# MAPPING DIGITAL TECHONOLOGIES:

## THE TAXONOMY AND INVENTORY OF DIGITAL GAME CHANGERS

Briefing

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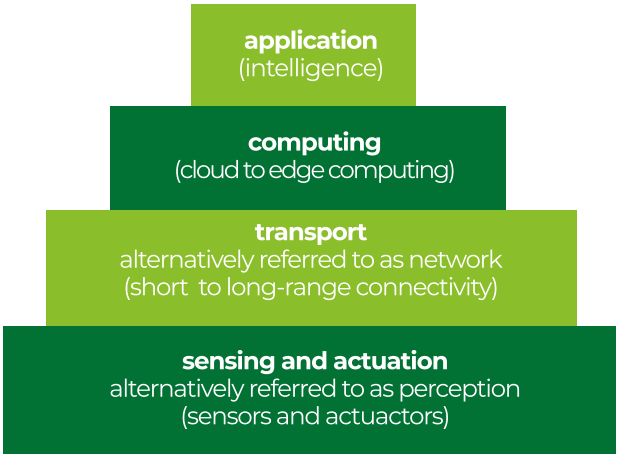
## INTRODUCTION

The DESIRA project is relying on the paradigm of **cyber-physical systems** (CPSs) to describe how technological systems can be understood by looking at their functionalities. This paradigm provides a systemic view. In other words, different digital technologies can be put in relation to each other and classified according to the functionality they provide. Hence, each digital tool has a specific function and can be used in one or more domains (agriculture, forestry, rural areas). For example, a Farm Management Information System (FMIS), which is a digital tool, is based on the use of one or more digital technologies, as for instance cloud computing, connectivity, and sensing capabilities.

Figure 1. A simple framework in four layers to describe cyber-physical systems




Source: DESIRA, 2020

A digital tool is a combination of software and hardware with a specific function, providing a service or an application. Through an online questionnaire answered by the project consortium, DESIRA has identified and described more than **600 digital tools with different functions**, which have been clustered in different groups according to the domain in which they can be used (**agriculture, forestry, and rural areas**), and then further differentiated in sub-domains, or specific **application scenarios.** Each tool exploits one or more digital technologies with the potential of acting as **digital game changers** (DGCs).

Later on the project, DESIRA will develop the **Digital Game Changers visualisation tool** which will present most of the 600 digital technologies collected to support the work on the DESIRA Living Labs. The visualisation tool will allow to browse and search digital tools by: 1) application scenarios; 2) domains (agriculture, forestry and rural); and 3) qualitative evaluations of potential socio-economic impacts. This tool will enable DESIRA Living Labs and other stakeholders to identify potential digital tools that can help in addressing a potential challenge in the area or seize an opportunity.

In Figure 2, the relation between the digital technologies (with the potential of being game changers) and the application scenarios per domain is depicted.

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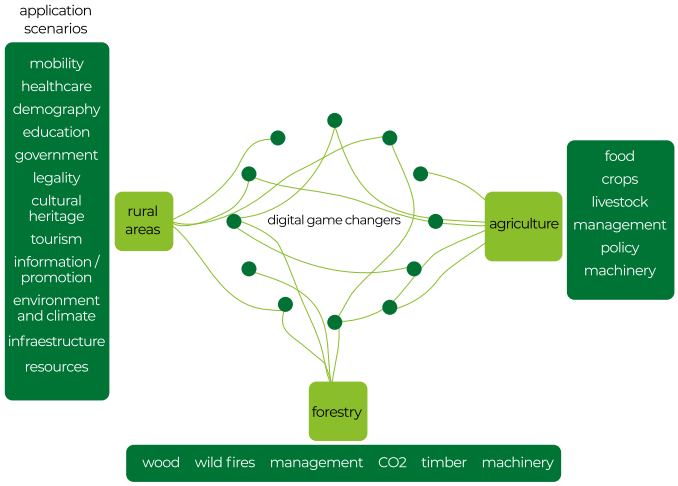
Figure 2. The use of digital technologies in different application scenarios can have game-changing effects.




