  - iii. higher aggregate stability avoiding crusting or sealing
  - iv. biological pores (roots and worms) are left undisturbed

Higher biodiversity

- **Increase in the number of species.** Soil cover and no-till farming favour the development of a living structure of micro-organisms, worms, insects, nesting, etc. in the soil, which enhances soil formation and fertility. Additionally, they also promote biodiversity in general increasing population of pollinators and birds.

CO_2 emissions savings

- **Carbon sequestration.** By not tilling, the soil mineralisation and decomposition of organic matter is minimized. Hereby the carbon content in soil will increase reducing CO_2 emissions. In addition, residue retention implies carbon input to soil.
- **Lower CO_2 emissions link to diesel savings.** CO_2 emissions decrease from a reduction in the use of machinery that leads to lower fuel consumption and thus combustion emissions.

European Green Deal | Common Agricultural Policy (CAP) 2023-27 | EU's Next Generation Funds

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba.

Spain and Italy, due to their geographical and climatic characteristics, face significant soil erosion compared to the other countries, with an average loss of more than 10 tonnes per hectare per year

90%

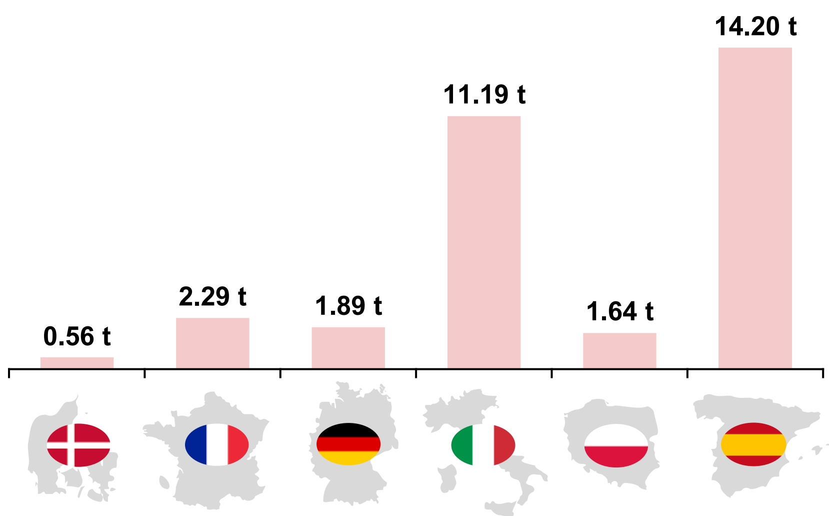
CA can achieve a reduction in soil erosion of up to 90% of that observed with conventional agricultural practices[1]

- CA contributes to **reduce soil erosion**. **Soil cover**, along with other factors, helps to **protect the soil** from the two main causes of soil erosion:

Wind | **Water**

- **Tillage erosion** is considered an important cause to soil degradation, together with water and wind erosion.

Average soil erosion (t/ha/year)



Breakdown by erosion level of agricultural land[2]

	Moderate	Severe
	2k ha (0.1% of land area)	0.1k ha (0.0% of land area)
	1,822k ha (7.6% of land area)	787k ha (3.3% of land area)
	1,191k ha (7.1% of land area)	350k ha (2.1% of land area)
	2,355k ha (15.5% of land area)	5,412k ha (35.7% of land area)
	694k ha (4.1% of land area)	332k ha (2.0% of land area)
	3,888k ha (15.9% of land area)	2,852k ha (11.7% of land area)
	*Soil loss estimated **between 6 and 10 t/ha/yr**.*	*Soil loss estimated above **10 t/ha/yr**.*

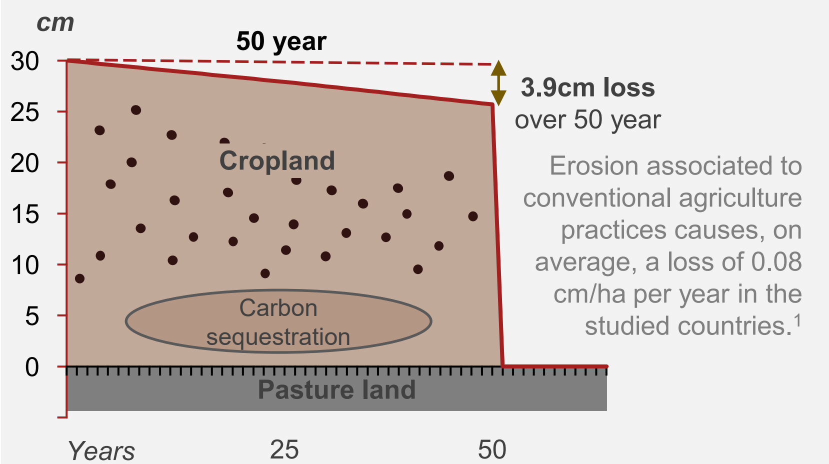
1) Based on the extensive literature on the reduction of soil erosion in Spain. For Denmark, France and Poland 70% reduction in soil erosion is observed, in Germany a 80% reduction, and in Italy a 58% reduction. 2) 2016 data from European Commission - Joint Research Centre (JRC).
Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on European Commission, AEAC.SV, Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015), Carreta, L. et al (2021),

Preventing land depreciation due to erosion results in economic savings of €58/ha, which currently amounts to €238M, and in a maximum potential adoption scenario could increase up to €1,811M

34M tonnes

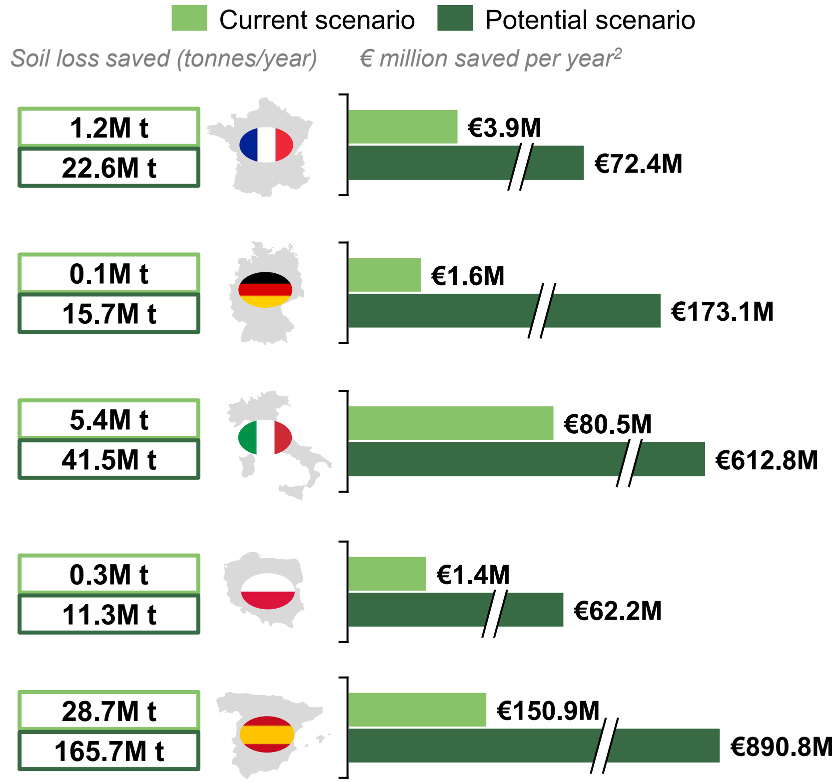
CA currently saves 34 million tonnes of soil per year in the countries studied. In the potential scenario this figure could increase up to 219 million tonnes

Land loss associated to conventional tillage



Erosion associated to conventional agriculture practices causes, on average, a loss of 0.08 cm/ha per year in the studied countries.[1]

CA annual economic benefits[2]



1) Economic losses from soil erosion in Denmark are not significant (not included), as low soil erosion is balanced by the creation of new fertile soils through plant growth, and the presence of deeper soils. 2) Using country average cropland prices based on Eurostat, Destatis and MAPA.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on Eurostat, European Commission, Destatis, MAPA, Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015) and the technical support from PwC.

As heavy rainfall becomes more frequent in Europe, soils under CA are more resilient because the infiltration rate is up to 3 times higher and water evaporation is 10% to 50% lower

x3 infiltration rate

Conservation Agriculture improves water infiltration

10-50%

Lower water evaporation under Conservation Agriculture

Higher infiltration rate

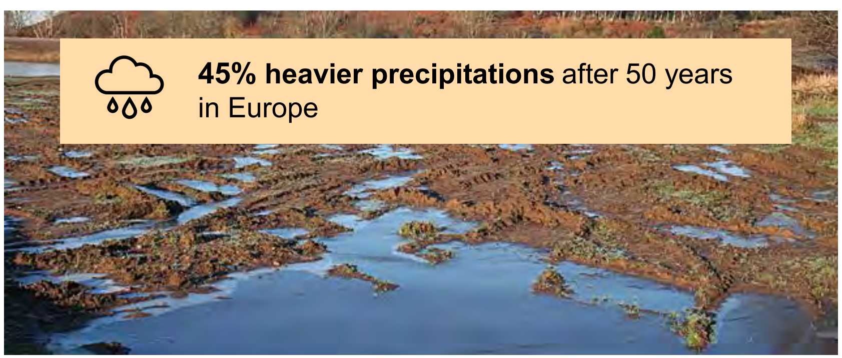
- Denotes the ability to more rapidly absorb greater amounts of water into the soil profile. This allows for **better soil preservation** during periods of heavy rainfall.

When rainfall exceeds the infiltration rate of the soil, there is an **overland water flow** that loosens and wears away the fertile topsoil.

Lower water evaporation

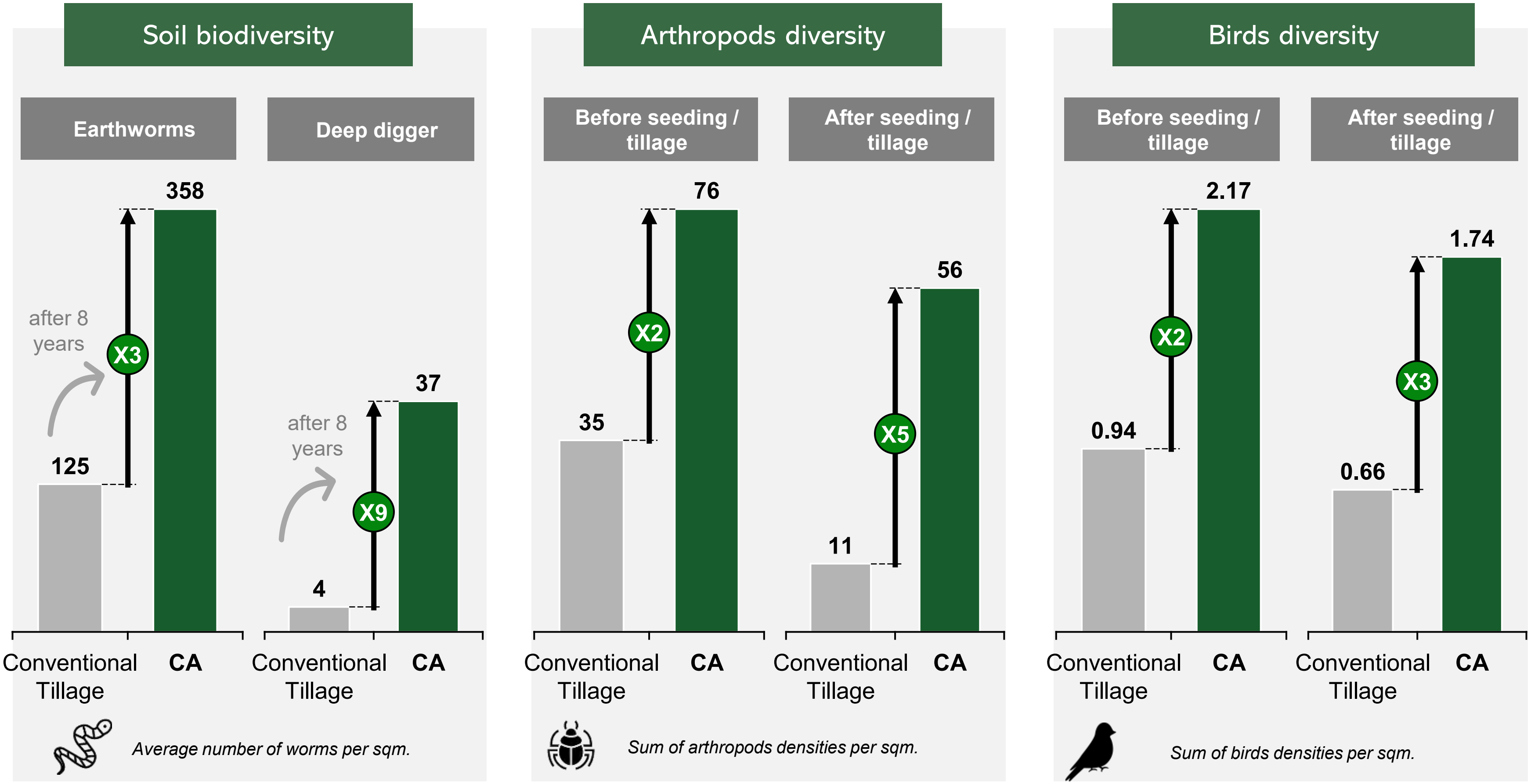
- It achieves a longer lasting moisture accumulation in the soil. This ensures the **availability of nutrients** for crops even during long periods of drought.

