# EGDC Case study: Ekobot

Case Study Methodology

April 2024

Provided by: Telia

EUROPEAN GREEN DIGITAL COALITION

Funded by the European Union

**Deliverable name:** EGDC Case study: Ekobot

**Dissemination Level:** Public

**Published:** April 2024

**Developed:** February 2024

**Prepared by:** Deloitte

The European Green Digital Coalition (EGDC) is an initiative of companies, supported by the European Commission and the European Parliament, based on the request of the EU Council, which aims to harness the enabling emission-reducing potential of digital solutions to all other sectors.

The secretariat of the European Green Digital Coalition is managed by the consortium of the European Parliament Pilot Project for the EGDC, funded by the European Commission, namely the leading associations GeSI, the European DIGITAL SME Alliance, DIGITALEUROPE, ETNO and GSMA, working together with Carbon Trust, Deloitte, and Sustainable ICT Consulting.

This deliverable has been produced by the consortium of the European Parliament Pilot project for the EGDC.

Global Enabling Sustainability Initiative (Coordinator)

DIGITALEUROPE

European Telecommunications Network Operators' Association

European DIGITAL SME Alliance

SUB-CONTRACTORS

Carbon Trust

Deloitte

GSMA

Sustainable ICT Consulting

# 1 Introduction

The European Green Digital Coalition (EGDC) is an initiative of companies, supported by the European Commission and the European Parliament, based on the request of the EU Council, which aims to harness the enabling emission-reducing potential of digital solutions on all other sectors.

The main aim of the EGDC is to maximise the sustainability benefits of digitalisation within the ICT sector, while supporting sustainability goals of other key sectors such as energy, transport, agriculture, and construction. The Coalition recognises the need for science–based methods to estimate the reduction and avoidance of greenhouse gas (GHG) emissions by specific ICT solutions across sectors. This will accelerate the sustainability and circular transitions of these sectors while contributing to an innovative, inclusive, and resilient society.

To support the EGDC, a set of case study calculators are developed to provide a practical example of calculating the net carbon impact of a green digital solution in line with the European Green Digital Coalition (EGDC) methodology. This work aims to support the members of the EGDC with Action 2 of the EGDC Declaration.

This case study methodology accompanies the 'Ekobot' case study calculator and provides further details, additional context and transparency around the case study calculator to ensure the outcomes of the case study are interpreted and used correctly.

## Disclaimer for European Parliament Pilot Project – European Green Digital Coalition (EGDC) Case Studies

The following disclaimer is intended to provide clarity and context for the case studies prepared as part of the EP Pilot Project, which have showcased the net carbon impact of specific digital solutions using the EGDC ICT Methodology developed during the project:

**1. Purpose of the Case Studies:**

The case studies served multiple purposes, including:

- **Development of the Methodology:** They contributed to the development of the EGDC ICT Methodology. These case studies were conducted concurrently with the methodology's creation and served as a valuable testing ground for its initial formulation.
- **Application Examples:** They provided practical examples of how the methodology can be applied to real-life use cases. These case studies were essential in demonstrating the practicality and effectiveness of the methodology when applied to concrete situations.
- **Identification of Improvement Areas:** By conducting these case studies, we aimed to highlight parts of the calculation in need of improvement. They shed light on the challenges and limitations inherent in using available data and indicated the necessary steps to move towards best practices in assessing net carbon impacts.

**2. Data Quality as a Key Determinant:**

It is imperative to emphasize that data quality is a fundamental determinant of the quality and reliability of the case studies. The accuracy and completeness of the data used significantly influence the outcomes and findings of these case studies.
It is essential to acknowledge that the data available for each case study may differ in terms of accuracy, granularity, and coverage. As a result, the case studies may not necessarily represent the best practice application of the EGDC ICT Methodology. Instead, they reflect the application of the methodology at various stages of data availability.