Source: DESIRA, 2020

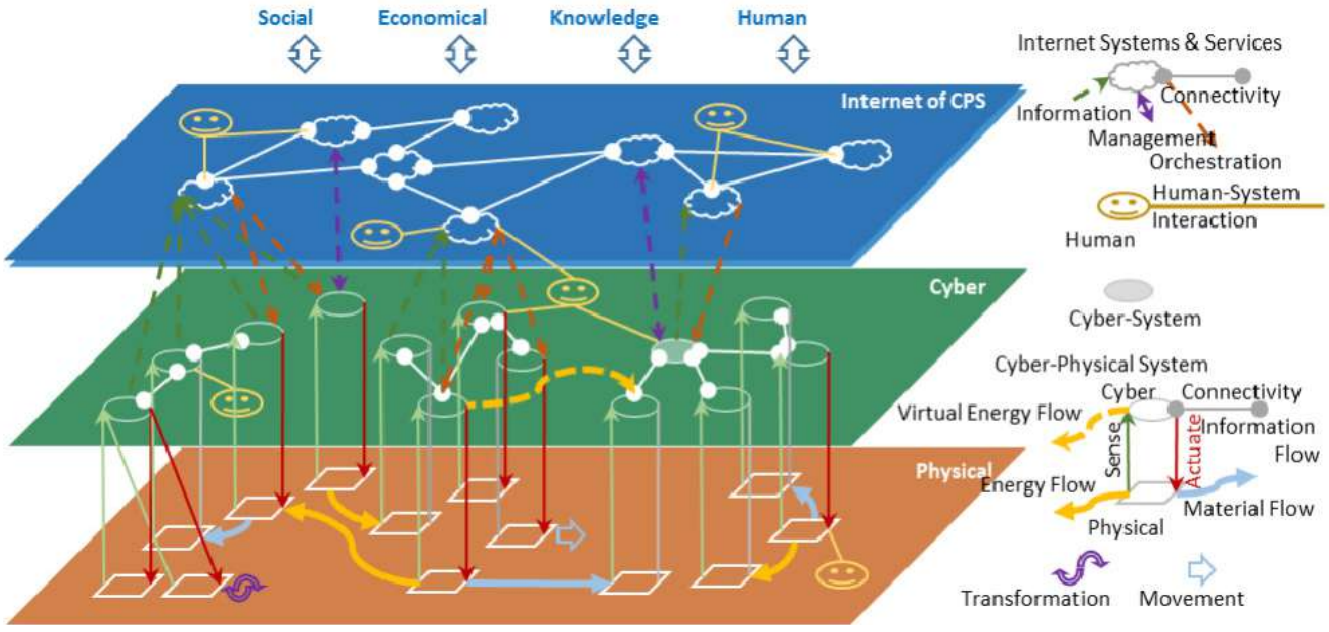
## 1. Digital technologies and digital game changers

Currently, the world is in the middle of the fourth industrial revolution, with digital technologies transforming entire sectors. Such a revolution will drive disruptive changes, reshaping the future of urban and rural areas. Digitisation, in order to occur, needs *basic conditions*, such as IT infrastructures, networks, and data protection, and enablers, such as digital skills and investments[1]. Digital technologies have the potential to thrive and provide benefits once those conditions are met. Digital technologies amplify their potential when jointly used (*integration*), and when the context is ready for adoption.

Digital technologies have ability to support the digitisation process through the so-called *physical-digital-physical loop,* which is the possibility to sense the physical world to collect digital data. Data are analysed to extract meaningful information, which are used to act on the physical world, closing the loop.

The fourth industrial revolution is based on the concept of **integration**[2], which can be horizontal (along a value chain), vertical (extensive automation in a specific activity of the value chain), and end-to-end (connecting the value chains). A key enabler of integration is the CPS paradigm: systems embedding the aforementioned *physical-digital-physical loop,* and system of systems (the integration of several CPSs). Smart connected things, as in the Internet of Things (IoT) paradigm, are designed to sense the physical world and/or act on it. They are at the physical-cyber border, a blurred line where the cyber and physical dimensions converge. Figure 3 shows the relation between the physical and cyber dimensions, highlighting how CPSs can be used to describe this interaction; also, the role of Internet in connecting CPSs is shown, generating system of systems. It shows that the physical world can be sensed, thus opening to the possibility to represent it in the cyber dimensions. The CPS paradigm has been introduced to model such a dynamic, which can be further expanded from a logical viewpoint to connect (integrate) different CPSs. Their use has social and economic effects.

Figure 3. CPS paradigm and the concept of Internet of CPS.




