EGDC Case study – TCS Digital Platform for NextGen Agriculture

February 2026

Case Study Methodology

EUROPEAN GREEN DIGITAL COALITION

Funded by the European Union

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 '*TCS Digital Platform for NextGen Agriculture*" 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 Results

ICT Solution and assessment overview
TCS' Digital Platform for NextGen Agriculture (DNA) supports rice farmers in adopting Carbon-Smart Crop Protocols (CSCP) through a mobile app that records field operations and integrates weather, satellite, and soil data. The platform guides farmers in implementing climate-smart practices such as water-saving irrigation, precision fertiliser use, and organic soil treatments. Data collected and input by the farmers into the app feed into a process-based simulation model to estimate GHG emissions and soil carbon changes, while a machine-learning model analyses crop images to optimise farming practices, such as fertiliser application, reducing N_2O emissions without compromising, and often increasing, yield. This case study is an ex-post assessment carried out to quantify the avoided emissions from improved nitrogen application through fertiliser efficiency and reduced machinery fuel consumption for tilling under two carbon-smart crop protocols (CSCP-1 and CSCP-2), representing two different scenarios, compared to conventional practices. The assessment is based on a pilot in Tamil Nadu, India during the rice harvesting season of July-October 2021.

Quantified impacts	
Assessment period:	1 year (based on 2021 pilot)
Net carbon impact range:	-6.93 to -44.14 tCO_2e/year
Net carbon impact:	CSCP-1: -3.38 tCO_2e CSCP-2: -4.09 tCO_2e Total: -7.47 tCO_2e
Net carbon impact per kg of rice:	CSCP-1: -0.09 $kgCO_2e$/kg CSCP-2: -0.12 $kgCO_2e$/kg

Organisational contribution
TCS worked to innovate, develop, and deploy the solution. This aligns with A-level classification as defined by ITU-T L.1480 (contribution of the integrated solution or the innovation of the solution).

Other identified impacts
Reductions in fertiliser and fuel lead to cost savings for farmers. If all cost savings are invested into typical business carbon-intensive activities, this could result in an increase in emissions.

3 Methodology

TCS Digital Platform for NextGen Agriculture	
Assessment Objective	The purpose of this assessment is to quantify the avoided emissions from reduced fuel use and more efficient nitrogen use enabled by the TCS' DNA solution under two different carbon-smart crop protocols (CSCP), CSCP-1 and CSCP-2, compared to conventional practices. The assessment focuses on emissions reductions from more efficient tillage operations and machinery use, and from optimized fertilizer application. This assessment focused on a pilot of the solution across ten rice fields in the Cauvery Delta Zone (CDZ) of Tamil Nadu, India, where half of the farms followed CSCP-1 and the other half followed CSCP-2. The data was collected over the July-October 2021 time period aligned with the crop harvesting season for rice.
Solution Description	TCS' Digital Platform for NextGen Agriculture (DNA) is a data-driven solution that enables farmers to adopt climate-smart agricultural practices. The solution recommends the implementation of CSCP practices in rice farming, through a digital participatory sensing platform. These protocols were piloted in the CDZ of Tamil Nadu, India, where traditional rice cultivation is known for high GHG emissions. The TCS DNA platform enables farmers to record field operations in real time. By following the recommended CSCP guidelines, farmers adopt carbon-smart practices (e.g. improved water management, optimized fertilizer use, organic amendments to fertilisers) which are monitored and analysed via the digital platform. This integrated approach is designed to reduce carbon and nitrous oxide emissions and to enhance soil organic carbon storage. Two carbon-smart variants, which for the purpose of the assessment will be referred to as two difference solution scenarios, were implemented among ten pilot farmers (split into two groups of five): • **CSCP-1:** Emphasizes organic methods in which farmers use organic manures, biofertilizers, and traditional practices. Synthetic inputs are minimized. This scenario focuses on natural soil amendments and aerobic techniques to curb emissions.

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- **CSCP-2:** Follows an Integrated Nutrient Management (INM) approach which balances the use of both organic inputs and inorganic fertilizers. It aims to maximize fertilizer use efficiency (right source, dose, timing) while still leveraging organic carbon additions to the soil.

Both scenarios include improved tillage and fertiliser use and are monitored via mobile-based participatory sensing.

