Deployment Guidelines – Agriculture Sector

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EUROPEAN GREEN DIGITAL COALITION

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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.

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1 Introduction

To help maximise the benefits of ICT solutions with the potential to enable a positive net carbon impact[1], the European Green Digital Coalition (EGDC) European Parliament (EP) Pilot Project has developed a set of Deployment Guidelines. These guidelines aim to provide recommendations for solution developers and providers, as well as considerations for buyers/users of ICT solutions, investors, and policy makers to:

1. Maximise carbon, resource, and energy savings enabled by ICT solutions
2. Minimise solutions' emissions
3. Define metrics and track them to understand solutions' impact
4. Going further: Designing the solution to broaden its reach; and
5. Appropriately consider other sustainability impacts beyond carbon.

Six separate sets of guidelines have been developed to cover the six sectors identified as priority areas by the EGDC: Energy/Power; Transport; Construction/Buildings; Manufacturing; Agriculture; and Smart Cities. This specific guidance document focuses on the ***Agriculture Sector***.

To ensure that the Deployment Guidelines bring benefits to all involved parties and reflect the needs of each sector, the EGDC EP Pilot Project has consulted relevant stakeholders via a series of sectorial workshops, involving parties from each priority sector, including solution developers, end-users, and decision makers.

It should be noted that any reference to carbon or carbon emissions designates emissions of all greenhouse gases

[1] Digital Solutions with the potential to enable a positive net carbon impact are technologies that can help users avoid or reduce climate-harming greenhouse gas emissions, usually through a reduction or avoidance of resource use (e.g. fuel, electricity, raw materials, etc.).

1.1 Agriculture Sector – A Call for Decarbonisation

Decarbonising the agriculture sector is essential to the delivery of the Green Deal strategy for a sustainable European food system. The European agricultural sector represents just under 400 Mt CO_2e of GHG emissions annually, or 10.3% of the EU's total emissions.[2] Nearly 70% of these come from the animal sector.[3] Decarbonising the agriculture sector would deliver substantial progress in tackling climate change, protecting the environment, preserving biodiversity, and promoting a circular bio-based economy.

Decarbonisation for the sector will require reductions in chemical pesticide use, widespread adoption of organic farming practices, reduction in energy and carbon intensity, and improvement of resource efficiency of farming practices.

In this, ICT has a big role to play. In an era marked by mounting environmental concerns and the urgent need to combat climate change, maximising carbon, resource, and energy savings has become an imperative for sustainable development. As societies strive to transition to a greener and more resilient future, harnessing the potential of ICT solutions has emerged as a crucial strategy. From precision robotics and moisture sensors, to measuring chemicals and nutrients in soil and predicting challenging weather conditions, ICT technologies are revolutionising the way we interact with the environment and offer significant opportunities for carbon footprint reduction for the sector.

To keep on track for a net zero world and reach the European Green Deal's target of a climate neutral economy by 2050, greenhouse gas emissions from the agriculture sector must decrease at a much faster rate than the current projected decrease of 2% by 2030, compared with 2005 levels[2].

At the heart of this transformation lies the recognition that ICT solutions possess the ability to optimise resource consumption, minimise waste generation, and enhance energy efficiency across the value chain. By harnessing advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cloud computing, the whole ecosystem of agricultural stakeholders can unlock new avenues for sustainability and drive substantial positive change.

However, it is also acknowledged that much of the ability of ICT solutions to contribute to the decarbonisation of agriculture is dependent on wider shifts within the sector. It

[2] European Environment Agency: Greenhouse gas emissions from agriculture in Europe

[3] EU Farm to Fark Strategy

will require cooperation with external stakeholders including policymakers, financiers, and other businesses within the field. The implementation of these ICT solutions will be driven by collaboration with farmers, landowners, foresters, and local stakeholders. For instance, for many ICT solutions in the agriculture sector the carbon saving potential increases considerably when more energy-efficient 5G networks are available and national electricity grids decarbonise. To prepare for the transition, stakeholders will have to consider green financing opportunities, both in the near and long-term to implement these solutions. For many companies, the shift will require a significant set of changes for their business model and existing products and services offerings. Similarly, not all recommendations provided in this document will always align to business interests in the short term. Recognising the current state of the agriculture sector, this file, together with the overall methodology will be updated periodically to align with future developments in the wider sector.

2 Maximising net carbon impact from the implementation of ICT solutions

ICT solutions hold great potential for enabling decarbonisation across sectors. Their integration can optimise processes and reduce carbon emissions. However, simply adopting ICT solutions is not enough to achieve maximum decarbonisation potential. The development, deployment, and use of these solutions must be done strategically and purposefully to ensure their effectiveness, maximising co-benefits to the wider community. This requires a comprehensive approach that considers factors such as scalability, performance tracking, and post-sale support to demonstrate results in line financial and policy-maker expectations.

Below, you will find five key areas to consider and explore in order to help maximise the potential of ICT solutions:

Monitoring and tracking performance
- To quickly troubleshoot any issues
- To allow for an understanding of performance under different circumstances
- To inform future improvements

Post-sale Training
- Plan for adequate training and support resources to assist users in adopting and troubleshooting the solution.
- Provide documentation, tutorials, and a support system to assist users and address their queries.