Source: CPS Framework Release 1.0[3]

**Example of Physical-Digital-Physical Loop**

Sensors in the field collect data about the soil status. A physical status (soil status) is transformed into digital data by the sensors; collected data are transmitted, stored, and analysed in a cloud system. The information extracted from data is sent back to the farmer that can take informed decisions; for instance, irrigating or applying nitrogen.

In general, a physical phenomenon can be digitalized through the use of sensing technologies (*physical to digital*). The information extracted from the digital data representing the physical phenomenon can be used to act on the physical world (*digital to physical*), closing the loop.

Which digital technologies can be considered crucial to support such a process?

At today, the so-called fourth industrial revolution — and related technologies — is driven by the use of technologies that to digitally transform existing practices in the industrial sector.

The digital technologies collected by DESIRA cannot all be considered Digital Game Changers as such. They have been selected complementing two approaches. The first one is based on a **literature review**, taking into account scientific papers, technical reports, and other sources; the second one is inspired from the **CPS paradigm**, which is used as a reference model to describe the *physical-digital-physical loop*; it also puts technologies in relation with each other, gluing those together in a systemic view. The core digital technologies to enable CPSs, relevant for the DESIRA project, can be read in Table 1.

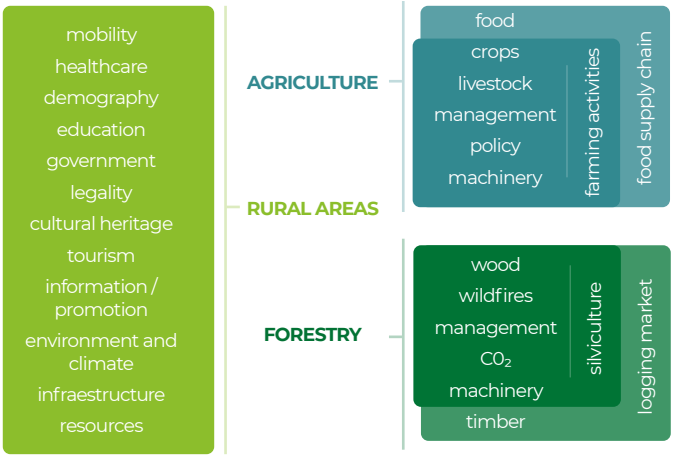
Table 1. Digital technologies with the potential to change the game.

| DIGITAL TECHNOLOGIES | DESCRIPTION and EXAMPLES |
|---|---|
| social media and social networks | social tools for interaction or access to services |
| web sites and online platforms | web tools for interaction or to access/ offer services in a coordinated manner |
| cloud/edge services and applications | services available through mobile applications, web platforms, or other interfaces (e.g. image analysis for disease / pest recognition by sending pics) |
| sensors, drone and/ or satellite imagery (data sources) | use of sensors in the field, drone (UAV) and satellite imagery to collect data |
| blockchain or other certification / traceability services | services to certify products, processes, etc. or to trace products |
| data analysis | techniques to extract information from data |
| augmented reality / virtual reality | extended reality techniques for training, education, or other purposes |
| 3D printing | production of 3D objects through a printing-like process |
| artificial intelligence | use of AI to analyse data or to suggest actions / decisions |
| autonomous systems and robotics | robots (like milking robots) or other systems performing actions autonomously |

## 2. Application Scenarios

In DESIRA, the concept of application scenarios is used to describe the technical context in which a digital tool is used, the actors involved in it, and the interactions among them. This concept is used as a high-level reference for DESIRA Living Labs as each of them face specific application scenarios defined by their research focal question (e.g. the impact of weeding robots in agricultural practices). Later in the project, DESIRA will build five use cases* to provide, in a Responsible, Research & Innovation (RRI) fashion, novel digital tools – approved by DESIRA – that can be used in specific scenarios in the domains of rural areas, forestry, and agriculture.

Figure 3. Application scenarios identified in DESIRA




Source: DESIRA elaboration. Data collected from an internal survey

*Use cases are specific digital solutions develop to address some of the research focal questions in the Living Labs.

## 3. Socio-economic impacts

DESIRA has performed a literature review and identified the areas of socio-economic impacts of specific digital technologies. These areas of socio-economic impacts are presented in Table 2.