Droughts, such as those recently experienced in Europe in the summer of 2022 and 2018, greatly affect farmland and farmers' production.



Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on Schmitz, Mal and W. Hesse (2015) and European Environmental Agency.

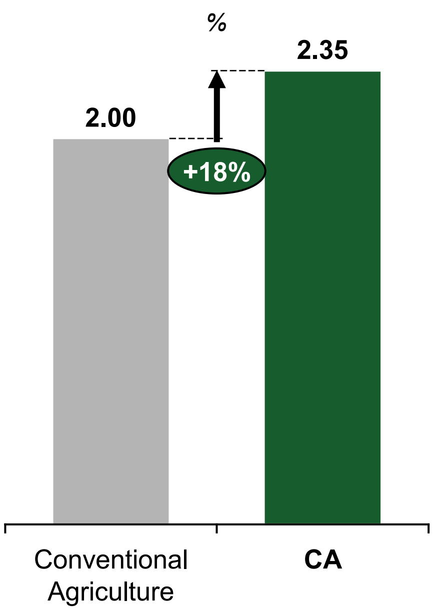
According to evidence from different European countries, CA soils have between 2 to 9 times higher densities of species, compared to conventional tillage soils



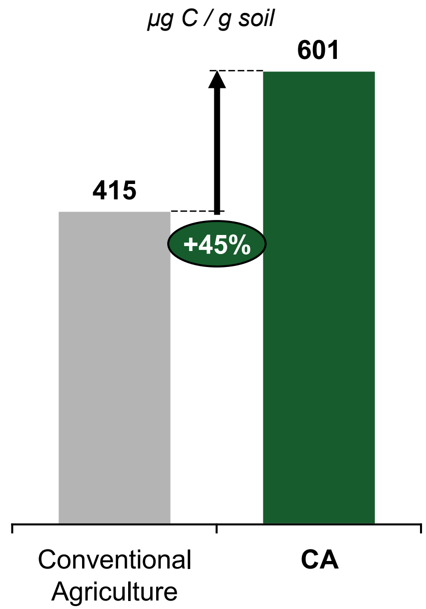
Source: Schmitz, Mal and W. Hesse (2015) and Søby, Julie Marie (2020).
Note: More evidence can be found at Hundebøl, NRG & Axelsen, JA (2022), Axelsen, J. (2019), Thingholm, L. B, (2019, 2020) in terms of microorganisms and at Krogh, P.H. and Qin, J (2018) in terms of earthworm and microarthropod populations.

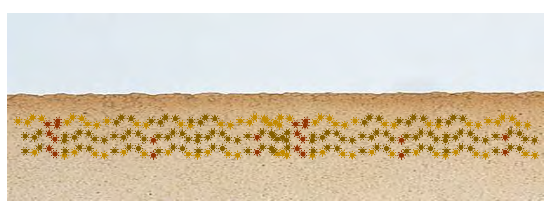
In addition, humus formation, aggregate stability and microbial biomass under CA show higher values than conventional tillage techniques

Humus formation

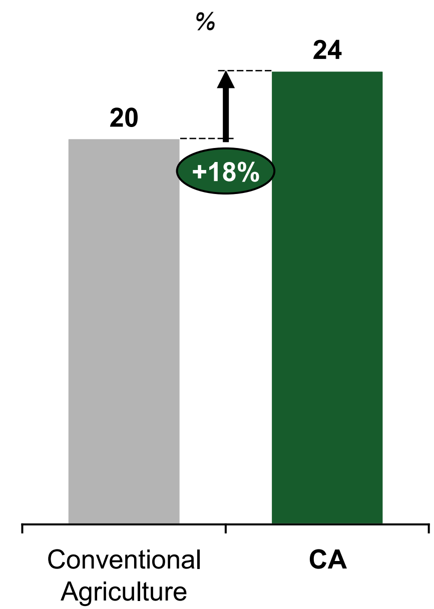


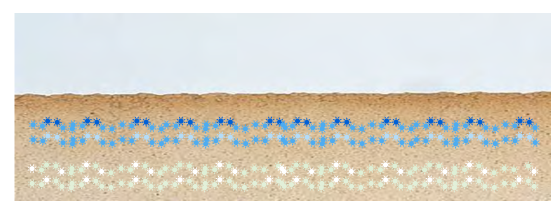
Microbial biomass





Aggregate stability





Source: Schmitz, Mal and W. Hesse (2015).

Due to minimal soil disturbance and soil cover, CA increases soil carbon sequestration, saving above 10M tonnes of CO_2 per year, which could reach about 105M tonnes of CO_2 in the potential adoption scenario

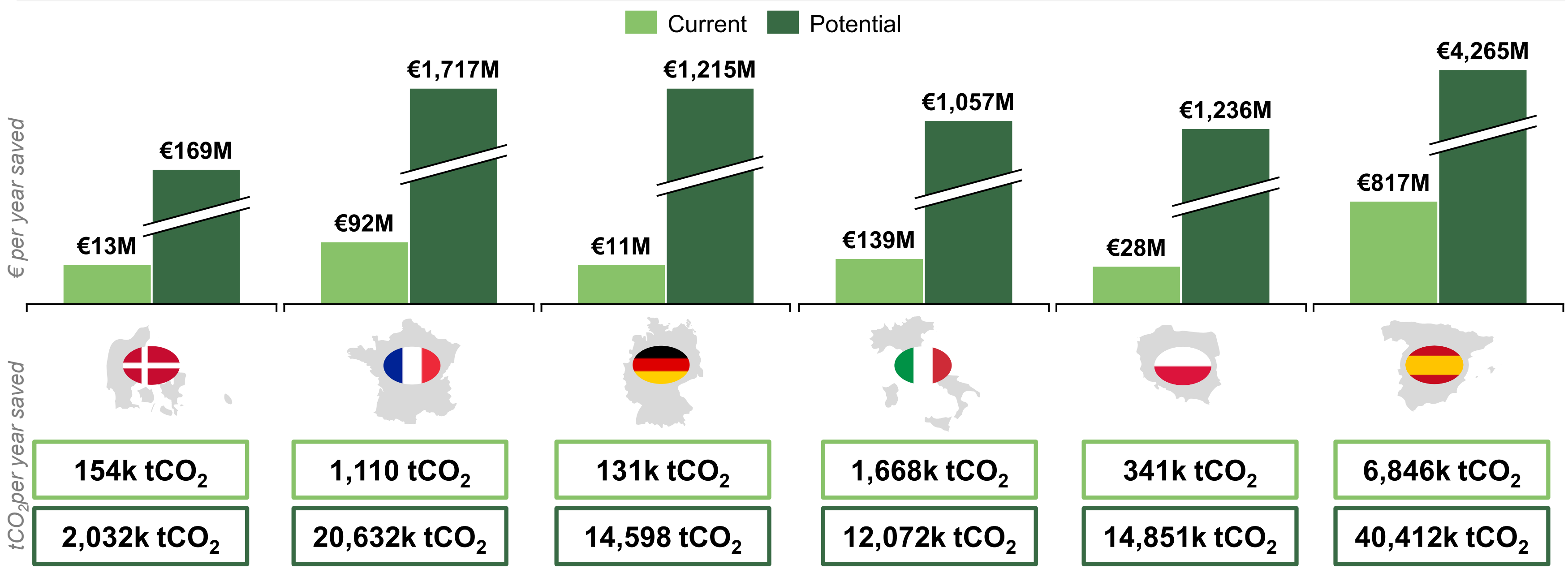
1.4 - 4.5 tCO_2/ha

Each additional hectare under CA allows from 1.4 to 4.5 tonnes of CO_2 to be saved

€263/ha

On average, each additional hectare under CA brings soil CO_2 savings valued at €263

Conservation Agriculture savings in soil CO_2 emissions[1]



Note: In addition to carbon sequestration, conservation agriculture has also been shown to help capture nitrogen in the soil, preventing emissions of environmentally harmful gas forms of this elements. 1) €83.2 per tonne of CO_2 based on the emission allowance market for 2022 (as of 20 June 2022), Sendeco2.

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on APAD (2021), Vestergaard, A.V. et al, (2020), González-Sánchez, E. J., & Basch, G. (2017), Schmitz, Mal and W. Hesse (2015), Cillis, D. (2018), González-Sánchez, E. J., et al. (2012), Tebruegge, F. (2001), and technical support from PwC.

The lower fuel need from the use of CA techniques currently saves above 333k tonnes of CO_2 per year, and could reach 4.7 million tonnes of CO_2 in the maximum potential adoption scenario

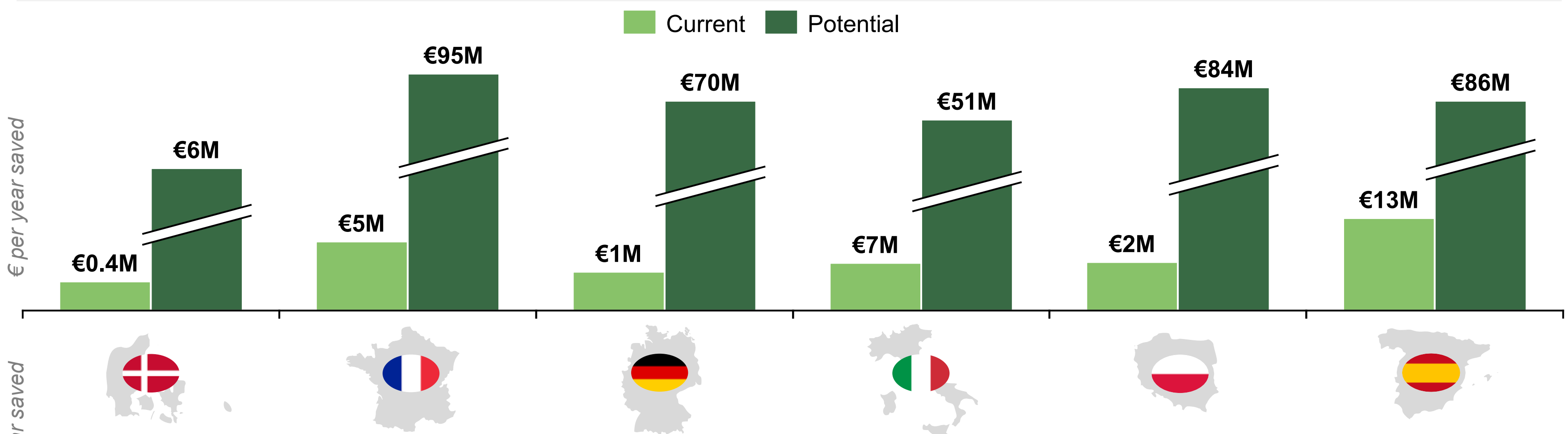
0.1 tCO_2/ha

On average, each additional hectare under CA allows 0.1 tCO_2 to be saved[1]

€6.6/ha

On average, each additional hectare under CA brings diesel CO_2 savings valued at €6.6[2]

Conservation Agriculture savings in soil CO_2 emissions



tCO_2 per year saved

5k tCO_2	61k tCO_2	8k tCO_2	81k tCO_2	23k tCO_2	155k tCO_2
69k tCO_2	1,139k tCO_2	844k tCO_2	615k tCO_2	1,008k tCO_2	1,033k tCO_2

1) Diesel engines produce 2.7 kg of CO_2 per litre of diesel fuel consumed. 2) €83.2 per tonne of CO_2 based in the emission allowance market for 2022 (20 June 2022), Sendeco2. Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on Krogh, P.H. and Qin, J., (2018), Munkholm, L.J. et al, (2020), Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015), Bialczyk, W. et al. (2012), Agricare (2017), Arnal Atares, P. (2014), and technical support from PwC.