**3. Liability for Errors/Omissions:**

While reasonable steps have been taken to ensure that the information contained within the case studies is correct, the EGDC gives no warranty and makes no representation as to its accuracy. We accept no liability for any errors or omissions that may be present in the case studies, methodology, or related information. Users and readers are advised to exercise their judgment and seek further clarification if needed, as the information provided may evolve over time and depend on external factors beyond our control.

**4. Appropriate Use of the Case Study Calculators:**

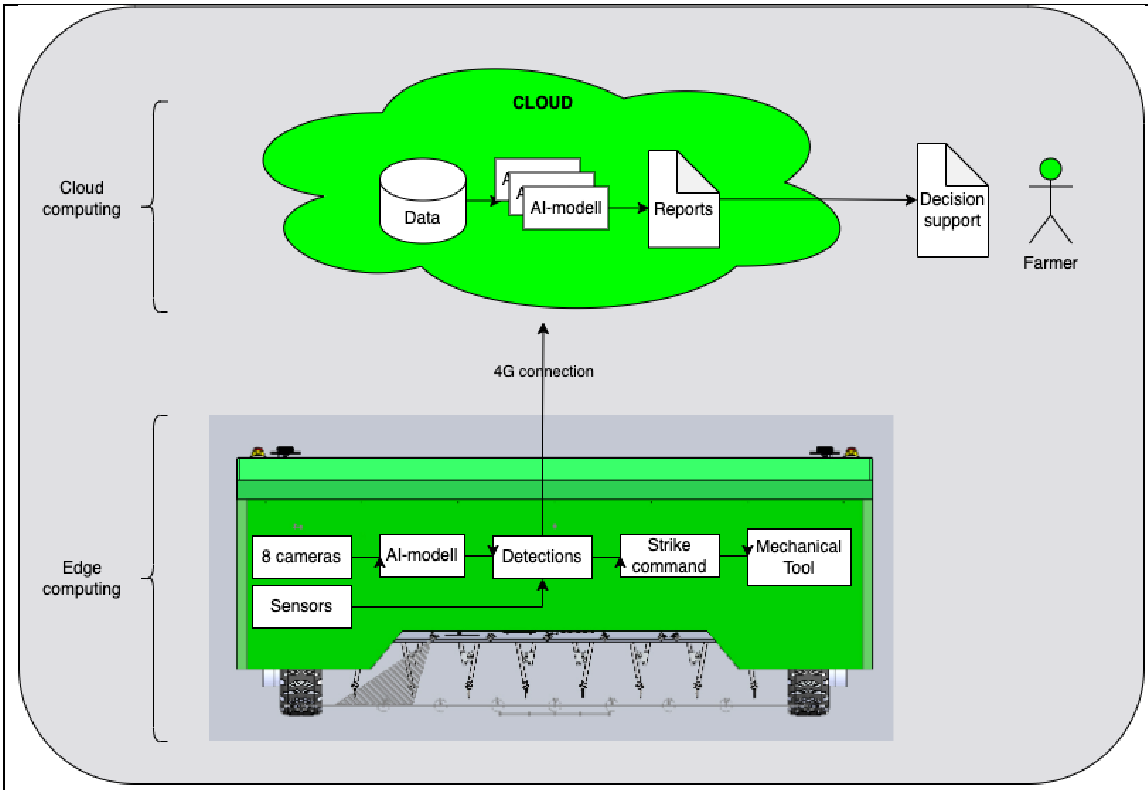
The case study calculators are intended for educational and informational purposes. They rely on certain assumptions and input data to generate results.
The results of the calculators are specific to the implementation of the ICT solution and may not be representative for other implementation contexts.
As such, it is imperative for users to refrain from directly extrapolating these results to ICT solutions or implementation contexts that may seem conceptually similar.
Instead, users are advised to use the calculators as a means to understand the practical application of the EGDC ICT Methodology, thereby equipping themselves with the knowledge required to develop customized calculators specifically tailored to their unique ICT solutions and implementation circumstances.