Post-sale Support
- Carbon benefits may decrease over time without adequate maintenance and support; support should be provided to ensure lasting positive impacts.

Integration
- Determine how the solution will integrate with existing systems or third-party services
- Consider data exchange to ensure smooth integration

Performance Optimisation and Automation
- Consider the potential of automation.

2.1 Monitoring and tracking performance

To maximise the emissions-reducing benefits of an ICT solution, it is essential to implement robust monitoring and tracking mechanisms to assess its performance. By continuously monitoring the solution's effectiveness, potential issues can be quickly identified and addressed, minimising disruptions and maximising reductions.

Monitoring and tracking also provide valuable insights into the solution's performance under different conditions, allowing for a more comprehensive understanding of its strengths and limitations. For solution developers and buyers, this knowledge can serve as a basis for informed decision-making and helps identify areas for improvement.

On the other hand, providing solution users with access to usage and performance data empowers them to better understand their consumption patterns and make more informed decisions. Solutions should therefore aim to measure and analyse relevant data and generate feedback that highlights the environmental impact of users' actions and behaviours. This feedback serves as a valuable tool for raising awareness and promoting behavioural change towards more sustainable practices. With clear information about their consumption habits, users can identify improvements such as reducing energy usage, optimising resource utilisation, or adopting eco-friendly alternatives.

Agriculture Sector

Due to the high variability of farm types, soil types, animal species and direct environments in the European agriculture sector, as well as its exposure to climate-related physical risks, it is possible that a solution will be used under different circumstances or conditions when compared to where the solution was trialled.

Therefore, it is important to enable a certain degree of customisation. For instance, in the case of a solution that optimises field irrigation using groundwater, an area with tidal waterways may benefit from region-specific tidal optimisation. Similarly, for a solution using IoT sensors, the location of installation can be tailored to the user's farm and direct environment. This may more accurately represent the measurements taken from the farm relative to its possible neighbouring farms, factories, and natural surroundings.

Barriers to adequate data collection may be the lack of assigned responsibility within the business as well as control procedures to ensure quality within the data collection process. If primary on-land measurement is not available, regional data collection, as well as satellite imagery can be a lever to monitor performance. This should not be seen as utilising resources in a way which is detracting from daily operations. Rather, assigned responsibility reinforces the reliability of data-driven tools and the useability of their outputs, thereby strengthening overall effectiveness of operations.

2.2 Post-sale training

In the context of maximising the benefits of an ICT solution for emissions reduction, post-sale training plays a key role. Without proper training, users may struggle to fully grasp the solution's features, leading to suboptimal usage and missed opportunities for emissions reductions.

The availability of comprehensive documentation, tutorials, and a responsive support system during rollout and installation significantly enhances users' ability to troubleshoot issues and address queries. By prioritising the provision of post-sales training, solution developers and providers help users have the necessary knowledge and resources to optimise the solution's performance. Collaboration with higher education institutions to encourage training of green technology engineers could support a sustained supply of skilled labour.

Agriculture Sector

Post-sale training should enable ICT solutions to be properly integrated into existing systems and ensure solution buyers have adequate resources to implement the solutions. This includes ensuring farm workers have the skills and appropriate understanding of the tools to effectively use the solutions as intended. In addition, developers should consider providing any learning materials in multiple languages to ensure the guidance can be effectively communicated to all users.

Barriers to implementation of post-sale training may be the associated cost and time commitment. For instance, if a retailer pushes its suppliers to implement a specific ICT solution, this might impact their timeframes to deliver products and their existing business models. Whilst there is a short-term burden to a continued training expense, a sustained training programme ensures the workforce are kept up to speed with updates made to software and ensures that potential workforce turnover does not result in reduced understanding of the solution's features over time or reduced efficiency of the solution implementation.

2.3 Post-sale support

Post-sale support after the installation of the ICT solution is another component which can help increase savings. Without ongoing support, the carbon benefits achieved through the initial implementation may decrease over time.

Adequate maintenance and support are necessary to ensure the solution continues to operate optimally, adapt to evolving needs, and deliver lasting positive impacts on emissions reduction. Post-sale support includes addressing technical issues, offering guidance on best practices, assisting in system updates and upgrades, and providing the appropriate replacement parts. This ensures that the ICT solution remains effective and efficient throughout its lifespan, sustaining the desired emissions reductions and maximising the long-term environmental benefits.

Agriculture Sector

Equipment or System Malfunction: Over time, existing or solution-specific agricultural equipment and systems may experience malfunctions or performance degradation. Ongoing support driven by regulation helps avoid these issues going unnoticed or unresolved, by identifying and addressing equipment malfunctions promptly, ensuring that the ICT solution continues to operate and deliver optimal savings.

Changes in Land Usage: Agricultural practices are dynamic and constantly evolving. Changes in land use or crop rotation, as well as changes in regulation framing the use of certain chemicals may impact the application and use of ICT solutions. Without ongoing support, an ICT solution may not adapt to these changes effectively, leading to resource inefficiencies and increased emissions.