Widespread environmental benefits derived from the use of CA facilitate the fulfillment of the objectives related to the European Green Deal, the future CAP and the EU's Next Generation Funds

Environmental targets

European Green Deal

- ✓ **«Farm to Fork» strategy:** Allowing the EU's food system to become more sustainable.
- ✓ **«Biodiversity for 2030» strategy:** Protecting nature and reversing the degradation of ecosystems

Common Agricultural Policy (CAP) 2023-27

- ✓ Contributing to climate change mitigation
- ✓ Efficient natural resource management
- ✓ Halting and reversing biodiversity loss

EU's Next Generation Funds

- ✓ 55% reduction in GHG emissions by 2030 compared to 1990
- ✓ Green transition in agriculture and the environment
- ✓ Energy efficiency, green heating and carbon capture and storage

CA's contribution to the fulfilment of environmental targets

90%
The soil erosion is reduced by up to 90% using the CA technique in the countries studied

x3
CA improves water infiltration around 3 times compared to conventional agriculture

x2-9
Increase between 2 and 9 times in the density of worms, arthropods and birds compared to tillage based Agriculture

24%
Under the potential adoption of CA, current agricultural GHG emissions would be reduced by 24%[1]

Soil loss reduction

€58/ha

CA adoption would enable an annual soil loss reduction valued at €58/ha.

Current scenario

Soil Tonnes per year	€M per year
34M t soil	€238M

Potential scenario

CO_2 Tonnes per year	€M per year
219M t soil	€1,811M

Reductions in CO_2

€269/ha

CA adoption would enable an annual CO_2 reduction valued at €269/ha

Current scenario

CO_2 Tonnes per year	€M per year
11M tCO_2	€1,128M

Potential scenario

CO_2 Tonnes per year	€M per year
110M tCO_2	€10,049M

1) Figure estimated based on the CA potential adoption scenario and EU agricultural GHG emissions in 2020 of 463 million tonnes (European Environmental Agency).

5. Conservation Agriculture contribution to European targets:

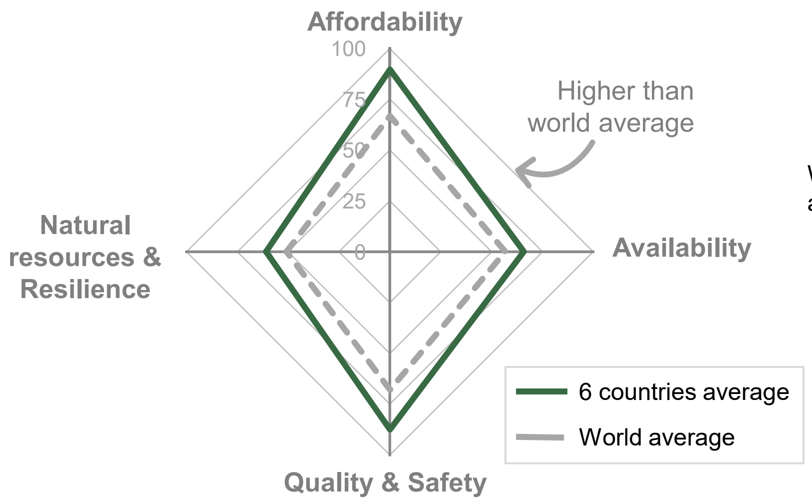
5.2 Food security targets

Food security, which is a concept linked to food affordability, availability, quality and safety, is currently gaining momentum due to increasing prices of key agricultural inputs

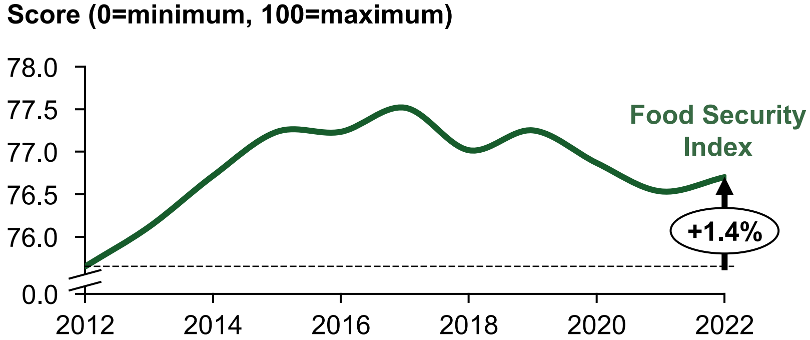
76.7

The 6 countries studied rank in the top 30 countries in the Global Food Security Index. Averaging 76.7 points over 100, these countries stand out in affordability, and quality & safety

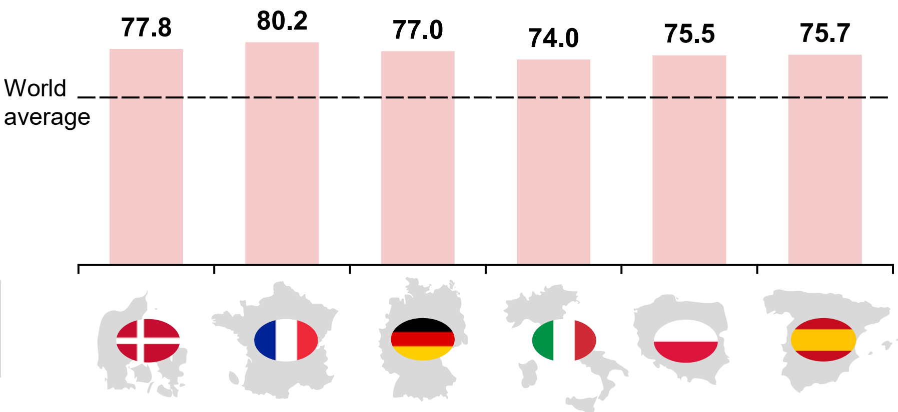
Global Food Security Index (GFSI) in 2021



Evolution of the Global Food Security Index (Simple average 6 countries)



Results of the Global Food Security Index per country (2022)



Note: The Global Food Security Index (GFSI) considers the issues of food affordability, availability, quality and safety, and natural resources and resilience across a set of 113 countries. The index is a dynamic quantitative and qualitative benchmarking model constructed from 58 unique indicators that measure the drivers of food security across both developing and developed countries.
Source: The Economist Group.

Trade in agricultural crops is 2.5 times higher now than two decades ago, with Denmark, France, Germany, Italy, Poland and Spain accounting for 50% of the total EU agricultural crop trade

50%

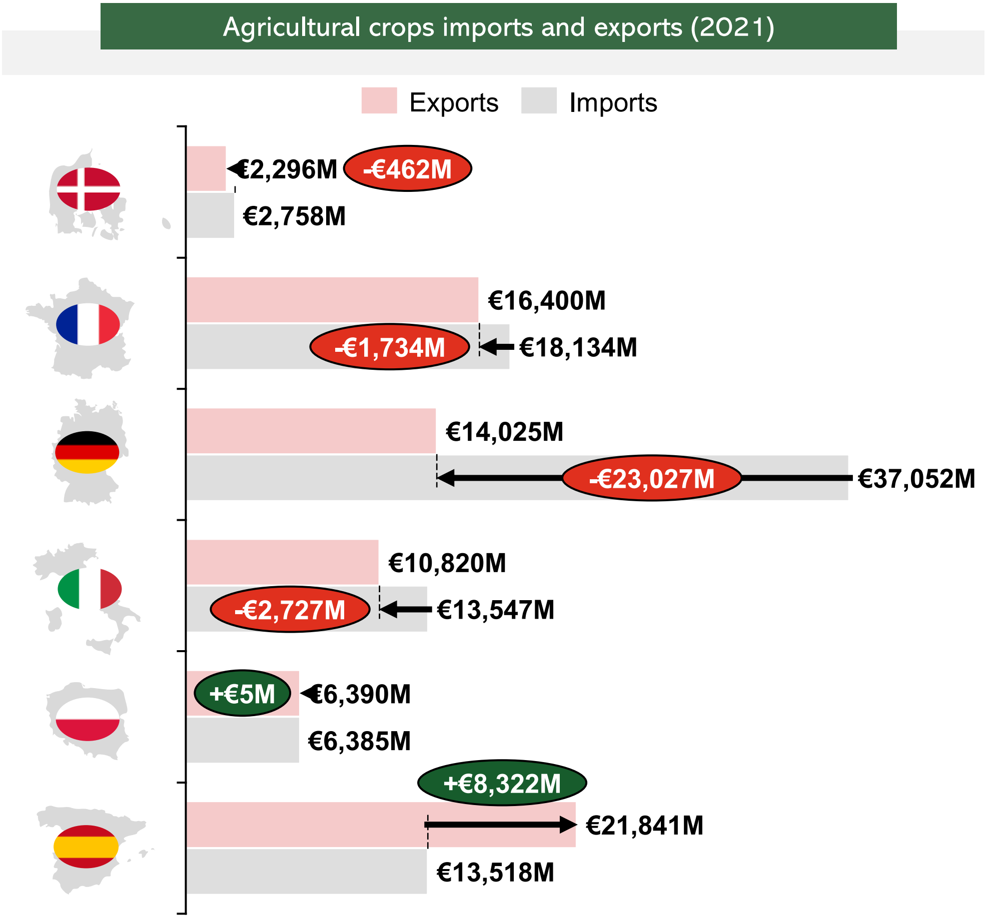
Over 50% of EU27 agricultural crop trade is accounted for by Denmark, France, Germany, Italy, Poland and Spain

x2.5

Agricultural crop trade has grown by 2.5 times since 2000

~30%

Cereals and oilseeds represent, on average, about 30% of the total agricultural crops traded

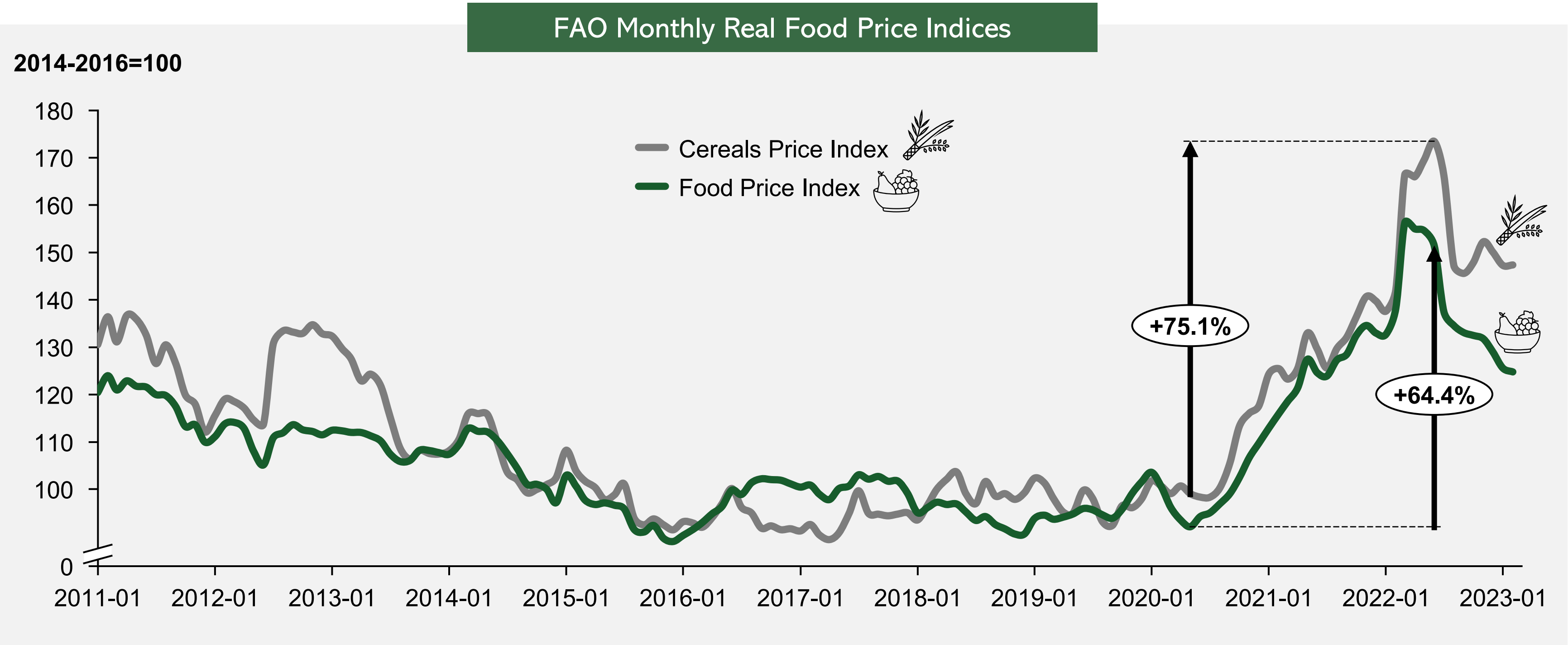


Source: Eurostat 2022.