In conclusion, these case studies provide valuable insights into the calculation of the net carbon impact of digital solutions through the practical application of the EGDC ICT Methodology. However, it is vital to exercise caution when interpreting the results, considering the variances in data quality and the evolving nature of the methodology. The findings are indicative of the methodology's potential and its room for refinement as we work towards more accurate and comprehensive assessments of net carbon impacts.

# 2 Methodology

| Ekobot | |
|---|---|
| **Assessment Objective** | The assessment is intended to determine to what extent Ekobot solution can have a net positive impact on the agricultural sector when implemented in a specific context. Furthermore, the aim of the assessment was also to test the EGDC ICT Sector Guidance for Net Carbon Impact Assessments and identify sector-specific methodological considerations.<br><br>The assessment only considers one implementation context, namely deployment of Ekobot in Sweden operating on onion fields.<br><br>The assessment is ex-post, determining the actual effect of the ICT solution by analysing data from 2-month trial in 2022 after implementation of the solution.<br><br>The calculator considers both organic and conventional farming. Please note that when selecting organic in the calculator, results will not be aligned to the EGDC ICT methodology as calculations for these are based on secondary data. |
| **Solution description** | Ekobot is a listed Swedish company that provides customers with autonomous field robots for mechanical weed control. It allows for efficient and environmentally conscious farming. Ekobot can identify and mechanically remove weeds using advanced camera sensors and Artificial Intelligence. It enables reductions in the use of chemicals on the field for healthier crops, soil, and produce.<br><br>It reduces greenhouse gases in three distinct ways. First, it lowers fossil fuel usage normally consumed by tractors. Next, for conventional farms it diminishes the use of herbicides, fungicides, and any type of pesticides, henceforth |

| | |
|---|---|
| | collectively referred to as "chemicals". Finally, it boosts yields, optimising field use.<br><br>The solution is currently being demo-ed in Sweden and the Netherlands. All measurements included into the assessment were taken in Sweden.<br><br>The solution has the potential to be deployed on conventional and organic crop fields, however currently it has only been tested on onion fields. All measurements included into the assessment were taken in onion fields. There are no other known limitations to using the solution. |
| **Solution boundary** | The solution's components include the following:<br>- Frame, including electronics, its roof, wheel system, gearboxes, tool carrier, tool engines and tool frames;<br>- Li-ion battery and battery case<br>- Electrical wiring<br>- Tool glider<br>- Electronics hardware<br>- Wheels<br><br>The robot weighs 464 kilogrammes. Ekobot did not specify whether the robots were manufactured by Ekobot itself or by a third party.<br><br>Moreover, the autonomous robot infrequently connects to a cloud-based server through 4G connectivity. Ekobot estimates this to have been 2 vCPU during the trial. In Sweden, connectivity was provided by Telia.<br><br>The robot's energy use totals 144.5 kWh per hectare per season (see calculation in the calculator) and has been included in the calculations. |




| | |
|---|---|
| **Functional Unit** | The function of the solution is improving the efficiency in crop yield and associated energy intensity.<br><br>The unit quantity is the improved tonnes of yield per season.<br><br>The performance is related to the improved efficiency of crop yield within the crop growing season.<br><br>The functional unit chosen is kg $CO_2e$ per tonnes yield per season. In the reference scenario this was 56 days. Ekobot estimated there to be 1 season per year.<br><br>The tonnes yield, instead of hectares, was chosen to reflect a possible increase in yield after the introduction of the solution.<br><br>The season was chosen to reflect the economy of agriculture where most crops are harvested per season. |
| **Assessment Boundary** | The emission factors used to calculate the net carbon impact of the ICT solution cover all GHG emissions covered by the Kyoto Protocol and are reported in terms of CO2e. Furthermore, the well-to-tank and lifecycle emissions are also included in the emission factor. |