Technological Advancements and Updates: Innovations in farming practices require ongoing post-sale support to ensure the solution does not become outdated or incompatible with newer technologies, limiting its effectiveness and potential carbon savings. Ongoing support can help ensure that the solution remains up-to-date, compatible with the latest advancements, and capable of leveraging new features or functionalities that enhance efficiencies.

Opportunity:

This support, along with post-sale training, can also be an opportunity for companies to extend their portfolio of services.

2.4 Integration

Implementing ICT solutions requires careful consideration of how ICT solutions will interact with existing systems or third-party services. An important step in the integration process is determining how the solution will fit into the current infrastructure, minimising disruptions, and maximising efficiency gains.

Solution developers should assess solution compatibility, identifying potential dependencies, and designing interfaces for smooth interaction between different systems. They should engage with solution buyers and users to understand the case-by-case circumstances and provide guidance accordingly. Solutions buyers and users should work collaboratively with developers and providers to provide insight into their systems and highlight any potential issues or roadblocks.

Agriculture Sector

ICT solutions in the agriculture sector may use sensors or other IoT devices to measure and influence variables like soil health, water usage, animal health, weather conditions, biodiversity, and optimisation of land usage. Ideally, solutions are designed so that they allow farmers to share data collected to suppliers, investors, wider cooperative members, and other key stakeholders. This would create a broader picture of the neighbouring environment and enable coordination on a local, regional, or national level to maximise the carbon savings delivered by a solution or solution type. Moreover, interoperable systems allow for other solutions to build on top of existing technologies, expanding a solution's reach, and maximising its carbon savings.

The success of data sharing, and cross-sector cooperation needs to be driven by policy which require farmers to disclose decarbonisation metrics and targets, thereby creating incentives for the agriculture sector to adopt green ICT solutions and disclose their impact. A final constraint for farmers is finding the financiering for transferring existing systems and shifting production styles, which may add to existing pressures from suppliers and customers to keep prices low.

2.5 Performance Optimisation and Automation

Lastly, performance optimisation and automation are components of maximising the potential benefits of ICT solutions. Automation plays a key role in this process by reducing or eliminating human intervention, and streamlining operations, by enabling real-time monitoring, predictive analytics, and intelligent decision-making. This allows for timely adjustments to minimise energy and resource waste. By limiting human intervention, the potential for errors and inefficiencies decreases.

Agriculture Sector

Some parts of the agriculture sector are still dependent on manual labour for tasks including seeding, fertilising, weeding, picking, harvesting, herding, and monitoring. This may limit business optimisation and scaling, and in some instances present health and safety risks.

Optimisation and automation can help farms move away from some labour-intensive jobs and help grow business performance. Typical solutions include automating tasks like seeding and weeding through robotics, streamlining decision-making through AI, or forecasting through precise monitoring. For some crop types, the efficiencies achieved can help deliver the same yield output with reduced greenhouse gas emissions.

3 Minimising emissions

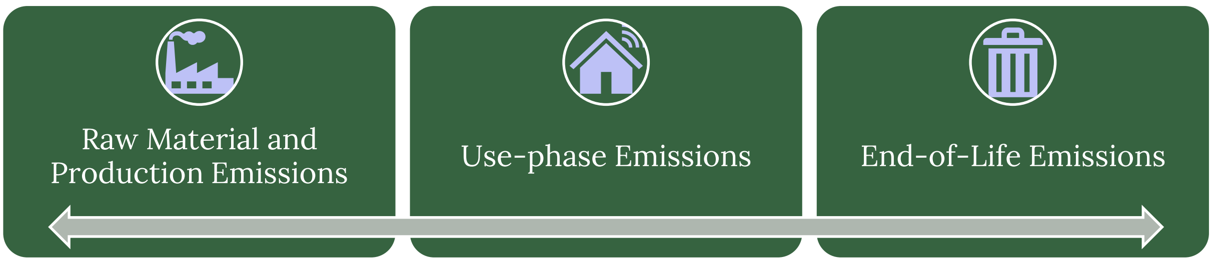
As the focus is often on maximising the net carbon impact potential of an ICT solution, it is critical not to forget the need to minimise the 'cradle to grave' emissions resulting from the deployment and use of that same ICT solution. While digital can be a force for good it has the potential to inadvertently contribute to environmental harm. By prioritising emission reduction strategies, solution developers/providers, buyers, and users can ensure that the benefits derived from an ICT solution are not offset by its carbon footprint. This section of the Deployment Guidelines therefore focuses on the need to actively mitigate and reduce emissions associated with the creation, adoption, utilisation, and disposal of ICT solutions.