Food and agricultural crops such as cereals have experienced a progressive increase in prices, which has created further pressures on international trade

x1.7 From 2020 to 2022 the price of cereals increased by up to 1.7 times

x1.6 From 2020 to 2022 the price of food increased by up to 1.6 times

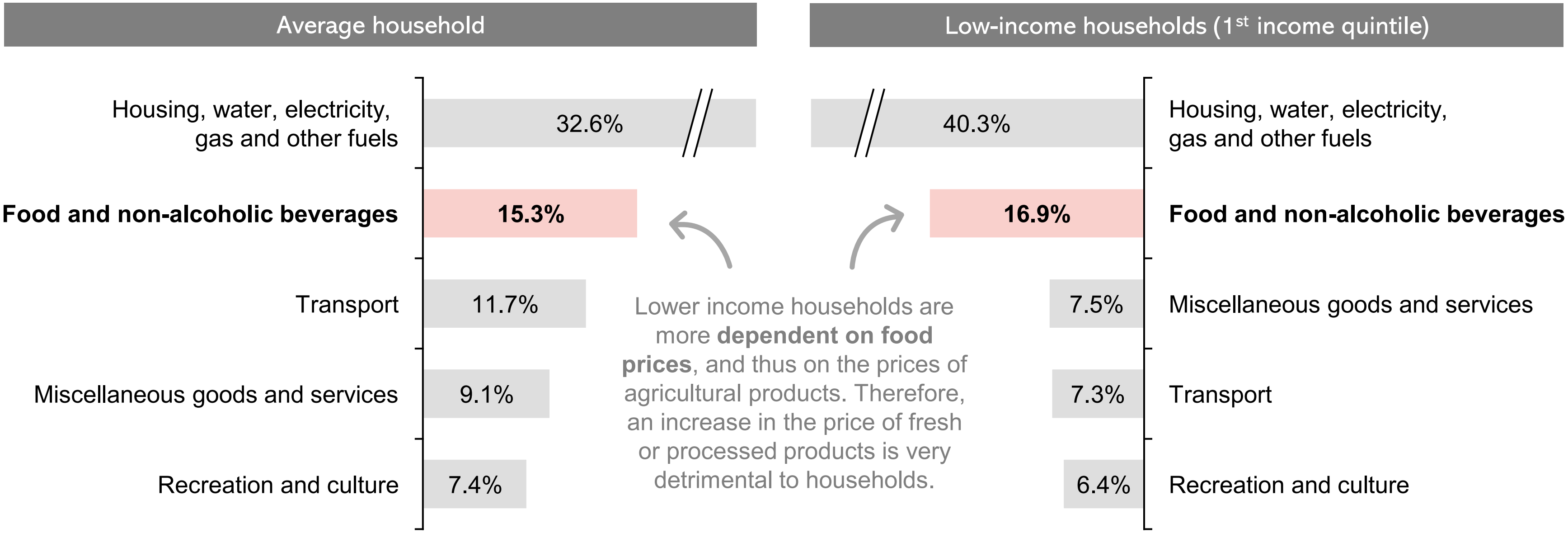


Note: Data from January 2011 to February 2023.
Source: FAO. https://www.fao.org/worldfoodsituation/foodpricesindex/en/

Price fluctuations have a significant impact on low-income households, as food products and beverages account for 16.9% of the total household budget, the second largest expenditure

15.3%

On average, over the six countries studied, a household spends 15.3% of its expenditure on food and non-alcoholic beverages. For the lowest income quintile, the proportion rises to 16.9% and becomes the second largest expenditure



Source: Eurostat 2022.

The use of CA can contribute to alleviating food insecurity by improving crop quality and affordability, which has a positive impact on agricultural trade balance

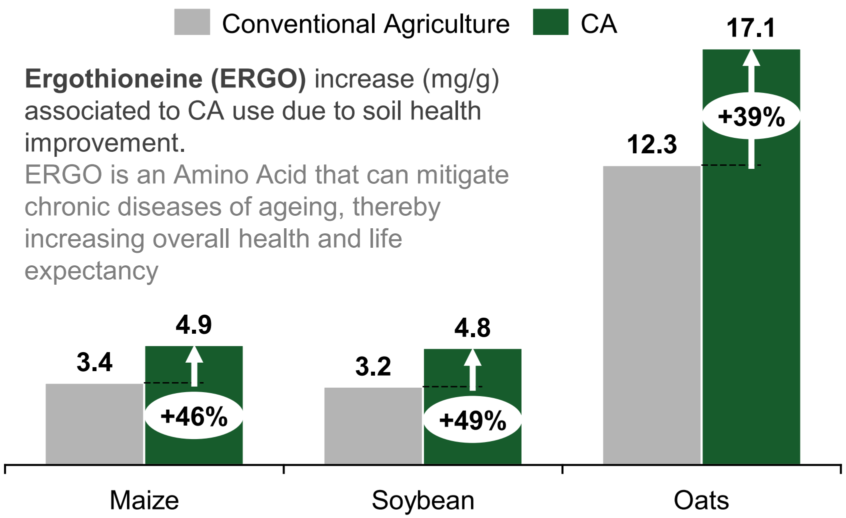
45%

Crops under CA have, on average, 45% more Ergothioneine (an anti-ageing, antioxidant and anti-inflammatory Amino Acid) than conventional agriculture[1]

Quality of the food/products (ERGO)

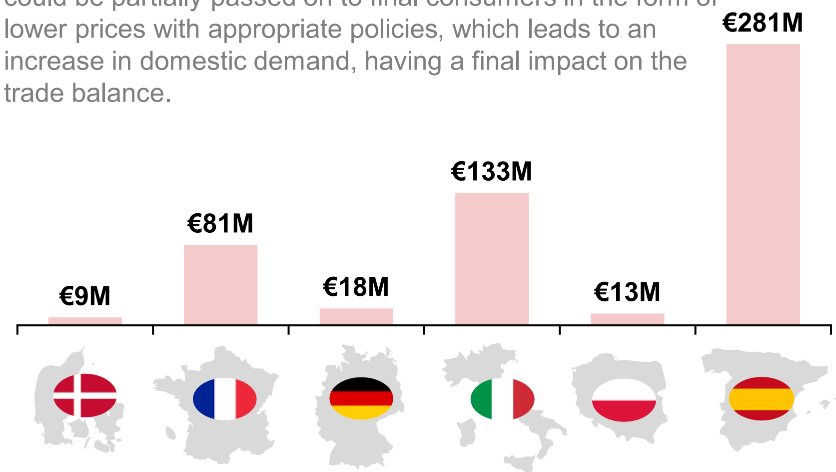
Ergothioneine (ERGO) increase (mg/g) associated to CA use due to soil health improvement.

ERGO is an Amino Acid that can mitigate chronic diseases of ageing, thereby increasing overall health and life expectancy



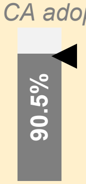
Affordability (CA contribution to agricultural crops trade balance)

Farmers using CA techniques can get **20% savings** in production costs compared to conventional agriculture.[2] This could be partially passed on to final consumers in the form of lower prices with appropriate policies, which leads to an increase in domestic demand, having a final impact on the trade balance.



Potential scenario

CA adoption



In the maximum potential adoption scenario of CA, the **trade balance contribution** from CA could increase up to **€6,871 million,** equivalent to **35%** of the current agricultural crop trade balance in the 6 countries analysed

Note: Impact on trade balance estimated according to: 20% cost reduction in hectares under CA, 23% share of final price of CA crops based on USDA breakdown prices of different crops and final food products, pass-through of farmers of 80%, and import, export and consumption elasticities based on Ghodsi et al (2016) and PwC internal analysis. 1) International evidence from Beelman, R. B., et al. (2021). 2) Schmitz, Mal and W. Hesse (2015). Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on FAO, Eurostat, The Economist Group, USDA, Beelman, R. B. et al (2021), Ghodsi et al (2016), Schmitz, Mal and W. Hesse (2015) and technical support from PwC.

In addition, reducing food prices through the use of CA creates an opportunity to reduce food insecurity figures and support the most vulnerable households

1%

of households, on average, are classified as severely food insecure

Prevalence of severe food insecurity (% of households)

1.1%

1.2%

0.7%

0.5%

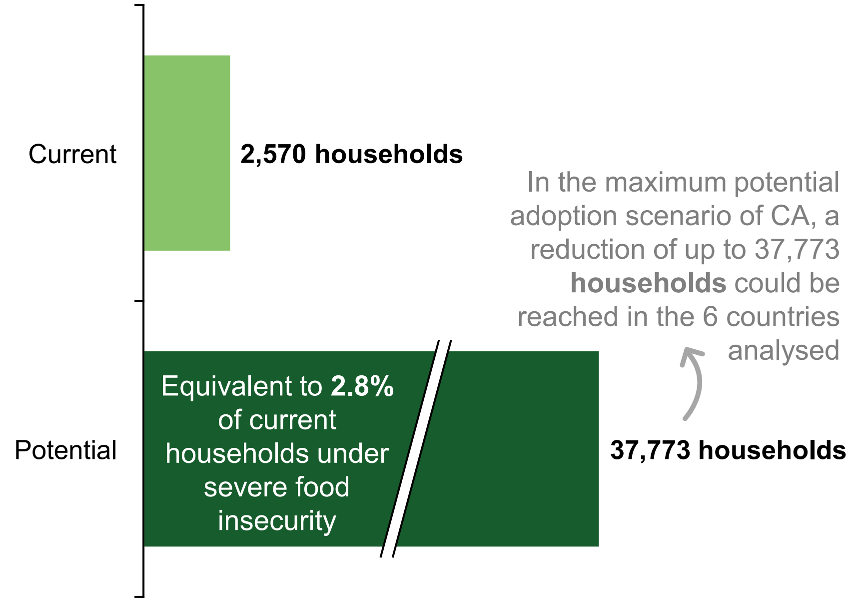
0.7%

1.8%

Relationship between changes in food prices and prevalence of food insecurity (%)

2,570 households

The reduction in food prices from the use of CA can be associated to a reduction of about 2,570 households that live under severe food insecurity in the 6 countries analysed



Note: Food insecure household: when at least one adult in the household has reported to have been forced to reduce the quantity of the food, to have skipped one meals, having gone hungry, or having to go for whole day without eating because of a lack of money or other resources.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on FAO, Eurostat, The Economist Group and technical support from PwC.