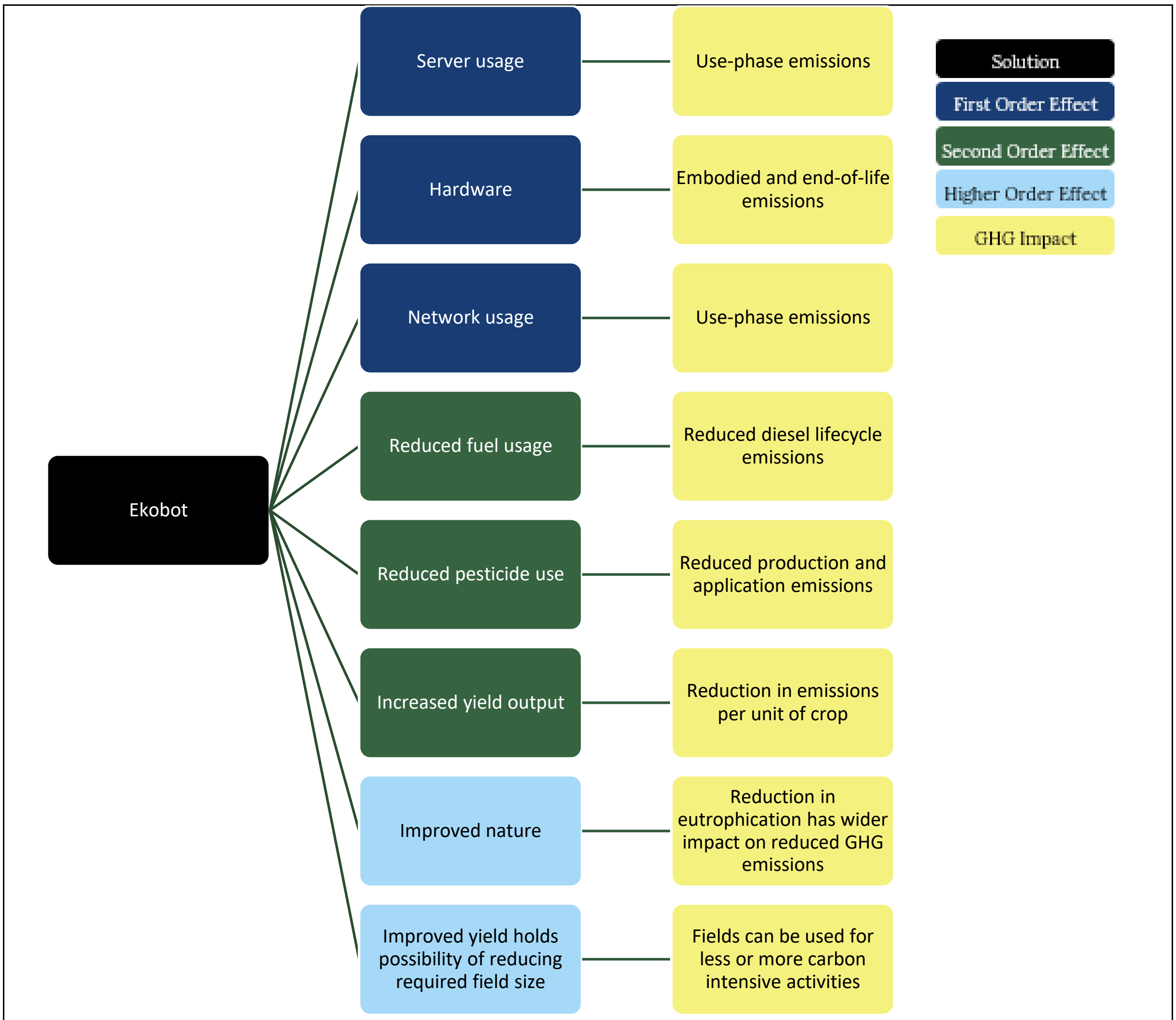
| | |
|---|---|
| | The time boundary for the assessment is a single year. The trial period in Sweden lasted two months.<br><br>The geographical boundary for the assessment is onion crop fields in Sweden. While it has not been disclosed, it is presumed these fields are flat and represent an average farm in Europe. |
| **Reference scenario** | The reference scenario was a conventional farm in Sweden, where two hectares of an onion field were tracked in a block trial. The reference block was treated with chemicals using a conventional tractor. The other block was treated with fewer chemicals and was weeded by the electric robot. The trial lasted 2 months. There were also several reference blocks. The farm in the Netherlands did not qualify for the trial since the measurements were not deemed reliable enough.<br><br>According to Ekobot, the assessment mirrored market average conditions on an average sized field.<br><br>Data was collected to acquire metrics before and after the solution of:<br>- Total yield;<br>- Amounts and types of herbicide used;<br>- Hours of conventional tractor use.<br><br>In the case of the Swedish farm, the following 6 pesticides were used:<br>- Boxer (3.5 kg / ha)<br>- Glyphosate (1 kg / ha)<br>- Gallery (0.2 kg / ha)<br>- Fenix (0.6 kg / ha)<br>- Lentagram (1.1 kg / ha)<br>- Starane 333 (0.1 kg / ha)<br><br>After the solution, the farm used<br>- Boxer (1 kg / ha)<br>- Glyphosate (1kg / ha)<br><br>During the trial, the machines ran autonomously without any requirements to be connected to a 4G network. However, during the trial, very limited diagnostic data about the machine was transmitted to the cloud via 4G. This equalled 2 vCPU per season and has been included into the calculations.<br><br>Additional estimates from the Swedish Board of Agriculture, 2020 were used for the organic farm, provided by Ekobot. |