To improve transparency around the technical basis of the solution, the solution description is supported by an existing study of the solution, a patent and peer-reviewed sources that describe the underlying digital farming platform concepts (data capture, analytics, and decision support) and optimised fertiliser application approaches:

- US12347102B2 (patent): technical provenance for the system design/implementation of a digital agriculture platform and decision-support mechanisms used in the solution.
- IEEE 9910612 (study): study demonstrating the use of digitally captured farm-operation records, modelling/analytics to estimate emissions outcomes, and data-driven fertiliser optimisation concepts aligned to CSCP scenarios.
- EP22170934 (EPO application): additional solution background / prior art for platform capabilities and methods relevant to variable-rate fertilisation and farm decision support.

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Solution Boundary

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The DNA platform consists of the following components:

Digital components:

- Cloud processing and storage
- Mobile phone
- Network and data transmission

Non digital components:

- Leaf colour chart

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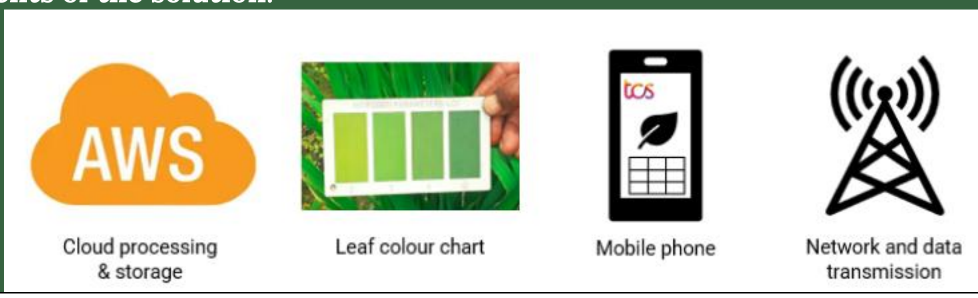
Components of the solution:



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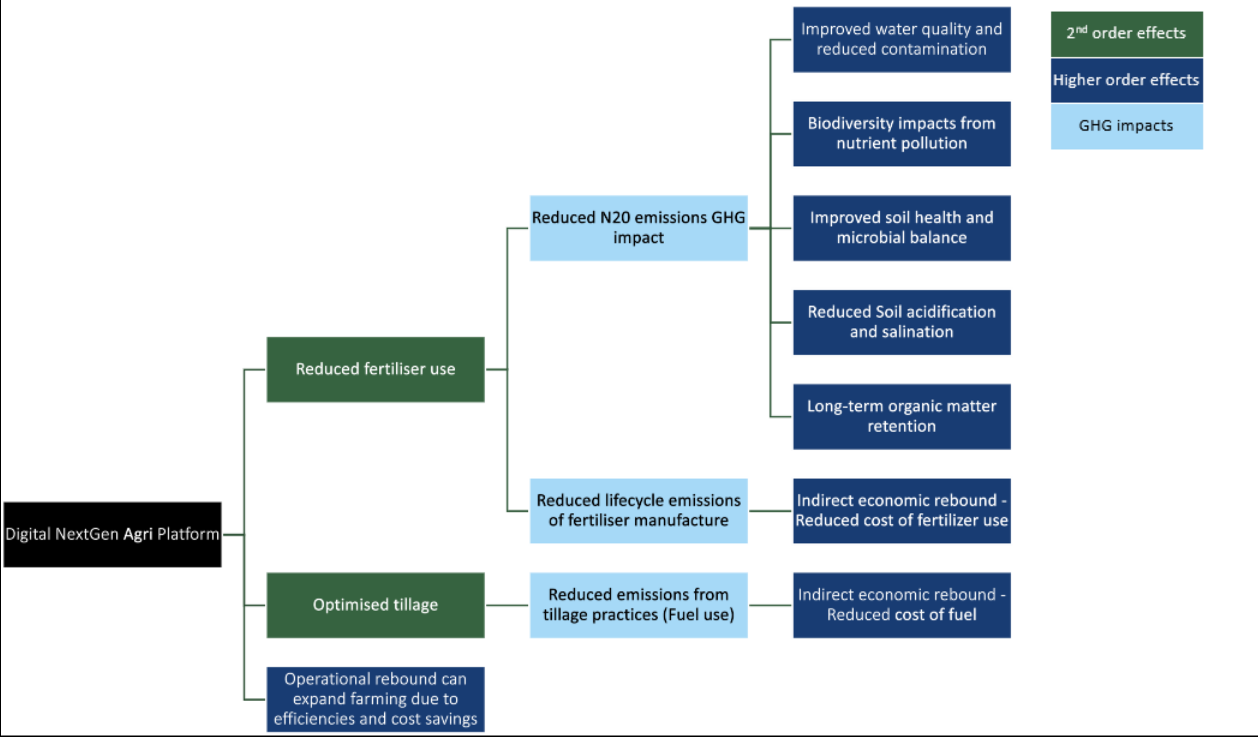
Functional Unit	The functional unit is annual tonnes of CO_2 equivalents per kilogram of rice produced (yield). Annual emission savings were also calculated per hectare ($kgCO_2e$ per ha).
Calculation Boundary	For the purpose of this assessment, fuel use from optimised tillage practices and fertiliser use was considered within the assessment boundary due to the availability of data and clear link to emissions avoidance mechanisms. Irrigation, soil organic carbon and other potential avoided emissions mechanisms are outside of the scope of the assessment. The calculation represents the farming period of rice in the CDZ region which is July-October. The geographic boundary of the solution is limited to CDZ, India, where the pilot study and fields implementing the solution are located.
Reference scenario	The reference scenario is conventional rice farming in the CDZ region, representing business-as-usual practices. Typically, this involves heavy reliance on chemical fertilizers, unoptimized tillage with a standard 3 tillage passes per field, and no specific measures for carbon management. Such practices lead to excess nitrogen application (producing nitrous oxide) and fuel use from tillage done via tractors. The higher fuel consumption and inefficient nitrogen application contribute to elevated GHG emissions. In the reference scenario, fields are managed without the carbon-smart interventions serving as a baseline for GHG emissions against which improvements are measured. It is assumed conventional flood irrigation occurs in both the reference and solution scenarios for the rice farming, which is responsible for producing methane. The assessment boundary therefore excludes methane emissions from flood irrigation in the rice-fields as the emissions are assumed to be the same in both scenarios. Improved irrigation regimes are excluded from the assessment boundary.
Description of 1st order effects	The first-order effects of the TCS DNA solution are related to the direct environmental impacts arising from the deployment and operation of the system's components. These include the embodied, use-phase, and end-of-life emissions of the solution's components including:

	1) **Cloud storage and processing** Emissions include use-phase emissions from electricity consumption during operation, which are calculated per year. 2) **Leaf colour chart** Emissions include embodied emissions of the materials that make up the chart as well as their end of life fate. 3) **Mobile phone** Emissions include use-phase emissions from electricity consumption, which is calculated per year. 4) **Network and data transmission** Annual electricity consumption related to the energy used to transmit data between phones and cloud/data centre via the network has been excluded due to the lack of data being available and on the bases of immateriality. Estimates based on secondary data were done which demonstrate these emissions are immaterial (<0.1%).
Description of 2nd order effects	The 2nd order effects of the solution are the decrease in the fertiliser use and fuel use. This is due to optimisation of fertiliser use and reduced tractor tillage per hectare across the fields.
Description of higher order effects	The decrease in fertiliser and fuel use because of the TCS' DNA platform has several indirect impacts which vary in potential magnitude of impact and likelihood of occurrence: • Indirect Economic Rebound: Cost savings from reduced fuel and fertilizer use may be redirected by farmers into other carbon-intensive activities such as increased mechanization, transportation, or consumption, potentially offsetting some of the emissions savings. • Improved Water Quality and Reduced Contamination: Lower fertilizer use under CSCPs reduces nutrient runoff into nearby water bodies, decreasing the risk of eutrophication, algal blooms, and contamination of groundwater and surface water, thereby improving aquatic ecosystem health and drinking water quality.

	• Biodiversity Impacts from Nutrient Pollution: Excess nitrogen from conventional practices can disrupt natural plant communities by favouring fast-growing species, which can negatively affect both plant and animal biodiversity in surrounding ecosystems. • Improved Soil Health & Microbial Balance: Reduced chemical inputs and increased organic matter under CSCPs enhance microbial diversity and nutrient cycling in soils, supporting healthier, more resilient crops and reducing emissions over time. • Reduced Soil Acidification & Salinization: Optimized fertilizer use and organic amendments help prevent the buildup of salts and acidity in soils, preserving long-term soil productivity and reducing the need for corrective inputs that may carry emissions. • Long-Term Organic Matter Retention: Practices like reduced tillage and residue retention increase soil organic carbon and improve water retention, contributing to long-term carbon sequestration and reduced emissions from input use. • Rebound Effect - Operational Expansion: Efficiency gains and cost savings may incentivize farmers to expand cultivated areas or intensify production, potentially increasing overall emissions and partially offsetting the benefits of CSCP adoption.
Mapping of 2nd and higher order effects	