To sum up, greater adoption of CA brings important food security benefits by improving food quality and affordability, especially among most vulnerable households

Food security goals

- ✓ Secure **food affordability**
- ✓ Incentive farmers to bring **additional agricultural land into production**
- ✓ **Support farmers of the member states** for specific agricultural products and input costs that are driving production challenges for farmers and putting inflation pressures on food prices

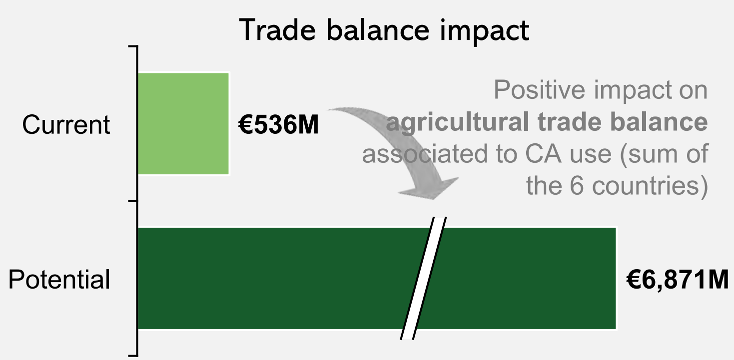
CA contribution to food security targets

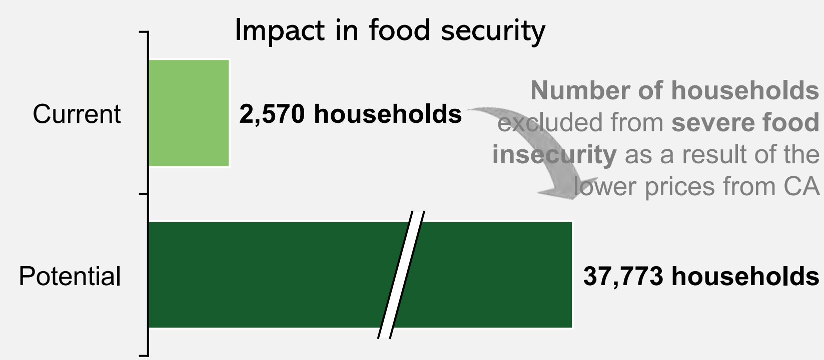
+45%

Crops under CA have, on average, 45% more Ergothioneine (an Amino Acid that can mitigate chronic diseases of ageing) than conventional agriculture

1%

of households, on average, are classified as severely food insecure



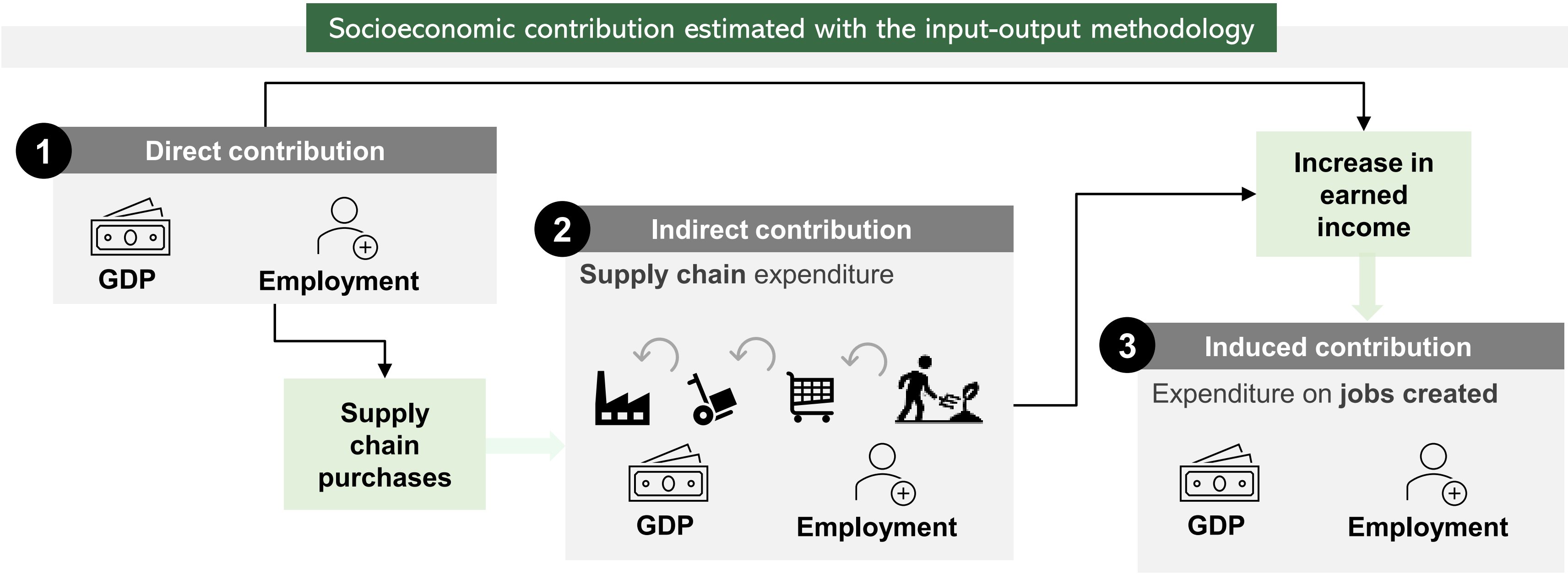


Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on FAO, Eurostat, The Economist Group, Beelman, R. B. et al (2021), Schmitz, Mal and W. Hesse (2015), Ghodsi et al (2016), FAO, Eurostat, The Economist Group, and technical support from PwC.

5. Conservation Agriculture (CA) contribution to European targets:

5.3 Socioeconomic targets

CA contribution in terms of Gross Domestic Product (GDP) and employment can be estimated by using an input-output model, which makes it possible to measure the direct, indirect and induced impacts



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.

The **input-output method** is a standard model 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

Note: Appendix A explains in detail the method used to calculate CA socio-economic contribution. We measure its relevance in socioeconomic terms without comparing CA with other agricultural techniques. In particular, we apply an approach to incorporate not only the effects generated directly by this technique, but also its effects along the value chain. This method serves as an economic tool to analyse the importance of this activity in the whole economy. The spillover effects captured by this method are referred to as indirect and induced impacts.

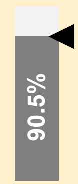
In 2021, the GDP contribution from CA totalled over €13,800 million, of which 51% is generated indirectly and induced due to the positive impact through the value chain

x2

For each €1 of GDP arising directly from CA, €2.0 of GDP is generated in total in the six countries analysed

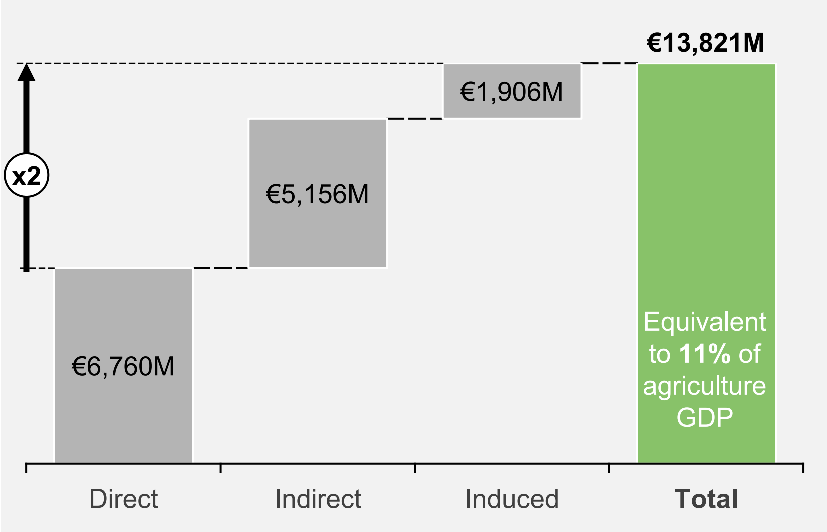
Potential

CA adoption

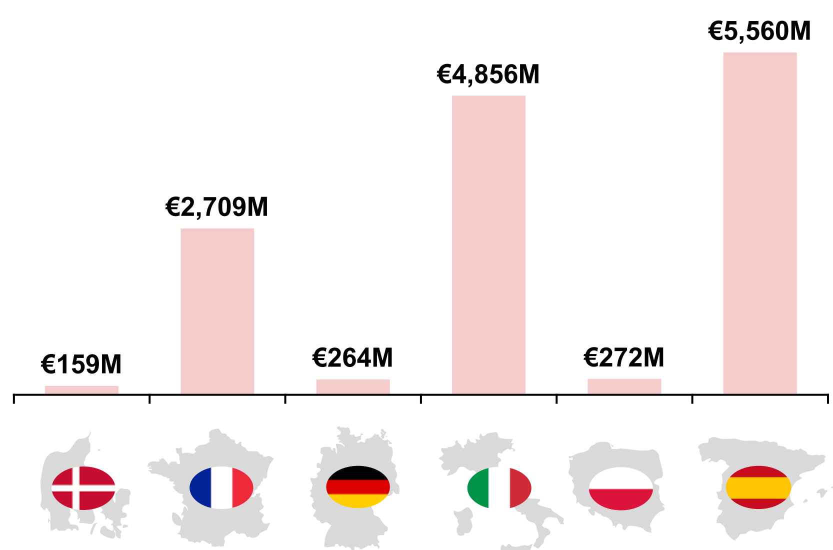


In the maximum potential adoption scenario of CA, the total GDP contribution from CA could increase up to **€163,501 million, €71,099 million** of which are generated directly

GDP contribution from CA in the six countries analysed (€M, 2021)[1]



Total GDP contribution from CA per country (€M, 2021)



1) GDP impacts are approximate using Gross Value Added at basic prices.
Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on OECD, Eurostat, and technical support from PwC

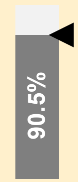
In terms of employment, the total contribution from CA reached 408 thousand workers in 2021, equivalent to 10% of agriculture employment in the six countries analysed

x33

For every million euros of output under CA in the six countries analysed, a total of 33 jobs are created (direct, indirect and induced) in the economy as a whole

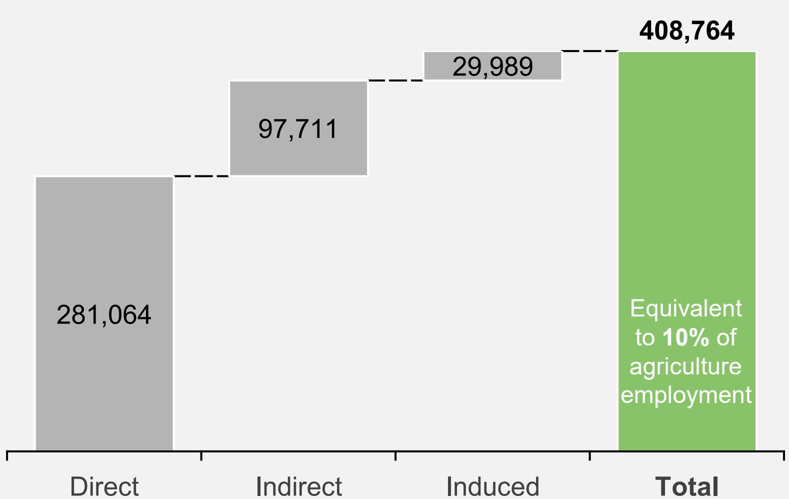
Potential

CA adoption

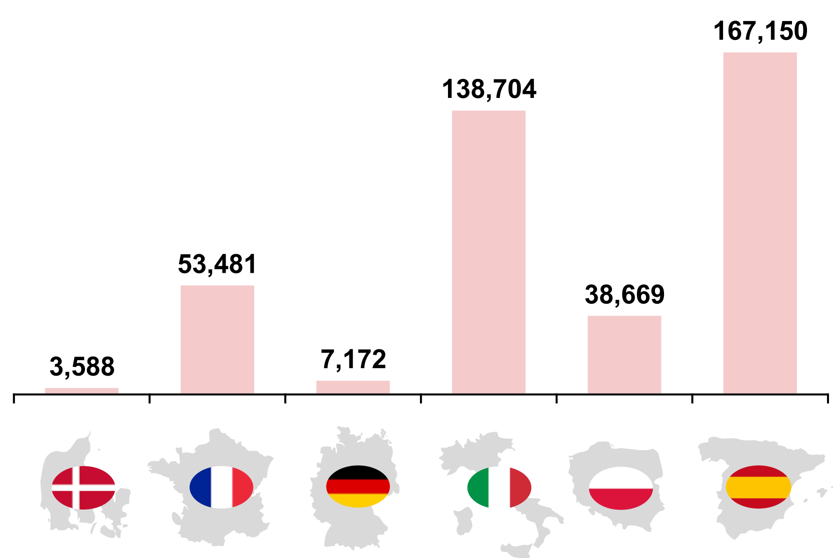


In the maximum potential adoption scenario of CA, the total employment contribution from CA could increase up to **5.6 million jobs, 3.7 million** of which are generated directly

Employment contribution from CA in the six countries analysed (2021)[1]



Total employment contribution from CA per country (2021)



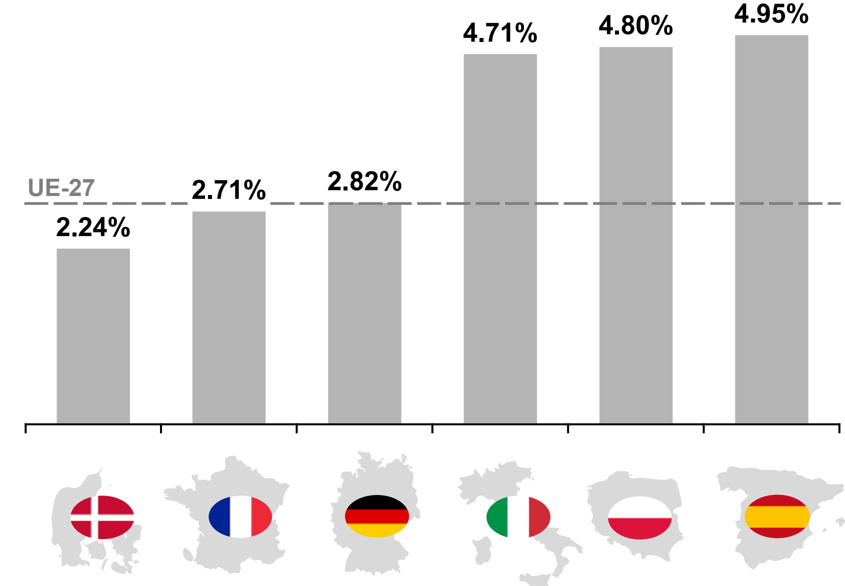
1) Absolute employment

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on OECD, Eurostat, and technical support from PwC.