| | |
|---|---|
| | For the assessment it was deemed not relevant to include multiple scenarios as the measured reference scenario was specific to a single crop type. There is potential to include multiple reference scenarios for different crops and geographies, which was explored. For example, a parallel trial was done in the Netherlands but did not qualify as measured data was deemed not reliable enough. |
| **Description of 1st order effects** | The following first order emission sources were identified:<br><br>- Lifecycle emissions (embodied, end of life, and in-use) of the robots. This hardware was not required before the implementation of the solution and is not part of the reference scenario.<br>- Network emissions (4G): the marginal increase in in-use network emissions is not part of the reference and has been considered for the calculation. There was no data available on this. They have been excluded from the calculation on the principle that they are not expected to meet the 5% materiality threshold in terms of carbon savings. A live calculation is performed in the case study calculator.<br>- The embodied and end-of-life emissions of the network can be justified to have existed without the implemenation of the solution and therefore have been exluded from the calculation. This is also true for the embodied and end-of-life emissions of the datacetnres used for processing and storage.<br>- The in-use emissions from data centre (server) processing and storage have been included in the calculation. They do not meet the 5% materiality threshold but as data existed, they have been included for illustrative purposes. |
| **Categorisation of digital technologies**<br><br>A=ICT Service<br><br>B=Service specific building block<br><br>C=Common ICT devices, services, infrastructure | The components in the implementation scenario can be categorised as follows.<br><br>**A**<br>- Robots, assumed to be manufactured by Ekobot due to a lack of data.<br><br>**C**<br>- 4G network for very limited data usage. In Sweden, this was provided by Telia.<br>- Cloud solution: Hetzner |