Assessing the impact of higher order effects

Higher order effect	Description	Magnitude	Likelihood
Indirect economic Rebound	Cost savings from reduced fuel and fertilizer use may be redirected to other carbon-intensive activities (e.g., increased mechanization, transport, or consumption).	**Medium**: redirecting spending from cost savings could offset some avoided emissions	**Medium**: reinvestment decisions will vary greatly by farmer (e.g. income, awareness, access to alternatives).
Improved Water Quality and reduced contamination	Reduced fertilizer runoff decreases nutrient loading in water bodies, limiting eutrophication and algal blooms that harm aquatic ecosystems. Lower chemical input reduces contamination of groundwater and surface water, improving drinking water safety and aquatic health.	**Medium to High**: strong link between fertilizer runoff and water quality degradation, thought dependent on proximity to water sources	**High**: Direct reduction in synthetic fertiliser use under the CSCPs, including reduced chemical inputs and run-off.
Biodiversity Impacts from Nutrient Pollution	Excess nitrogen can favour fast-growing species, disrupting native plant communities and affecting dependent fauna.	**Medium**: Nutrient pollution can significantly alter ecosystems	**Medium**: dependent on proximity to natural habitats and run-off pathways
Improved Soil Health & Microbial Balance	Reduced chemical inputs and better organic matter management support microbial diversity, enhance nutrient	**High**: long-term benefits for field productivity and resilience	**High**: CSCP directly promotes practices that support microbial health

	cycling, and improve plant resilience.		
Reduced Soil Acidification & Salinization	Optimized fertilizer use and organic amendments can reduce acidification and salt buildup, improving long-term soil productivity.	**Medium**: issues affect long-term soil viability	**Medium**: CSCP reduce chemical inputs, but outcomes depend on baseline soil conditions and water quality
Long-Term Organic Matter Retention	Practices that reduce tillage and increase residue return enhance soil carbon stocks and water retention, supporting long-term productivity and resilience.	**High**: strong link to carbon sequestration and soil health	**High**: CSCPs explicitly promote residue retention and reduced tillage
Rebound Effect - operational expansion	Increased productivity or cost savings from reduced fuel/fertilizer use may lead to expansion of cultivated area or more intensive farming.	**Medium**: land expansion to increase agricultural operations could offset gains	**Medium**: Dependent on land availability and market incentives

Description of calculation	**1st Order Effects** The solution emissions are calculated by summing the leaf chart embodied and end-of-life emissions, and the annual use-phase emissions of the hardware and software related to the use of DNA, consisting of the cloud processing and storage and mobile-phone use. Use-phase emissions are calculated from the annual estimated electricity consumption of the cloud platform and the mobile phone multiplied by the relevant emission factor for the electricity grid in India. It is assumed the hardware for these components would have been present in the absence of the solution, hence the hardware's embodied emissions are not calculated. Embodied emissions account for the materials used in the leaf colour chart, which is assumed to be composed of paper and plastic. End-of-life emissions are calculated by multiplying the weight of each material of leaf colour chart by the relevant waste emission factors. Total first-order emissions are obtained by summing up the contributions from all items including their relevant embodied, use-phase, and end-of-life emissions. **2nd Order Effects** The second-order effects represent the emissions from fertiliser use and fuel use after implementing the solution. For the fertiliser use, the difference between the fertiliser direct, indirect and embodied emissions before and after the solution is in place captures the fertiliser savings achieved by the DNA platform. For the fertiliser direct and

	indirect emissions, the calculations exclusively account for the nitrogen-based fertilisers and their nitrous oxide, leaching and volatilisation emissions. To ensure the assessment remains comparable, and representative when different fertilizer combinations and yields are used across the reference, CSCP-1, and CSCP-2 scenarios, a key assumption is that emissions are normalized per unit of agricultural output (e.g., per kg of rice). This functional unit approach allows for fair comparison of emissions efficiency, regardless of input mix or yield differences between the scenarios and ensures that the assessment reflects emissions intensity rather than absolute emissions alone. For the fuel use, the difference between the fuel consumption related to the field tilling before and after the solution is used, captures the fuel savings achieved by the DNA platform. TCS provided the number of tillage passes per field in the reference and solution scenarios. The same machinery (tractor) and fuel consumption per tillage pass is assumed and used in the reference and solution scenarios. **Net Carbon Impact** Net carbon impact is calculated by subtracting the first-order emissions generated by the solution itself from the 2^{nd} order effects. This ensures that the environmental benefit accounts for the emissions embedded in the solution components, providing a more accurate measure of the net avoidance of greenhouse gas emissions.
Net Carbon Saving Impact of the Solution	**CSCP-1** Annual net carbon savings: -3.38 tCO_2e Annual net carbon savings per ha: -0.15 tCO_2e Annual net carbon savings per kg of rice: -0.09 $kgCO_2e$ -46% fuel savings from reference scenario. **CSCP-2** Annual net carbon savings: -4.09 tCO_2e Annual net carbon savings per ha: -0.36 tCO_2e Annual net carbon savings per kg of rice: -0.12 $kgCO_2e$ -35% fuel savings from reference scenario. **Total** Total annual net carbon savings -7.47 tCO_2e