Given the impact in terms of GDP and employment, CA can serve as a key agricultural technique to alleviate economic and social pressures in rural areas reducing rural abandonment and social exclusion risk

Rural abandonment by 2030 (ha, % of land)[1]

Expected agricultural land hectares abandoned by 2030

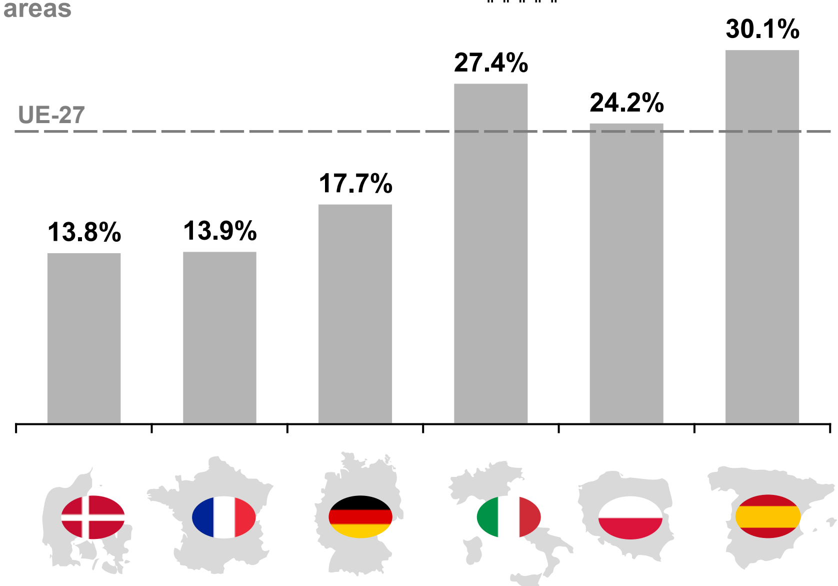


Total hectares abandoned by 2030

58k	625k	493k	453k	800k	1,096k

Risk of social exclusion in rural areas (2020)[2]

Households **at risk of poverty and/or social exclusion** that are living in rural **areas**



Total households at risk

262k	3,002k	2,853k	2,976k	3,696k	3,666k

1) Eurostat: People at risk of poverty or social exclusion by degree of urbanization (new definition). 2) The Europe 2020 strategy promotes social inclusion, in particular through the reduction of poverty. The poverty and social exclusion indicator corresponds to the sum of persons who are: (i) with a disposable income below 60 % of the national median (ii) severely constrained by a lack of resources (materially deprived) or (iii) living in households with very low work intensity (<20% of households work potential).
Source: Eurostat and LUISA Territorial Modelling Platform.

In addition, the increased time availability linked to this technique stimulates rural areas and makes them more resilient by diversifying farmers' income and improving work-life balance

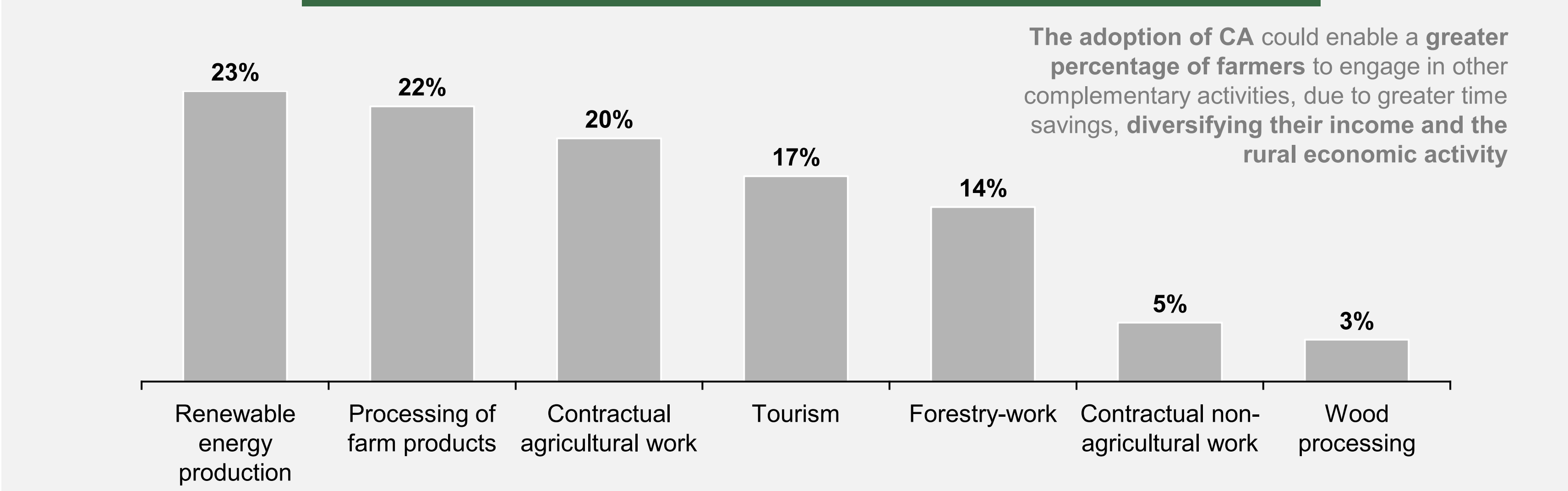
70%

On average, 70% of farm labour is carried out by the owner and his family who can devote the extra time derived from the use of CA techniques to other activities

8%

On average, 8% of farmers engage in other activities such as renewable energy production, processing farm products, further agricultural work or tourism related works

Main activities complementing farming (average of six countries)



Source: Eurostat (2016) Survey on farm structure: Labour force main indicators and other gainful activities.

In summary, the total socio-economic benefits of CA amount to €13.8 billion and above 408 thousand jobs in the current scenario and could increase by up to 14 times in the potential scenario

Socioeconomic goals

Common Agricultural Policy (CAP) 2023-27

Economic sustainability

- ✓ Supporting viable farm income
- ✓ Increasing competitiveness
- ✓ Improving farmers' position in the value chain

Social sustainability

- ✓ Generational renewal
- ✓ Jobs, growth and equality in rural areas
- ✓ Responding to societal demands on food & health

Summary of CA socioeconomic contribution (2021)

	Total cultivated area	GDP	Employment
Potential scenario	90.5%	€163,501M	5.6 million jobs
Current scenario	6.9%	€13,821M	408,764 jobs

€2
For each €1 of GDP arising directly from CA, €2 of total GDP is generated

x33
For every million euros of output under CA, a total of 33 jobs are created (direct, indirect and induced) in the economy as a whole

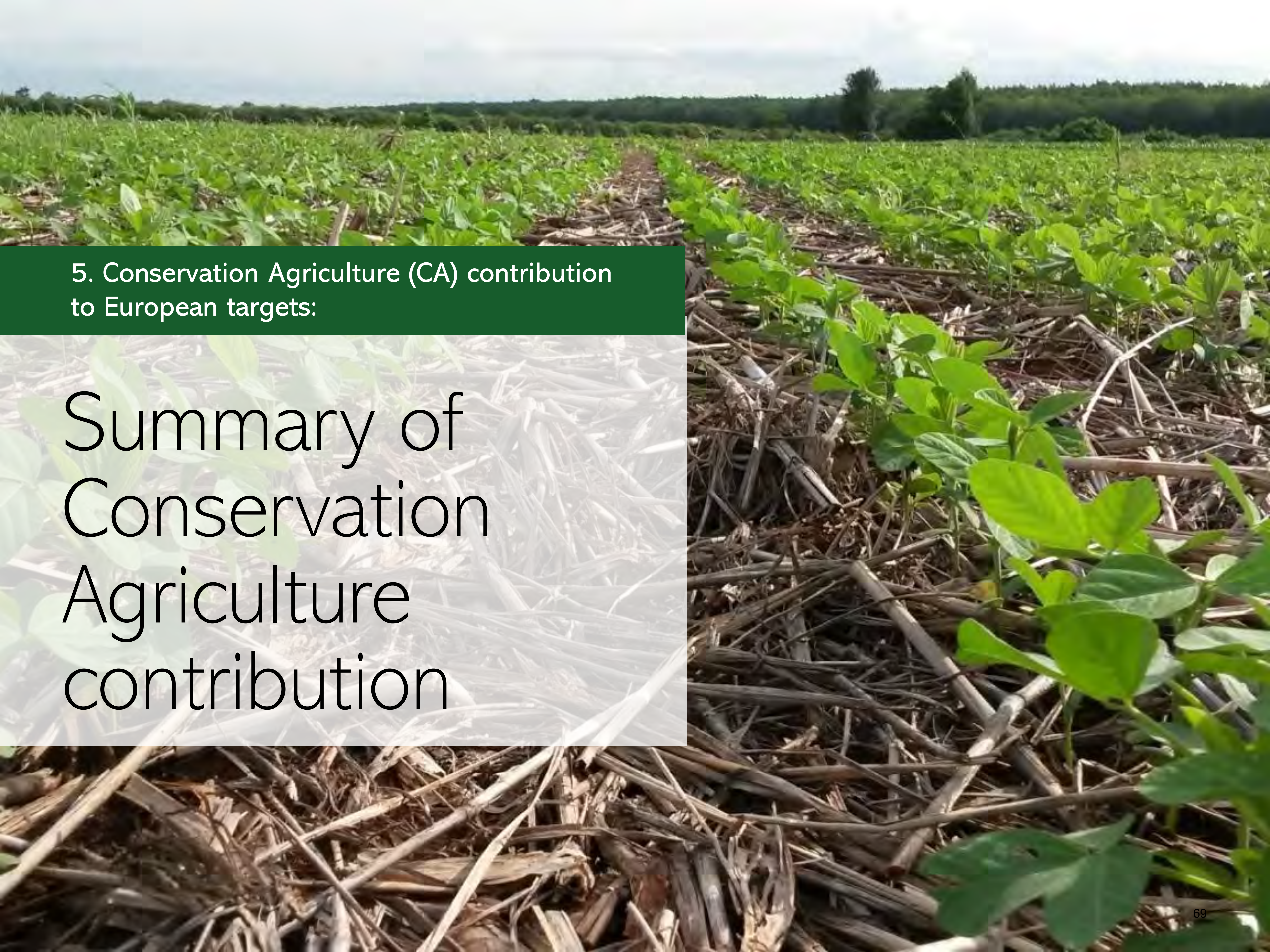
51%
On average, 51% of the total impact on GDP and employment is generated indirectly and induced

x14
The socioeconomic impact in the maximum adoption scenario would be up to 14 times greater than the current contribution from CA

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on OECD, Eurostat, and technical support from PwC.

5. Conservation Agriculture (CA) contribution to European targets:

Summary of Conservation Agriculture contribution



Taken together, the use of CA brings very relevant environmental, food security and socioeconomic benefits, which can accelerate the transformation of the agricultural sector in the coming decades

Environmental goals

Summary of CA environmental contribution

90%
The soil erosion is reduced by up to 90% using the Conservation Agriculture technique

x3
Conservation Agriculture improves water infiltration around 3 times compared to conventional tillage

x2-9
Increase between 2 and 9 times in the density and in the number of species

24%
Under the potential adoption of CA, current agricultural GHG emissions would be reduced by 24%

Food security goals

Summary of CA food security contribution

45%
Crops under CA have, on average, 45% Ergothioneine (an Amino Acid that can mitigate chronic diseases of ageing) than conventional agriculture

€536M
CA contribution to agricultural crops trade balance, which is equivalent to 3% of agricultural crop trade balance

2,570 households
Number of households excluded from severe food insecurity as a result of the lower prices from CA (six countries studied)

Socioeconomic goals

Summary of CA socioeconomic contribution

€13,821M
of CA total GDP contribution (including direct, indirect and induced impact), which is equivalent to 11% of agricultural GDP in the six countries analysed

408,764 jobs
of CA total employment contribution (including direct, indirect and induced impact), which is equivalent to 10% of agricultural employment in the six countries analysed

Source: ECAF, SEGES, FRDK, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on Eurostat, European Commission, OECD, INE, AEAC.SV, FAO, The Economist Group, Centre d'études et de prospective (2013), Schmitz, M., Mal, P., Hesse, J., (2015), Carreta, L. et al (2021), Søby, Julie Marie (2020), Beelman, R. B., et al. (2021), Ghodsi et al (2016), and technical support from PwC.