3.1 Negative direct effects from the solution itself

While emissions from the solution itself may not always be significant compared to the savings it enables, they remain something to be aware of and to minimise. Also referred to as First Order Emissions, typical hotspots for ICT solutions include the following:

- **Hardware and its manufacture**: ICT solutions often have physical hardware components. The production of these components involves the extraction and processing of raw materials, manufacturing processes, and assembly. Emissions hotspots in this phase of a solution's lifecycle include the energy consumption in factories, emissions from chemical processes, and the extraction of rare earth metals, such as lithium for batteries.
- **Use phase – hardware and software**: During the use phase, ICT solutions consume energy for operations, including charging, data processing, and network connectivity. The emissions hotspots in this phase of a solution's lifecycle are primarily associated with electricity consumption.
- **Use phase – network infrastructure**: ICT solutions do not often operate as a standalone. The operation of data centres, telecommunications networks, and other ICT infrastructure requires a significant amount of energy. Data centres, in particular, consume large amounts of electricity for cooling, server operation, and data storage.
- **End-of-life**: Due to limited waste management process and sometimes a lack of understanding of appropriate waste practices by users, e-waste is often disposed of incorrectly causing harm to the environment and costing society valuable natural resources. When ICT solutions reach the end of their life, they need to be adequately disposed of or recycled. Emissions can occur during the disposal process, especially if electronic waste is incinerated or ends up in landfill. If not conducted properly, recycling processes can also generate emissions than would be saved by the reuse of the materials.

3.1.1 Minimising emissions



Solution Embodied Carbon:

- **Life cycle assessment**: Ideally developers should conduct life cycle assessments of their solutions to identify and address emissions across the entire life cycle, from production to disposal. This can help optimise the environmental performance of the solutions. Developers should follow leading global standards (such as the GHG Product Life Cycle Accounting and Reporting Standard) or, if there are no in-house capabilities, consult third parties to support.
- **Raw material and production emissions**: Developers should select and work with suppliers that provide sustainable raw materials. They should measure and manage their Scope 3 emissions to reduce the associated production emissions.
- **End-of-Life emissions**: Developers should be designing ICT solutions to be circularity-ready. Integrating circularity involves two main key steps: designing for reuse/refurbishment and implementing effective e-waste management systems. This includes incorporating the possibility for components of the solution to be refurbished or maintained to extend the end of life of devices, as well as establishing collection and recycling programs to ensure proper disposal and recovery of valuable materials. Actions to tackle end-of-life of devices should be incorporated as part of post-sale support.
    - Important note: As far as software updates are concerned, while some might indeed allow to improve efficiency or compatibility of the solution with other technologies, updates could also lead to early obsolescence of devices. Solution developers and providers should be conscious of this when rolling out updates.

Overall, minimising solution emissions can be quite resource and cost intensive. However, solution developers and providers do not need to be doing of this alone. Solution developers and providers should strive to develop B2B partnerships to work together with other organisations. Policy and industry bodies also have a role to play incentivising data sharing and providing support for developers/providers to do these assessments and help facilitate B2B and industry wide engagements.

Operational Carbon:

Use-phase emissions:

- **Energy-efficient design**: Developers should prioritise energy efficiency in the design of their solutions, ensuring that the solutions consume minimal energy while delivering the desired functionalities. This can include optimising algorithms, reducing standby power, and using energy-efficient components.

- **Partners:** When developing a solution, it is important to consider who to partner with and the impact of their contribution. If your solution will use the cloud/data centres, what is the impact of this? Do the cloud/data centres run on renewable energy?

Agriculture Sector

- Depending on the region, businesses in the agricultural sector may have non-productive land that could be repurposed and are therefore well positioned to minimise the energy usage linked to ICT solutions by leveraging on-site green electricity generation, for instance by installing solar panels. For energy-intensive solutions, including those using robotics or complex computations, green energy provision may considerably reduce a solution's own emissions.
- Similarly, to avoid additional emissions related to building, expanding, or strengthening wireless 4G/5G internet connectivity, agricultural solutions in areas of low connectivity may consider moving the majority of their computation power to on-site computers or servers. This allows any additional computation power required on the fields to be on low-energy, wide-range bandwidths. However, it is to be noted this will not be possible for all use cases and depends on local network characteristics.
- Finally, it is important to take into consideration any environmental consequences from changes to the land. Changing the function of uncultivated land may have the beneficial property of enabling a natural carbon sink, or allow for carbon sequestering, thereby reducing GHG emissions.

3.2 Minimising rebound (negative indirect) effects and other potential negative impacts on the climate

Increases in emissions from the introduction of a solution can come not only directly from the solution itself but can be the result of unintended consequences, often driven by behavioural change. These negative higher order effects are known as Rebound Effects, and typically occur as effects that cause an increase in consumption due to improved efficiency of resource use, for example, an efficient product is cheaper to operate, and hence more is consumed. The improved efficiency is not limited to cost but can be any resource, such as materials, time, cost, or space.

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This subsection will take stock of circumstances where the positive climate impacts of the solution could be diminished or reversed and will provide guidance on how to address this.

Agriculture Sector

A rebound effect is the increase in emissions occurring as result of the introduction of the ICT solution, often driven by behavioural changes in demand for carbon-intensive goods or activities .