Uncertainty and sensitivity analysis	**Total carbon savings enabled (tCO_2e):** Total net carbon impact: -7.47 Lower uncertainty range: -6.93 Higher uncertainty range: -44.14 **Uncertainty analysis:** Fertiliser use is the main driver of uncertainty. In the ranges assessed, fertiliser emissions (2^{nd} order effects) vary from -7.37 tCO_2e to -44.38 tCO_2e. Platform use-phase emissions from cloud processing and storage increase from 0.50 tCO_2e at the lower range to 1.23 tCO_2e at the higher range. Fuel emissions (2^{nd} order effect) show moderate variation, with emissions increasing from -0.07 tCO_2e to -1.13 tCO_2e at the higher range. Mobile phone use-phase emissions show a small variation increasing to 0.14 tCO_2e at the higher range. Leaf colour chart embodied emissions remain immaterial, increasing to 0.002 tCO_2e at the higher range.
Assumptions	• Platform cloud processing and storage annual power consumption estimates are assumed to be representative. It is assumed the platform runs on 50,000 computing hours a year, uses 500 GB of cloud storage annually, and 400 GB for data transferring annually. Assume annual cloud processing and storage emissions scale per field which is considered to be equivalent to a user of the solution. • The expected lifetime of the leaf colour chart is assumed to be one year as a conservative value based on literature sourced in the calculator. Weights of the materials of the chart are also assumed to be representative and are based on secondary sources. It is assumed 1 chart is used per field. • Mobile phone annual electricity consumption estimates are assumed to be representative. It is assumed the phones are used at 70% daily. It is assumed one iPhone 13 is used per field.

	• Proxy liquid fertiliser densities are assumed to be representative and are based on fertiliser composition provided by TCS and secondary sources. All sources are in the calculator. • Due to data availability, to be conservative it is assumed the diesel consumption per pass would be the same in both the reference and solution scenarios. • For organic fertilisers, embodied emissions are expected to be immaterial, reflecting the expectation that their production involves negligible industrial processing, energy consumption, and upstream supply-chain impacts. To adopt a conservative approach, the average emission intensity per kilogram of fertiliser from India's fertiliser industry, is applied to calculate the embodied emissions of the organic fertilisers and assumed to be a conservative proxy. • All data provided by TCS is assumed to be complete and accurate. • It is assumed that the increase in yield is primarily attributable to the solution's implementation, while recognising that other external factors, common in agricultural systems, may also influence yield; these external effects fall outside the solution boundary.
Data sources	**Data provided by TCS:** Primary data has been provided from TCS for hectarage, crop month seasonality, yield of crop, tillage passes per field, as well as types and amounts of fertiliser used per field. **Secondary data sources:** All secondary data sources used during calculations of the 1st order effects have been documented in the calculator. All sources for emission factors, proxies and the fuel consumption per pass are sourced in the calculator. **Methodological / technical references supporting the solution description:** • US12347102B2 • IEEE Xplore document 9910612 • EPO Register: EP22170934

Input adjustments and key considerations for usage of results	**List of things to consider if using results in other use cases:** • Country (for the electricity grid) • Field location • Yield of crop • Crop type • Field size (ha) • Nitrogen content • Data periods • Nature of tillage practice (machinery, tractor, etc) and related fuel usage
'Do no harm' criteria	Do not foresee any negative impacts on any of the EU Taxonomy's environmental nor social objectives and strongly supports objective 1: Climate change mitigation. The TCS DNA solution does not pose significant harm, as it is inherently scalable and contributes positively to environmental and human well-being. By reducing the reliance on chemical fertilisers, and the associated runoff, and reducing fossil-fuel-related emissions, the solution supports healthier ecosystems and improved air and water quality, which can in turn enhance overall quality of life.
Key areas for improvement	1. Utilising the more complex fertiliser calculation considering other criteria such as synthetic vs organic fertiliser, base of fertiliser, and fertiliser specific production emission factors which were highly dependent on secondary sources and proxies. 2. Include other avoided emissions mechanisms enabled by the TCS DNA platform (irrigation, soil organic carbon). 3. Make cloud processing and storage estimates more accurate based on cloud provider primary data and include network and data transmission emissions.