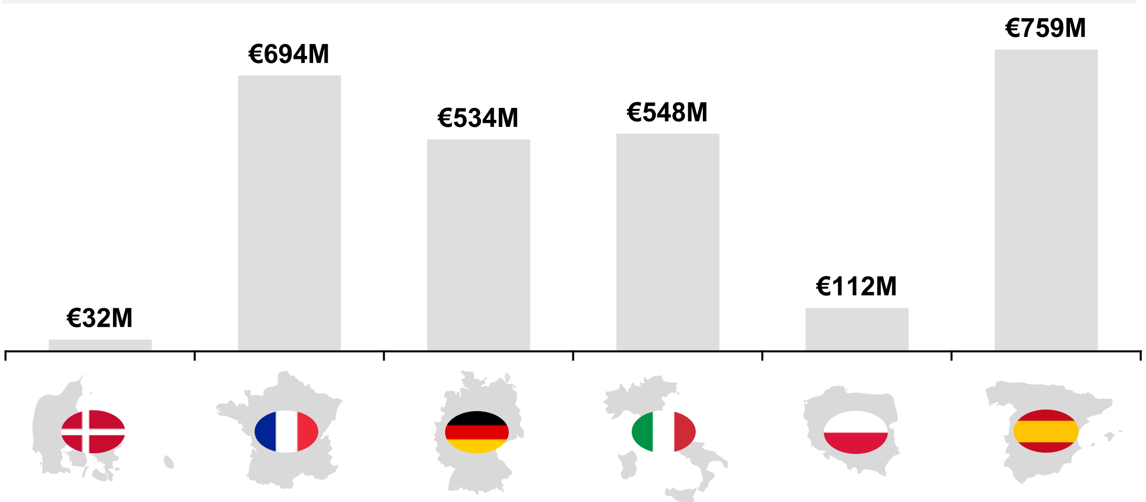

Appendix A
> Glyphosate socioeconomic contribution to agriculture

Considering the total use of glyphosate in the six countries analysed and the yield increase associated to its use, about €2,680 million of total crop production can be linked to the use of glyphosate

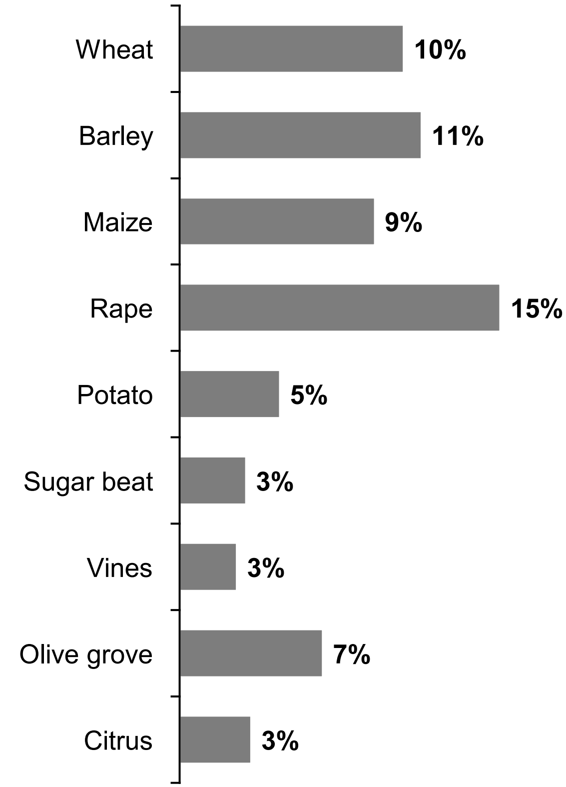
€2,680 million

On average, glyphosate is estimated to be responsible of €2,680 million of the current crop production in the 6 countries analysed

Crop output associated to glyphosate use



Average yield decrease without the use of glyphosate (%)



Note: Hectares treated with glyphosate estimated based on Antier, C., et al. (2020) for France, Germany and Italy (vineyard and olive grove); Kynetec for Denmark and Poland; and MAPA: Encuesta de Utilización de Productos Fitosanitarios Campaña 2019 (August 2021) for Spain. Hectares have been completed for some specific crops using Eurostat database: potato and sugar beat in France, wheat, maize, rape, fruit orchards and potato in Italy. To take into account the limitations on the use of glyphosate introduced in France in 2021, we applied a reduction for each crop analysed based on the limitations of the plot area and the reduction compared to the previously authorized maximum rate from ANSES (2020). Source: ECAF and colaborating entities based on Eurostat, Keynetec, European crop protection (2020), European Crop Protection (2016), Luchia Garcia-Perez & Harriet Illman (2020), Antier, C., et al. (2020), and technical support from PwC.

As a result of increased yields, glyphosate total annual socio-economic contribution in the six countries amounts to €2,799 million of GDP and 63,262 jobs

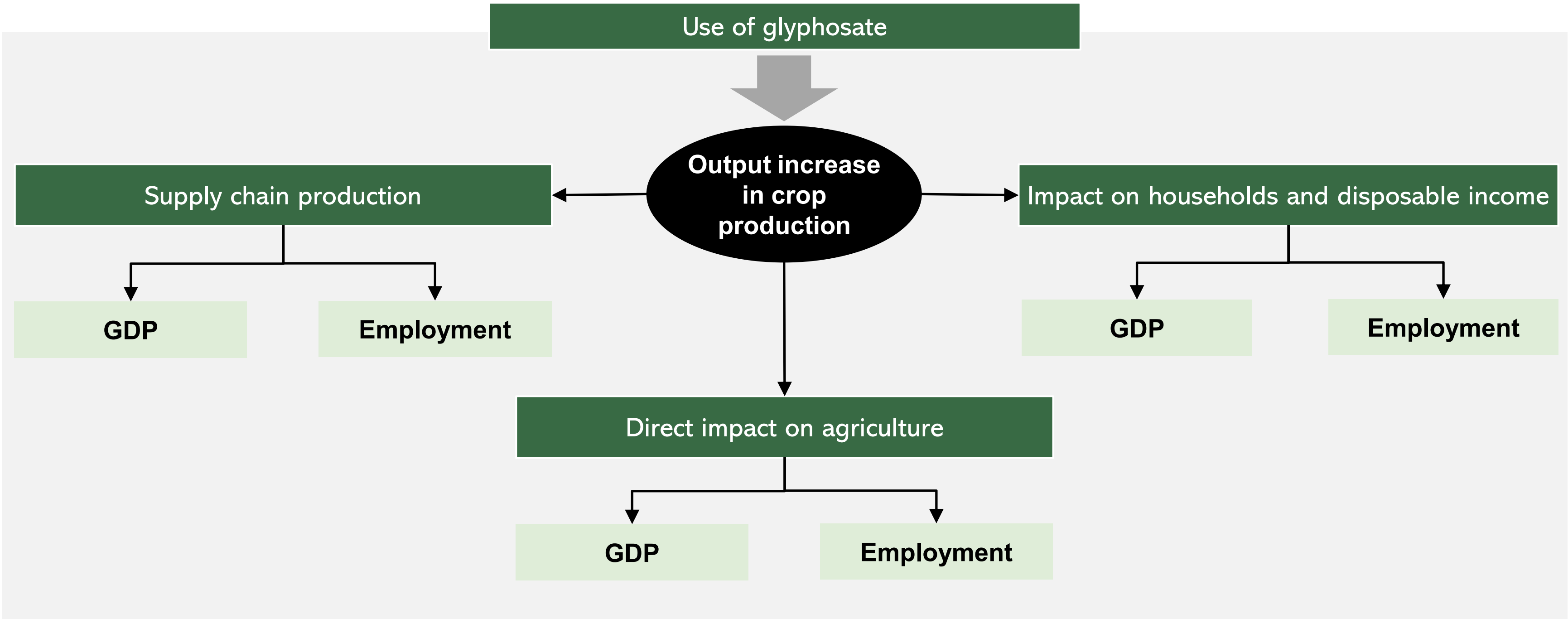
Glyphosate macroeconomic contribution (2021, annual impacts)

	GDP (€M)			Employment (absolute)		
	Direct contribution	**Spillover effects[1]** *associated sectors and households*	**Total contribution** *(Equivalent to % of crop GVA)*	**Direct contribution**	**Spillover effects[1]** *(associated sectors and households)*	**Total contribution** *(Equivalent to % of agriculture employment)*
	€6M	**€27M**	**€33M** (1.7%)	**160**	**332**	**492** (0.9%)
	€326M	**€465M**	**€791M** (2.3%)	**5,798**	**6,574**	**12,372** (2.0%)
	€185M	**€196M**	**€381M** (2.0%)	**4,398**	**3,651**	**8,049** (1.8%)
	€362M	**€321M**	**€684M** (2.1%)	**9,443**	**5,442**	**14,885** (1.7%)
	€36M	**€72M**	**€108M** (1.3%)	**5,657**	**4,132**	**9,789** (0.7%)
	€413M	**€388M**	**€801M** (2.7%)	**10,300**	**7,374**	**17,675** (2.4%)

1) Details on spillover impacts are shown in the next slide.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on Eurostat, OECD, European crop protection (2020), European Crop Protection (2016), Luchia Garcia-Perez & Harriet Illman (2020), Antier, C., et al. (2020), and technical support from PwC.

The indirect contribution has been estimated based on the interrelationship of the farming industry with suppliers and households for each country



The estimated impacts are based on information on **costs incurred by the agricultural industry in Denmark, France, Germany, Italy, Poland and Spain,** all obtain from the **Input-Output OECD tables for each country**. In addition to the impact on supply, the use of glyphosate also has an impact on disposable income in households. This effect was also calculated with the input-output model given the rise in the number of employed persons and thus in the volume of wages and salaries associated to the increase in crop production. A detailed explanation of the input-output model can be found in Appendix B: Input-Output methodology.

Source: ECAF, Université Fédérale Toulouse Midi-Pyrénées, Fachhochschule Südwestfalen, Università degli studi di Teramo and Universidad de Córdoba based on OECD and technical support from PwC.

Appendix B

> Input-Output methodology

Method for estimating the socioeconomic contribution
Input-output model (1/2)

Input-output method

This methodology has been use to estimate the socio-economic contribution made by Conservation Agriculture (Section 5.3.) and glyphosate (Appendix A). Both have been estimated independently using the input-output model, built on data from OECD.

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 36 in Denmark's National Accounts), y is a column vector representing final demand in each sector, and A is a matrix (36 rows x 36 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:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \dots \\ X_{36} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{163} \\ a_{21} & a_{22} & a_{23} & \dots & a_{263} \\ a_{31} & a_{32} & a_{33} & \dots & a_{363} \\ & & \dots & & \\ a_{361} & a_{662} & a_{363} & \dots & a_{363} \end{bmatrix} * \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \dots \\ X_{36} \end{bmatrix} + \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \dots \\ y_{36} \end{bmatrix}$$

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, …, 36, while a_{11}, a_{21}, a_{31}, …, a_{36} are the weights of the output of sector 1 goods and services demanded, respectively, from sectors 1, 2, 3, …, 36.

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.

Method for estimating the socioeconomic contribution

Input-output model (2/2)

Input-output method

The output multiplier matrix used in our analysis was calculated using data published by the OECD. 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 OECD 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.

Estimation of the direct contribution

The direct contribution made by Conservation Agriculture to 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.

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 2021. These costs and investments were estimated using information extracted from the input-output tables 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 OECD, the industry multiples were calculated. These multiples indicate the impact in terms of output and employment in Denmark 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 economy, as well as the amount of costs incurred and investments made in each of these sectors by the farming industry.