The classification in Table 2 is based on three main concepts:

1. **Domain:** it refers to the macro-dimensions involved in the digitalisation process as emerging from the literature review. The macro-dimensions have been summarised in: economy, environment, social). To emphasize policy and administrative dimensions, it is proposed to consider the dimension of "governance" separated by social macro-domain, thus it is separated by the latter to emphasize its policy and administrative macro-dimensions.
2. **Area of impact:** sub-dimensions or specific areas within each domain, as emerging from the literature review. It should not be considered as exhaustive, yet it identifies several areas of interest to provide a detailed map of potential socio-economic impacts.
3. **Outcome:** for each area of impact, the main outcomes of digital technologies have been identified and selected.

The extensive analysis of the literature (both white and grey) regarding digital transformation in agriculture, forestry and rural areas enabled to identify socio-economic impacts linked with the use of digital technologies. Data collected has been classified and clustered based on the principle of **prevalence:** A technology has a greater effect in a specific socio-economic *domain*, it affects a specific dimension or *area of impact*, and it produces a certain *outcome*. The responses of nearly 600 digital technologies collected in DESIRA through the online questionnaire have been used to test and refine the proposed classification.

Table 2. Areas of socio-economic impacts.

| DOMAIN | AREA OF IMPACT | OUTCOME IN | | | | |
|---|---|---|---|---|---|---|
| Economic | **Organizations** | Autonomy | Cooperation | Financial risk | Incomes | Marketing |
| | | Product/process security | Productivity | Resilience | Resource efficiency | Responsibility |
| | | Transaction costs | | | | |
| | **Value chain** | Bargaining power | Food quality | Resource efficiency | Transparency | Trust |
| | **Markets** | Equal opportunities | Market concentration | Prices | Stability | Transparency |
| Environment | **Animal wellbeing** | Animal health | Animal welfare | | | |
| | **Ecosystem services** | Biodiversity | Clime | | | |
| | **Natural resources** | Energy | Nutrients | Plant health | Soil | Water |
| | **Risk management** | Prevention | Proactivity | | | |
| Governance | **Operationality** | Cooperation | Law enforcement | Administrative burdens | Transaction costs | |
| | **Equity** | Law enforcement | Participation | | | |
| Social | **Individuals** | Health | Responsibility | Skills | Wellbeing | Learning |
| | **Access** | ICT | Information | Resources | | |
| | **Rights** | Autonomy | Equity | Gender gap | Power | Resilience |
| | **Social capital** | Cohesion | Identity | Inclusion | Participation | Trust |
| | **Control** | Prediction | Privacy | Security | Surveillance | Transparency |
| | | Responsibility | | | | |