Common rebound effects to look out for are outlined below:

- **Increased output:** The efficiencies that may be brought about by ICT solutions can help grow the output of a farm. Boosted business performance may help businesses increase in size, which ultimately may lead to a net increase in carbon emissions. It should be considered that food security can be considered a public good and users could track versus revenue or calories produced.
- **Disincentivising moves to more sustainable farming practices:** The creation of efficiencies and carbon reductions on a farm may reduce the need to move to other types of farming that, if implemented, would have more significant carbon impacts, including organic farming, or agroforestry.
- **Increased demand for carbon-intensive produce:** Efficiencies may also incentivise farms to change production to outputs that are worse in terms of the volume of greenhouse gas emissions they generate. For instance, an improved digital irrigation system may lead a farmer to produce more water-intensive crops. Similarly, more efficient production of dairy production may incentivise a farmer to expand its business into the more polluting beef production industry.

It is important to note that rebound effects are context specific. Factors impacting them include user behaviour and the design and implementation of ICT solutions. For instance, the likelihood of a digital irrigation system incentivising the cultivation of more water-intensive crops may depend on the farmer's existing physical equipment and machinery. Solution developers/providers, buyers and users should carefully consider these rebound effects and adopt measures to mitigate them through user awareness and education.

3.2.1 How can rebound effects or negative impacts be avoided or mitigated?

While rebound effects will often be outside of the direct control of solution developers, it is important for prevention and mitigation processes to be put in place. Developers, providers, buyers, and users of ICT solutions should consider how to minimise rebound effects throughout the solution lifecycle. Not considering this can lead to the diminishing or reversal of savings enabled by the ICT solution.

Agriculture Sector

Tracking rebound effects in the context of ICT solutions requires collaboration and shared responsibility among different stakeholders. The responsibilities can be divided as follows:

1. ***Solution developers/providers***: Developers and providers of ICT solutions have a primary responsibility to design and offer solutions that prioritise energy, fuel and resource efficiency. They should conduct thorough assessments of potential rebound effects influenced by user behaviour during the development and deployment phases of their solutions. Developers should also provide guidance and information to solution buyers and users regarding energy consumption and the optimal use of their solutions. For instance, for an autonomous weeding robot, it is key to indicate the number of rounds required to keep crops healthy. To minimise its significant electricity usage, farmers should be cautioned not to overuse it.

Farmers and labourers: Solution buyers, including farmers, play a role in ensuring the effective monitoring and management of rebound effects. They should consider the possible ways in which rebound effects may materialise in the different circumstances for which they are purchasing the ICT solutions. Buyers should then engage with users to establish clear performance indicators to track and mitigate rebound effects over time. For example, this could include consistent tracking of increased crop production. Tracking of rebound effects should involve a collaborative effort among solution developers/providers, buyers, farmers/labourers. By establishing clear responsibilities and promoting cooperation, it becomes possible to effectively monitor and mitigate behavioural rebound effects associated with the deployment of ICT solutions in the agriculture sector.

Avoidance or Mitigation of Rebound Effects:

Rebound effects can be avoided or mitigated through a combination of approaches involving solution design, awareness, and prevention. By incorporating preventive measures through solution design, promoting awareness among users and buyers, and encouraging energy-efficient behaviours, rebound effects can be avoided or mitigated.

Here's how each stakeholder can contribute to avoiding or mitigating rebound effects:

1. **Solution developers/providers:**
   a. Solution design: Developers can incorporate features that automate processes and limit human intervention, reducing the potential for behaviour-driven rebound effects. For example, implementing robotics and AI to automate processes.
   b. Supporting users by increasing user awareness and providing training: Users should receive appropriate training and education to understand the potential rebound effects associated with ICT solutions.

2. **Solution buyers** (including farmers):

   a. Assessing risks and increasing user awareness: Solution buyers should consider the possible ways in which rebound effects may materialise and assess the risks in each of the users/uses for which they are purchasing a solution. Buyers should establish performance monitoring of the deployed solutions to track impact and assess any rebound effects. Like solution developers and providers, solution buyers should engage with users to raise user awareness to the risks of rebound effects and provide appropriate training and incentives to avoid or mitigate the potential rebound effects.
   b. Collaboration with developers: Buyers should also bring to the attention of solution developers/providers any identified rebound effects, to raise awareness and seek their expertise in mitigating potential impacts. This collaboration can lead to the development of tailored solutions and continuous improvement.
   c. Behaviour modification: Buyers should actively adopt energy-efficient practices and being mindful of their consumption behaviours. Regular reminders and feedback mechanisms can help users track and modify their behaviours to mitigate rebound effects.
   d. Continuous monitoring and feedback: Buyers should engage in regular monitoring of energy consumption and provide feedback on the performance of the solutions and savings to solution buyers, who can feed this back to the solution developers/providers.

4 Measuring net carbon impacts

Metrics are essential to support the solution's value proposition and to assess benefits and impacts. This section will provide guidance on which metrics to use and/or how to select them and can also address pitfalls to avoid in the process of selecting and communicating metrics.

4.1 Selecting the most relevant metrics

Different stakeholders care about different metrics. For example, solution developers might focus primarily on energy/fuel savings, whereas customers might focus more on reduced input costs. Focusing communication on metrics that matter to solution developers but don't matter as much to their clients or financial backers may lead to limited adoption. To optimise the deployment of a solution, understanding what metrics matter most to solution users and other stakeholders is key.