References

References (1/3)

AEAC.SV (2019). Sinergias de la agricultura de conservación en el control de malas hierbas. http://agriculturadeconservacion.org/images/SINERGIAS_DE_LA_AC_EN_EL_CONTROL_DE_MALAS_HIERBAS.pdf

Agricare (2017). Introducing innovative precision farming techniques in AGRIculture to decrease CARbon Emissions, LIFE13 ENV/IT/000583. https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=4934

Agriscienza (2022). Article (in Italian): Glifosate in cifre: quanto costerebbe all'italia la revoca europea dell'erbicida. https://agriscienza.it/glifosate-in-cifre-quanto-costerebbe-allitalia-la-revoca-europea-dellerbicida/

Antier, C., Andersson, R., Auskalnienė, O., Barić, K., Baret, P., Besenhofer, G., Calha, I., Carrola Dos Santos, S., De Cauwer, B., Chachalis, D., Dorner, Z., Follak, S., Forristal, D., Gaskov, S., Gonzalez Andujar, J. L., Hull, R., Jalli, H., Kierzek, R., & al. (2020). A survey on the uses of glyphosate in European countries. INRAE. http://www.endure-network.eu/content/download/8352/55633/file/ENDURE_Glyphosate_Report.pdf

APAD (2021). Livre Blanc: ACS et Potentiels de Stockage Carbone. https://www.reseaurural.fr/sites/default/files/documents/fichiers/2020-12/2020_rrf_rapport_mcdr_Livre_blanc_ACS_carone_apad.pdf

Arnal Atares, P. (2014). Ahorro energético, de tiempos de trabajo y de costes en agricultura de conservación. Agricultura de Conservación 27, 36-43. http://www.agriculturadeconservacion.org/index.php/descargas/revista-ac

Axelsen, J. (2019). Conservation agriculture - slå mange fluer med et smæk. Høring på Christiansborg i Folketingets Energi-, Forsynings- og Klimaudvalg, 23 april 2019. https://www.ft.dk/samling/20181/almdel/EFK/bilag/258/2048654/index.htm

Baker C.L., Saxton, K.E., Ritchie, W.R., Chamen, W.C.T., Reicosky, D.C., Ribeiro, M.F.S., Justice, S.E., Hobbs, P.R., 2007. No-tillage Seeding in Conservation Agriculture (2nd ed.). Baker, C.L. and Saxton, K.E. (Eds.). FAO, ISBN: 92-5-105389-8

Beelman, R. B., Richie Jr, J. P., Phillips, A. T., Kalaras, M. D., Sun, D., & Duiker, S. W. (2021). Soil disturbance impact on crop ergothioneine content connects soil and human health. Agronomy, 11(11), 2278. https://www.mdpi.com/2073-4395/11/11/2278#

Białczyk, W., Cudzik, A., Czarnecki, J., Brennensthul, M., & Kaus, A. (2012). Ocena systemów uprawy w aspekcie zużycia paliwa, plonowania roślin i właściwości gleby. *Inżynieria Rolnicza*, *16*, 17-27. http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BAR0-0067-0064

Carretta, L., Tarolli, P., Cardinali, A., Nasta, P., Romano, N., & Masin, R. (2021). Evaluation of runoff and soil erosion under conventional tillage and no-till management: A case study in northeast Italy. Catena, 197, 104972. https://doi.org/10.1016/j.catena.2020.104972

Centre d'études et de prospective (2013). L'agriculture de conservation, nº 61. https://agriculture.gouv.fr/lagriculture-de-conservation-analyse-ndeg61

Cillis, D. (2018). Introducing innovative precision farming techniques in agriculture to decrease carbon emissions. http://hdl.handle.net/11577/3425242

European commission (2019). The European Green Deal. COM(2019) 640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

European commission (2020). EU Biodiversity Strategy for 2030. COM(2020) 380 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380

European commission (2021). The new common agricultural policy: 2023-27. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27_en

European commission (2022). Safeguarding food security and reinforcing the resilience of food systems. COM(2022) 133 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:133:FIN

European Crop Protection (2020). Low Yield II Cumulative impact of hazard-based legislation on crop protection products in Europe. March 2020. https://croplifeeurope.eu/wp-content/uploads/2021/08/Low-Yield-Report-II.pdf

Eurostat (2020). Agri-environmental indicator - tillage practices. https://ec.europa.eu/eurostat/statisticsexplained/index.php/Agri-environmental_indicator_-_tillage_practices#Analysis_at_regional_level

Fairclough B., Mal P. & Kersting S. (2017). The economic relevance of glyphosate in Germany. Edited by Kersting S., Kleffman Group. Prepared for 'Task Force Glyphosate' https://www.gkb-ev.de/publikationen/2017/17-08-24-studie-engl.pdf

Frascarelli A. (2014). L'Italia di fronte alla riforma della PAC 2014-2020, Quaderno dellacollana di Europe Direct Veneto, n. 16, Veneto Agricoltura, Legnaro (PD), p. 15-103, ISBN: 978-88-6337-139-0.

Ghodsi, M., Grübler, J., Stehrer, R. (2016). Imported Demand Elasticities Revisted. The Vienna Institute for International Economic Studies. Working paper 132, November. https://wiiw.ac.at/import-demand-elasticities-revisited-p-4075.html

References (2/3)

González-Sánchez, E. J., Carbonell, R., Veroz, O., Gil-Ribes, J. A., Ordóñez, R. (2012). Meta-Analysis on atmospheric carbon capture in Spain through the use of conservation agriculture. Soil and tillage Research 122, 52-60. https://doi.org/10.1016/j.still.2012.03.001

González-Sánchez, E., Moreno M., Kassam A., Holgado A., Triviño P., Carbonell R., Pisante M., Veroz O. and Basch G. (2017) Making Climate Change Mitigation and Adaptation Real in Europe. ECAF, ISBN:978-84-697-4303-4. http://dx.doi.org/10.13140/RG.2.2.13611.13604

Hundebøl, NRG & Axelsen, JA (2022) Eurasian Skylarks in conservation agriculture DOFT (Dansk Ornitologisk Forenings Tidsskrift 116,1 p17-24. https://pub.dof.dk/artikler/2492/download/doft-116-2022-17-24-sanglaerker-i-conservation-agriculture

INRAE (2019a). Alternatives au glyphosate en viticulture. Evaluation économique des pratiques de désherbage. hal-02790508. https://www.inrae.fr/actualites/alternatives-au-glyphosate-grandes-cultures-evaluation-economique

INRAE (2019b). Alternatives au glyphosate en arboriculture. Evaluation économique des pratiques de désherbage. hal-02500402. https://www.inrae.fr/actualites/alternatives-au-glyphosate-grandes-cultures-evaluation-economique

INRAE (2021). Alternatives au glyphosate en grandes cultures. Evaluation économique. hal-02496282. https://www.inrae.fr/actualites/alternatives-au-glyphosate-grandes-cultures-evaluation-economique

Kassam, A., Friedrich, T., & Derpsch, R. (2022). Successful experiences and lessons from conservation agriculture worldwide. Agronomy, 12(4), 769. https://doi.org/10.3390/agronomy12040769

Krogh, P.H. and Qin, J. (2018). Effect of reduced tillage and conservation agriculture systems on earthworm and microarthropod populations assessed by conventional meth-ods and by metabarcoding. AU eDNA Center and Institute for BioScience, Aarhus Uni-versity. https://sp.landbrugsinfo.dk/Afrapportering/innovation/2018/Sider/Pl_18_2706_Rapport_jordbundsfaunaen_Aulum_Jerslev.pdf

Lal, R., 2015. Sequestering carbon and increasing productivity by conservation agriculture. Journal of Soil and Water Conservation 70, 55A-62A. https://doi.org/10.2489/jswc.70.3.55A

*Luchia Garcia-Perez & Harriet Illman (2020). Socio-economic value of glyphosate: A review of EU studies assessing the value of glyphosate to the agriculture industry. https://issuu.com/cropprotection/docs/glyphosate_final_report_eu_results_*

MAPA: ESYRCE (2021). Encuesta sobre superficies y rendimientos de cultivos. Ministerio de Agricultura, Alimentación y Medio Ambiente. España. https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/agricultura/esyrce/

Munkholm, L. J., Hansen, E. M., Melander, B., Kudsk, P., Jørgensen, L. N., Heckrath, G. J., Ravnskov, S. og Axelsen, J. (2020). Vidensyntese om Conservation Agriculture. Aarhus Universitet, DCA - Nationalt Center for Fødevarer og Jordbrug. 134 s. - DCA rapport nr. 177. https://dcapub.au.dk/djfpdf/DCArapport177.pdf

Montanarella, L., & Panagos, P. (2021). The relevance of sustainable soil management within the European Green Deal. Land use policy, 100, 104950. https://www.sciencedirect.com/science/article/pii/S0264837720304257/pdf?isDTMRedir=true&download=true

Onnen, N., Heckrath, G., Stevens, A., Olsen, P., Greve, M. B., Pullens, J. W., ... & Van Oost, K. (2019). Distributed water erosion modelling at fine spatial resolution across Denmark. Geomorphology, 342, 150-162. https://doi.org/10.1016/j.geomorph.2019.06.011

Perpina Castillo, C., Kavalov, B., Diogo, V., Jacobs-Crisioni, C., Batista e Silva, F., & Lavalle, C. (2018). Agricultural land abandonment in the EU within 2015-2030 (No. JRC113718). Joint Research Centre (Seville site). https://joint-research-centre.ec.europa.eu/document/download/fd756a75-5aba-4051-9aaa-e1c21485f34d_en?filename=jrc113718.pdf

Petersen PH., Krog J., Fabricius C. & Jensen JE (2021). Omkostninger ved udfasning af glyphosat i dansk landbrug. SEGES Rapport Promilleafgiftsfonden, project no. 7840. https://www.landbrugsinfo.dk/basis/1/b/d/plantebeskyttelse_omkostninger_udfasning_glyphosat

Petito, M., Cantalamessa, S., Pagnani, G., Degiorgio, F., Parisse, B., & Pisante, M. (2022). Impact of Conservation Agriculture on Soil Erosion in the Annual Cropland of the Apulia Region (Southern Italy) Based on the RUSLE-GIS-GEE Framework. Agronomy, 12(2), 281. https://www.mdpi.com/2073-4395/12/2/281

Pisante M. (2019). Editoriale: Agricoltura conservativa, vent'anni di crescita. TerraèVita, 29: 1.

Pisante M. (2020). Conservativa e precisa l'agricoltura dei risultati. Speciale EIMA Digital.TerraèVita, 32: 48-50.

References (3/3)

Ponisio L.C., M'GONIGLE L.K., Mace K.C., Palomino J., De Valpine P. et al. (2015). Diversification practices reduce organic to conventional yield gap. Proceedings of the Royal Society B: Biological Sciences. doi: 10.1098/rspb.2014.1396.

Schmitz, M., Mal, P., Hesse, J. (2015). The Importance of Conservation Tillage as a Contribution to Sustainable Agriculture: A special Case of Soil Erosion . Agribusiness-Forschungt. 33, ISSN 1434-9787. http://www.agribusiness.de/images/stories/Forschung/Agribusiness_Forschung_33_Conservation_Tillage.pdf

Søby, Julie Marie (2020). Effects of agricultural system and treatments on density and diversity of plant seeds, ground-living arthropods, and birds. https://www.ft.dk/samling/20201/almdel/KEF/bilag/109/2300225/index.htm

Steward Redqueen (2017). The cumulative agronomic impact of glyphosate in Europe. Impact of Glyphosate on European agriculture. https://croplifeeurope.eu/report/the-cumulative-agronomic-and-economic-impact-of-glyphosate-in-europe/

Tebruegge, F., (2001). No-tillage visions- Protection of soil, water and climate and influence on management and farm income. En García-Torres, L. Benites, J. Martínez-Vilela, A. (eds.). I World Congress on Conservation Agriculture: Conservation Agriculture, a worldwide challenge. Volume I: 303-316. FAO, ECAF. Córdoba. https://doi.org/10.1007/978-94-017-1143-2_39

The international "4 per 1000" Initiative: Soils for Food Security and Climate. https://4p1000.org/discover/?lang=en

Thingholm, L. B. (2019). Statistical analysis Report by BiomCare. 10/12/2019 (Bacteria): https://sp.landbrugsinfo.dk/Afrapportering/innovation/2019/Sider/Pl_19_4580_Statistical_Analysis_report.pdf

Thingholm, L. B. (2020). Statistical analysis Report by BiomCare Aps. 04702/2020 (Fun-gus): https://sp.landbrugsinfo.dk/Afrapportering/innovation/2020/Sider/PM_20_4580_R3_ITS_Biostatistical_analysis_SEGES_2020_02_04.pdf

Vestergaard, A.V. et al. (2020). Kom godt i gang med conservation agriculture i Danmark. Landbrug & Fødevarer F.m.b.A. SEGES. https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/a/6/2/rapport_conservation_agriculture_danmark.pdf

Thank you