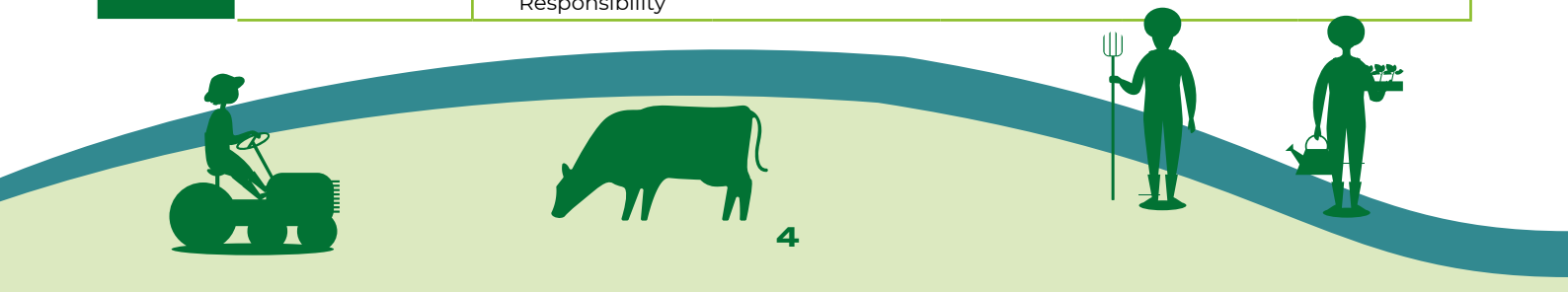


Table 3. Mapping DGC and socio-economic impacts

| | | | POTENTIAL DIGITAL GAME CHANGERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DOMAIN | AREA OF IMPACT | OUTCOME IN | Social Media | Cloud | Local / remote sensing | Distributed ledger | Data analytics | Augmented reality | 3D printing | Artificial intelligence | Autonomous systems | Connectivity |
| Economic | Organization | Autonomy | x | x | x | x | x | x | x | x | x | X |
| | | Cooperation | x | x | | x | | | | | x | x |
| | | Financial risk | x | | x | x | x | | | x | x | |
| | | Incomes | | | x | x | x | x | x | x | x | x |
| | | Marketing | x | | x | | x | x | | x | | x |
| | | Product/process security | x | | x | | x | | | x | x | x |
| | | Productivity | | x | x | | x | x | | x | x | x |
| | | Resilience | x | x | x | | x | | x | | x | x |
| | | Resource efficiency | | | x | | x | | | x | x | x |
| | | Responsibility | x | | | x | x | | | | | |
| | | Transaction costs | x | | x | x | x | | | x | | x |
| | Value chain | Bargaining power | | x | x | | x | | | x | x | x |
| | | Food quality | x | | x | x | x | | | x | x | x |
| | | Resource efficiency | | | | | x | | | x | | x |
| | | Transparency | | | x | | x | | | x | | x |
| | | Trust | x | | x | x | | | | | | x |
| | Markets | Equal opportunities | | | x | x | x | | | x | x | |
| | | Market concentration | | | x | | x | | | x | | |
| | | Prices | | | x | | x | | | x | x | x |
| | | Stability | x | x | x | x | | | | | | x |
| | | Transparency | x | | x | x | | | | | | x |
| Environment | Animal wellbeing | Animal health | | | x | x | x | | | x | x | x |
| | | Animal welfare | | | x | x | x | | | x | x | x |
| | Ecosystem services | Biodiversity | x | | x | | x | x | | x | | x |
| | | Clime | x | | x | x | x | | | x | x | x |
| | Natural resources | Energy | | | x | | x | | | x | x | x |
| | | Nutrients | | | x | | x | | | x | x | x |
| | | Plant health | | | x | | x | x | | x | x | |
| | | Soil | | | x | | x | | | x | x | |
| | | Water | | x | x | | x | | | x | x | |
| | Risk management | Prevention | x | | x | x | x | | | x | | x |
| | | Proactivity | | | | | | | | | | |

| | | | POTENTIAL DIGITAL GAME CHANGERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DOMAIN | AREA OF IMPACT | OUTCOME IN | Social Media | Cloud | Local/remote sensing | Distributed ledger | Data analytics | Augmented reality | 3D printing | Artificial intelligence | Autonomous systems | Connectivity |
| Governance | Operationality | Cooperation | x | x | | x | | | | | x | x |
| | | Law enforcement | x | | | x | | | | | | x |
| | | Administrative burdens | x | | x | x | x | | | x | | x |
| | | Transaction costs | x | | x | x | x | | | x | | x |
| | Equity | Law enforcement | x | | | x | | | | | | x |
| | | Participation | x | | | x | | | | | x | x |
| Social | Individuals | Health | x | | x | | x | | | x | | |
| | | Responsibility | | | x | x | x | | | x | x | x |
| | | Skills | x | x | | x | x | x | x | | | x |
| | | Wellbeing | x | | | | x | | | x | x | x |
| | | Learning | x | x | x | x | | x | x | | x | x |
| | Access | ICT | x | x | x | x | | x | x | | | x |
| | | Information | x | | x | x | | | | | | x |
| | | Resources | | x | x | | | | | | x | x |
| | Rights | Autonomy | x | x | x | x | | x | x | x | x | x |
| | | Equity | x | | x | x | x | | | x | x | x |
| | | Gender gap | x | | x | | x | | | x | x | x |
| | | Power | x | | x | x | x | | | x | x | x |
| | | Resilience | x | x | x | | x | | x | | x | x |
| | Social capital | Cohesion | x | | | x | | | | x | | x |
| | | Identity | x | | | | x | x | | | | x |
| | | Inclusion | x | x | | x | | x | | | | x |
| | | Participation | x | x | | x | x | x | x | | | x |
| | | Trust | x | | x | x | | | | | | x |
| | Control | Prediction | | | x | | x | x | | x | | |
| | | Privacy | x | | x | x | x | | | x | | x |
| | | Security | x | | x | | x | | | x | x | x |
| | | Surveillance | x | | x | | x | x | | x | | x |
| | | Transparency | x | | x | x | | | | x | x | x |
| | | Responsibility | x | x | x | x | | x | x | x | x | x |

## References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