On the other hand, tracking the right metrics to be able to quantify the net carbon impact and understand the positive environmental potential of a solution is crucial to aid the path to sectoral decarbonisation. Some suggestions for relevant metrics for pre and post implementation are discussed below.

4.2 Pre-implementation metrics

What needs to be measured before implementation to establish a baseline from which to measure the solution's benefits?

To understand the benefits enabled by ICT solutions, key metrics must be defined and tracked. It is key to start tracking the relevant metrics before the implementation of the solution to allow for a reliable comparison between the before and after scenario. Without this, establishing a baseline and evidencing the positive impact of an ICT solution may be difficult and will likely need to rely on high-level assumptions. It is the combined responsibility of solution developers/providers, buyers, and users to work in collaboration to track the current scenario before the implementation of the solution.

Procedures should be put in place to normalise this practice. For solution buyers and users, tracking the current conditions and impact allows them to better understand their own current environmental impact and identify key hotspots for emission reduction. Without understanding the current conditions, it is harder to know what needs to be reduced, and by how much. On the other hand, solution developers/providers should encourage this practice and request this information pre-sale or at sale. Not only will this

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data help them better deploy the solution for the buyers and users but will also help them better understand and quantify the impact.

Agriculture Sector

To quantify the solution's impact, it is important to measure datapoints as accurately as possible before its implementation. The specific metrics to track depend on the solution type, but common metrics to track for the sector include:

- **Environmental and animal health indicators:** Most agricultural ICT solutions seek to create efficiencies in the production of crops or improve animal health. Baseline data for crop-optimising solutions could include environmental variables such as soil health (chemical composition and density), weather conditions, water flow, and yield quality and output. Animal-related solutions may include monitoring of animals' physical health, and output and quality of production (dairy, eggs, wool, or meat).
- **Resource use:** For solutions that optimise the use of resources, including pesticides, fertiliser, water, fuel usage, medicine or land use, pre-solution measurements should be taken on these, as well as possible areas or moments of high resource use. These may be measured against output, e.g. [litres of water / kg yield], nutritional value, e.g. [calories or level of vitamins / crop], against area use, e.g. [kg pesticides / hectare], or unit of measurement, e.g. [kg yield discarded / kg yield produced].
- **Variability:** To ensure the reliability of data points before implementation of the solution, it is important to measure data over a longer timeframe, typically multiple agricultural seasons, or years, thereby monitoring and accounting for any fluctuations and changes over time.

While tracking this information may present a cost in the short run, the data could be leveraged to support other business functions in the medium to long-term, including in procurement.

4.3 Metrics to track during and after implementation

To quantify and evidence the net carbon impact of an ICT solution, please see below suggested metrics to track during and after implementation. These metrics should align to those measured pre-implementation and should ideally also be metrics of interest for

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solution developers, buyers, users, and financial backers so that this data can be used to inform tracking beyond emissions reductions.

Agriculture Sector

See below some examples of agricultural solutions and suggestions of how to measure. Please note this is not a comprehensive list.

- **Mechanic weeding:** Measure the amount and types of pesticides used before, during, and after implementation of the solution to assess the reduction in carbon due to lower pesticide use. Also measure the fuel and electricity usage before and after the solution to compare emissions from tractor-based weeding against mechanics-based weeding.
- **Improving animal health**: Measure key health indicators (e.g., stress hormone levels, respiratory rate, vitamin uptake, daily milk/egg production) for various animals before, during, and after the implementation of the solution to assess changes in health or production quality.
- **Weather-optimised farming:** Measure or consult public sources for weather conditions over multiple years to account for seasonal changes and climate variability, and correlate these to yield output (quantity or quality). Given expected changes to the climate, this will require continuous monitoring.
- **Resource use optimisation**: Measure the quantity or quality of each optimised resource type before, during, and after implementation of the solution and correlate these to output, area use or unit of measurement to assess increased efficiencies.

4.4 How to track effectively

Effective tracking of the deployment of ICT solutions requires careful consideration. To track their implementation, several key factors should be taken into account. Please find below the recommended checklist to follow:

Agriculture sector
Checklist:

- ❖ **Clearly defined metrics**: Define the specific metrics and indicators that will be tracked to assess the performance and impact of the ICT solution. Ensure that these metrics align with the goals and objectives of the solution and are measurable and quantifiable.
- ❖ **Baseline assessment:** Establish a baseline assessment of the farm, crop, or animal's performance before the deployment of the ICT solution. This provides a reference point for comparison and enables the measurement of the solution's effectiveness in achieving

improvements. According to the methodology, the baseline should be the market average. If it is impossible to measure against the market average, it should be considered what measurement adjustments must be made.