| | |
|---|---|
| **Description of 2nd order effects** | The following second order emission sources were identified:<br>• Reduction in tractor fuel consumption. The diesel emissions factor includes a well-to-wheel assessment.<br>• Reduction in use of chemical pesticides to treat weeds. Their emission factors are for the production and application of the pesticides.<br>• Increase in yield within conventional farms, reducing emissions per tonne of crop. This reduction is not reflected in the cumulative second order effect calculation as these emission reductions are only accomplished when considering the increase in output. It does not directly reduce emissions resulting from farming.<br><br>Moreover, the selective weeding of the autonomous robot reduces the hours of human labour required to plough and/or inspect the field, reducing the burning of human calories and the associated GHG emissions. The GHG savings related to the reduction in manual labour hours are currently not included into the calculator due to a lack of reliable data.<br><br>Please note that while the calculations for conventional (non-organic) farming are supported by primary data, data collection on organic farming is of secondary nature. Therefore, when selecting organic farming, outputs of the calculator are to be used as indicative and do not align to the methodology. |
| **Description of higher order effects** | The reduction in chemical use directly reduces GHG emissions. However, it is also beneficial to biodiversity and the condition of neighbouring soil and waterways, which may indirectly and positively impact GHG emissions at site and beyond.<br><br>Moreover, it is possible that at scale the increased yield per field reduces the number of fields required, which may cut GHG emissions, too. |
| **Mapping of all effects** | |



Funded by
the European Union




| | |
|---|---|
| **Description of calculation** | **1st order effects:**<br>For the lifecycle emissions related to the robot, the weight of several components are multiplied with the relevant emission factors for their production and end-of-life. These emission factors come from the ICE v3 database where possible. However, as not all materials are accounted for in ICE, gaps were filled using UK government GHG conversion factors. This included end-of-life emission factors which are not included into the ICE database. As no emission factor on rubber could be found, the emission factor for dense plastics was used. This mirrors the approach taken by the UK government Department for Environment, Food & Rural Affairs and the Government Statistical Service where they do the same.<br><br>The emissions related to the robots' electricity usage are accounted for by multiplying the robot's energy |



Funded by
the European Union

| | |
|---|---|
| | consumption with the relevant European electricity grid factor for generation, transmission and distribution.<br><br>The emissions associated with the (very limited) use of 4G in the trial are calculated by multiplying the server usage with an emissions factor.<br><br>**2nd order effects:**<br>The second order effects calculation captures GHG savings achieved through the solution, by reducing tractor hours, herbicide use, and increasing yield per field. For each of these, measurements before and after the reference scenario are made with different numbers for conventional and organic farms.<br><br>The reduction in tractor use is measured in hours, with the assumption that on average a tractor uses 25L of diesel per hour whilst on the field (Grisso et al., 2010). The saved fuel is converted to saved CO2e using well-to-wheel conversion factors.<br><br>The reduction in various types of chemical use is measured and their active ingredients are matched to the chemical type through the Swedish Chemical Inspection website, as suggested by Ekobot. Their associated production and application CO2e conversion factors are used the calculate the carbon impact (Cech, Leisch & Zaller, 2022).<br><br>The increased yield per hectare is used in the final savings per functional unit.<br><br>**Higher order effects:**<br>The higher order effects calculation captures the additional benefits of lowering herbicide use for the direct environment. With the available data such a calculation cannot currently be made.<br><br>Additionally, the relatively small reference scenario cannot accurately predict potential reduction in fields required as a result of higher yields. |
| **Net Carbon Saving Impact of the Solution** | For conventional farming:<br><br>Total carbon saved: **0.7 $tCO_2e$ / season**<br>1st Order effects: **0.02 $tCO_2e$**<br>2nd Order effects: **0.62 $tCO_2e$**<br>Savings per functional unit: **5.1 kg $CO_2e$ / tonnes yield / season** |