- **Data collection and monitoring systems**: Implement robust data collection and monitoring systems to gather accurate and reliable data on energy consumption, emissions, operational performance, occupant feedback, and other relevant parameters. Automated systems or sensors can help streamline data collection processes.
- **Timely and continuous tracking**: Initiate tracking efforts from the very beginning, ideally during the pre-deployment phase, to capture the baseline data. Continuously track and monitor the performance and impact of the ICT solution over time to assess its long-term effectiveness.
- **Long-term measurement**: The impacts of the ICT solution may evolve and change over time. It is important to monitor and measure the effects of the solution beyond the initial deployment phase to understand its sustained performance and identify any potential deviations or trends.
- **Avoiding tracking pitfalls**: Be cautious of common pitfalls in tracking, such as relying solely on self-reported data, inadequate data validation and verification processes, or inconsistent data collection methodologies. Implement rigorous quality control measures and ensure data accuracy and reliability.
- **Stakeholder engagement**: Clearly define roles and responsibilities for tracking among different stakeholders involved, including solution developers/providers, land owners, farmers, policymakers. Collaborate closely with stakeholders to ensure effective data collection, monitoring, and reporting.
- **Continuous improvement**: Utilise the tracking results to identify areas for improvement, optimise the performance of the ICT solution, and inform future decision-making processes. Regularly review and update the tracking methodologies and metrics to align with changing goals and emerging best practices.

5 Going further: designing the solution to broaden its reach

While it is important to focus the deployment and implementation of each ICT solution on maximising of carbon benefits, it is important not to forget the impact of scalability. The more instances of deployed and scenarios of use, the greater the overall carbon benefits. Solutions are often designed with a specific use case in mind – however, sometimes making small design or development changes can make the solution usable in more scenarios and circumstances.

5.1 Relevance across potential use cases

When deploying ICT solutions to maximise their impact in decarbonisation efforts, it is important to consider their relevance and potential use cases. ICT solutions should not be limited to specific sectors or large-scale applications but should aim to be versatile and adaptable to various use cases. This approach ensures that the benefits of digitalisation reach a broader spectrum of industries and applications, including use by small and medium-sized enterprises (SMEs).

By designing ICT solutions with scalability and flexibility in mind, solution developers/providers enable their relevance across diverse sectors and empower small players, like SMEs, to embrace sustainable practices. This might involve developing user-friendly interfaces, providing customisable features, and offering affordable implementation options. By making ICT solutions relevant to as many use cases as possible, their potential can be unlocked across the entire economy, accelerating decarbonisation efforts at scale, and fostering a more inclusive and sustainable future.

Agriculture Sector

The most impactful solutions are designed to be used across various crop types, livestock and landscapes. For instance, a solution that monitors the health of open-field cattle may be adjusted to enable monitoring other farm animals, such as pigs, sheep, and goats. A solution that requires the implementation and installation of physical sensors may consider whether these can be installed in different soil types, such as rock, clay, sand, and peat. What is more, solutions that rely on limited or no wireless connectivity are more widely implementable because the 4G/5G network coverage of agricultural land across Europe is inconsistent.

Below is a list of questions for solution developers to consider during the design phase of an ICT solution, to broaden the scope and use of solutions.

This section of the Deployment Guidelines aims to stay high-level, and it should be noted that these questions are only meant as a thought starter.

Technology and Infrastructure – Questions:

- How dependent is the solution on the availability and reliability of other technologies and infrastructure (e.g. mobile telecom grid, broadband network, electricity grid, roads, etc.)?
- Is the required infrastructure widely available in the markets where the solution could be deployed?
- Can the solution still work in areas where that technology/infrastructure is not as available/reliable?

- If not, would it be feasible and/or relevant to make the solution more adaptable to cases where those technologies and infrastructure are not available or reliable?

People – Questions:

- Does the solution require local labour skills for optimal implementation and after-sales/maintenance? (This is especially relevant if improper implementation and/or maintenance can lead to reduced carbon benefits.)
- If a lack of available skilled labour could lead to reduced carbon benefits, is there a way to prevent or mitigate this through solution design?

Physical environment – Questions:

- Is the solution limited to certain geographical and climatic conditions?
- Can the solution be adapted to work in a wider variety of geographic and climatic conditions?

Financial, business and policy environment – Questions:

- In the markets where the solution is intended to deploy, are there any financial, business and/or policy barriers (e.g. mobile data tariffs, regulatory barriers such as tariffs for importing technology and parts, licensing…) that would significantly hamper deployment?
- If so, would it be feasible and relevant to design out some of these barriers (e.g. using materials subject to lower tariffs)?

6 Beyond greenhouse gas emissions: wider sustainability impacts

This section aims to take stock of the solutions' impacts beyond its effects on the climate, and to provide general guidance on how to mitigate negative impacts. As the focus of these guidelines is climate benefits, this 'wider impacts' section is intended to be high-level rather than specific guidelines. Its purpose is to highlight potential positive impacts beyond emissions sayings that can be enabled by an ICT solution, while also helping stakeholders identify a range of potential negative impacts so that these can be prevented or mitigated before they arise. Where possible, solutions should adhere to the 'Do No Harm' principle.[4]

Possible areas to consider when assessing wider impacts of the solution:

Environmental impacts beyond carbon	Economic and Social impacts	Health and Safety Impacts

6.1 Environmental impacts beyond carbon benefits

Beyond carbon, ICT solutions have the potential to have both positive and negative environmental impacts. Through the enabled monitoring, optimising, and automating, ICT solutions can help identify and improve environmental impacts, particularly around waste and water. However, the ICT sector can sometimes be overly tech-optimistic, assuming that digital innovations will inherently lead to positive outcomes and this optimism can overshadow critical issues such as the short lifetime of digital devices, the generating of electronic waste, and posing safety concerns. Below are a few examples to help prompt and guide stakeholders (developers, buyers, and users of ICT solutions) to explore the non-carbon sustainability impacts of ICT solutions.