| | |
|---|---|
| **Qualitative data uncertainty and sensitivity analysis** | Data quality is relatively good for first order emissions due to precise measurements to the robots' material components. The conversion factor used for server emissions is of bad quality but is immaterial in terms of carbon impact. Second order emissions are also relatively good except for organic farms, where limited measurements were taken.<br><br>Almost all variables score very low in the sensitivity analysis. However, variables related to fuel consumption score very high, indicating that the electrification of conventional tractors has a high carbon impact.<br><br>It should be noted that the analysis performed is not a quantitative uncertainty analysis. By providing a more granular view of data quality, which builds on the data quality assessment, this analysis highlights areas of uncertainty within the calculation using a qualitative assessment framework. It can however be used to feed into a quantitative uncertainty analysis using guidance from the Greenhouse Gas Protocol on Quantitative Inventory Uncertainty: https://ghgprotocol.org/sites/default/files/2022-12/Quantitative%20Uncertainty%20Guidance.pdf |
| **Assumptions** | As set out in the description of the calculation section of this document, it is assumed that:<br>- A tractor on average consumes 25L of diesel per hour<br>- There is no increase in yield for organic farms (due to lack of data)<br>- Carbon savings realised in onion fields can be realised in other similar type crops<br>- The farm before Ekobot's solution uses per hectare and per season<br>  o 3.5 kg Boxer<br>  o 1 kg Glyfospate<br>  o 0.2 kg Gallery<br>  o 0.6 kg Fenix<br>  o 1.1 Lentagram<br>  o 0.1 kg Starane 333<br>- The robot runs 17 times per hectare per season (every 3rd day)<br>- A farm requires one robot per 10 hectares<br>- There is 1 agricultural season per year<br>- Carbon emissions related to server usage can be estimated with Amazon Web Service's emission factor. |

| | |
|---|---|
| **Data sources** | The data was collected by Ekobot on a Swedish conventional farm. Whilst the GHG savings have been measured for the conventional farm, the numbers for the organic farm have been estimated by Ekobot using average data from the Swedish Board of Agriculture.<br><br>The embodied emission conversion factors are taken from UK Government numbers and from the ICE V3 database.<br><br>The conversion factor for server usage is taken from Climatiq and has been based off Amazon Web Services in Sweden.<br><br>The conversion factor for the (quantitatively excluded) network emissions come from Telefonica. |
| **Input adjustments and key considerations for usage of results** | Inputs for other farms:<br>- Field size in hectares<br>- Type of farm<br>    o Conventional<br>    o Organic<br>- Country selection<br><br>Optional adjustments<br>- Average yield<br>- Tractor hours<br>- Pesticide use |
| **'Do no harm' criteria** | The solution is not expected to present significant harm to the environment.<br><br>The solution reduces the need for manual labour on farms. If Ekobot or similar solutions are deployed on a large scale, there is a risk the volume of manual labour jobs in agriculture will be reduced. Simultaneously, Ekobot also creates job within its own company and within the supply chain of manufacturing the robots. The balance between these two factors cannot currently be measured due to a lack of (long-term) data. |
| **Key areas for improvement** | Data provided for this solution was severely limited. Within the scope of this work, there was no verification of the data undertaken and the calculator is based on the assumption the data provided by the solution is correct.<br><br>Future calculators for agriculture-based solutions may consider the following improvements. |



Funded by the European Union

| | |
|---|---|
| | 1. Future calculators should include measurements on organic farms, significantly increasing the reliability for these.<br>2. Future calculators should be based of a larger sample size to increase its reliability.<br>3. Future calculators should include more crop and field types to broaden its usability. Measurements in more countries may also improve reliability.<br>4. Carbon emissions that arise from transporting the Ekobots should be measured and compared against emissions that arise when transporting Internal Combustion Engine (ICE) tractors.<br>5. Future calculators can include carbon emissions that arise from labourers being transported to and from the farm, especially when they travel from regions or countries far away.<br>6. Different types of pesticides should be included, as well as different mixes of them. This would allow for the creation of a different variable whereby users may select the pesticides they use and increase the calculator's usability.<br>7. A full life cycle analysis should be undertaken both for the Ekobots and for the tractors in the reference scenario to determine more accurately differences in greenhouse gas emissions.<br>8. If the solution is scaled up and starts using 5G (which Ekobot is expected to do), the emissions that are related to its use should be included into the calculator.<br>9. Future calculators should update publicly available electricity grid data to factor in developments towards decarbonising the electricity grid. |



Funded by
the European Union