[4] Please refer to the EGDC Net Carbon Impact Methodology for the definition and discussion of the Do No Harm Principle.

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Waste

Positive

ICT solutions can provide opportunities for training on waste reduction practices in the agriculture sector. By enhancing knowledge and awareness, these solutions empower professionals to adopt more sustainable practices, leading to reduced waste generation.

Negative

While designing an ICT solution to reduce carbon emissions, developers might overlook choices that do not directly affect the carbon impact but may still have a negative effect on the environment. For instance, the use of certain plastics as a material component can have a lower emissions footprint than many metallic components. However, given many plastics are hard to recycle, they tend to end up at landfill or in the natural environment, with considerable consequences for nature and local biodiversity. Capturing the wider environmental consequences of an ICT solution is challenging, but completing the appropriate lifecycle analysis will help solution developers and users to assess the end-to-end carbon impact of a solution more accurately.

On the other hand, electronic waste has also become a pressing environmental issue, as the proliferation of digital technologies leads to an increase surplus of discarded electronic devices. This increase is in part a result of a lack of ICT solutions being upgradable or repairable. Therefore, it is important that ICT solutions incorporate this into their deployment, to allow them to evolve with the changing requirements and advancements in technology.

Improper disposal of e-waste poses significant environmental and health risks, as most electronic devices contain hazardous materials. Many regions lack adequate recycling infrastructure, and as a result, a considerable portion of e-waste ends up in landfills or is informally processed, often in developing countries with more limited environmental regulations. There is a critical need for comprehensive and sustainable e-waste management strategies. This includes promoting the extension of product lifespans, encouraging responsible recycling practices, and designing electronics with eco-friendliness and ease of recycling in mind. Users should also be educated about the importance of recycling e-waste, to raise awareness of and promote the proper handling and recycling of electronic devices.

Water

Positive

ICT solutions in the agricultural sector that reduce or replace the use of chemicals, including pesticides and fertiliser, and antibacterial drugs for livestock, often have the additional effect of improving the quality and biodiversity of nearby waterways, counteracting eutrophication, and antimicrobial resistance. While this may be challenging to measure in terms of carbon emissions, the benefits to the natural surroundings may be considerable. Similarly, solutions that optimise water use may have beneficial effects on drought and flood resilience beyond the farm where the solution is implemented.

Negative

ICT solutions in the agricultural sector should be weary of any negative direct effects on the neighbouring environment, including solutions that may negatively impact biodiversity, soil health, waterways, or the use of natural resources. For instance, a solution that provides on-site water filtering from nearby water sources should take into consideration how its implementation affects fish and other aquatic life. Similarly, the installation of physical equipment should not hinder natural pass-throughs preventing wildlife from crossing habitats.

6.2 Economic and Social Impacts

Beyond climate and environment, ICT solutions should do no significant harm in any other ESG areas, including in economic or social matters. ICT solutions should consider how they affect the composition of the labour market and should be weary of not impacting any demographic unfairly.

Negative

The agriculture sector stands out as a sector where automation may considerably reduce the need for manual labour. While the solution itself may create new employment, either to support the implementation of the solution itself or by allowing the client farm to grow, it is likely to require upskilling. Solution developers, users and buyers should consider ways of mitigating these job displacements, e.g., by engaging with local government to offer upskilling training.

Positive

Decarbonising the sector also generates economic opportunities and fosters job creation. The increased efficiencies that are realised with the implementation of an agricultural solution drive innovation, technological advancements and move employment to areas of the economy where there is most potential to grow. This can be of benefit to economic activity within a community and spur economic development.

6.3 Health and safety impacts

Finally, developers should consider how their solution may affect health and safety. The agriculture sector has an important to role to play in supporting healthy diets, improving animal welfare, supporting fair labour treatment throughout the food supply chain, and contributing to the affordability of food sources.

In line with the European Green Deal Farm to Fork Strategy[3], the agriculture sector has a responsibility of supporting healthy diets and reducing obesity. By prioritising factors such as nutritional value and the minimising of bacterial drugs, ICT solutions have the ability to create healthier diets and contribute to preventative healthcare.

ICT solutions that interact with animals should ensure there are no adverse effects on animal welfare and should ideally improve them. This includes but is not limited to expanding physical space, supporting contact with other animals, improving shelter, and reducing animal stress.

Finally, any ICT solution should endeavour to limit increasing food prices and contribute to safe workplaces. If the solution requires the handling of heavy machinery, adequate training and safety equipment should be provided to mitigate any risks.