KEY DIGITAL GAME CHANGERS SHAPING THE FUTURE OF FORESTRY IN 2040

VIEWS FROM DESIRA'S RURAL DIGITALISATION FORUM EXPERTS

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1. Introduction

This document is a contribution of the EU-funded project DESIRA to the debate on the 'Long-term vision for rural areas' (LTVRA), which offers a multi-actor research and innovation perspective and evidence. We focus on a question, 'How can digitalisation shape and influence the future of the forestry sector in 2040?' with a particular focus on the competitiveness of the sector and sustainability of forestry resources in Europe.

In June 2019, the University of Pisa, together with 24 European organisations, launched a 4-year **Horizon 2020 project, DESIRA - Digitisation: Economic and Social Impact in Rural Areas.** DESIRA's main goal is to improve the capacity of society and political bodies to respond to the challenges that digitalisation generates in agriculture, forestry and rural areas in the next 10 years. The project also aims to **make a comprehensive assessment of both the opportunities and threats of digitalisation in these three domains**.

The project relies on the active involvement of external stakeholders to achieve its goals. For that purpose, DESIRA has established a EU **Rural Digitalisation Forum (RDF)**: an open EU-wide community of stakeholders with a common interest to work, learn and share knowledge about digitalisation in three domains: agriculture, forestry and rural areas. DESIRA's RDF also coordinates four virtual Working Groups (WGs), dedicated to i) Agriculture, ii) Forestry, iii) Rural Areas/Life and iv) Policy, formed by experts within DESIRA, Living Lab members and high-level external experts.

This document on **Key Digital Game Changers shaping the future of the forestry sector in 2040** has been developed within the framework of the WG on Forestry of DESIRA as a **contribution to the Long-Term Vision for Rural Areas** exercise, recently launched by the European Commission (EC). Due to the importance of rural areas for the future of the European project, the Commission has proposed to strengthen their role by developing a common vision through a public consultation, providing financial resources, and taking decisive steps to elaborate a corresponding strategy. This EC initiative on the LTVRA aims to set out a vision for the future of rural areas by 2040 and the role they play in society, covering challenges such as demographic change, connectivity, low-income levels, and limited access to services. It will also explore innovative, inclusive, and sustainable solutions related to climate and digital transformation, and the COVID-19 crisis.

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In the preparation of this document, **DESIRA has sought the opinion of experts and capitalised on the knowledge already developed in the project** to contribute to the Communication on the LTVRA that the EC will publish in 2021. During the months of October and November 2020, around 11 experts on digitalisation and forestry completed a questionnaire with the objective of collecting and analysing their views on digital technologies that will influence the future of the sector. These experts are partners of the DESIRA project, members of the RDF Forestry WG, coordinators and partners in other relevant H2020 projects, and external experts ranging from academics to local developers. The results from the answers are presented in this document and they reveal that many of the issues are multifaceted, and need to be regarded as such when digitalisation-related solutions are introduced in rural areas and their impacts are being assessed.

In addition, this document presents the state of play of digitalisation in the forestry sector, with a particular focus on its environmental and socio-economic impacts, as well as the challenges and opportunities it poses nowadays to the forestry areas. A number of digital technologies considered as potential key 'game changers' (Rijswijk *et al.*, 2020) for the forestry sector in the next decades are outlined, including examples of how some of these technologies have already been used. This paper concludes with a series of recommendations to ensure that the aforementioned threats are carefully considered in future digitalisation processes, and that the forestry sector and rural areas generally make the most of the opportunities it offers.

This document follows the understanding that **digitalisation is the means to an end, and not the end itself.**

2. The state of play of digitalisation in forestry

Digitalisation is understood as 'the sociotechnical processes surrounding the use of multiple digital technologies. Such technologies have an impact on social and institutional contexts, which in turn increasingly require and depend on these digital technologies' (Tilson *et al.*, 2010). Digital technologies can have both positive and negative social, economic and environmental impacts on rural areas (Bacco *et al.*, 2020). The use of digital technologies often induces social, economic and institutional changes, but also, these changes can lead to the demand for the development of digital technologies, as a result of ongoing and interactive processes (Notcha *et al.*, 2019).

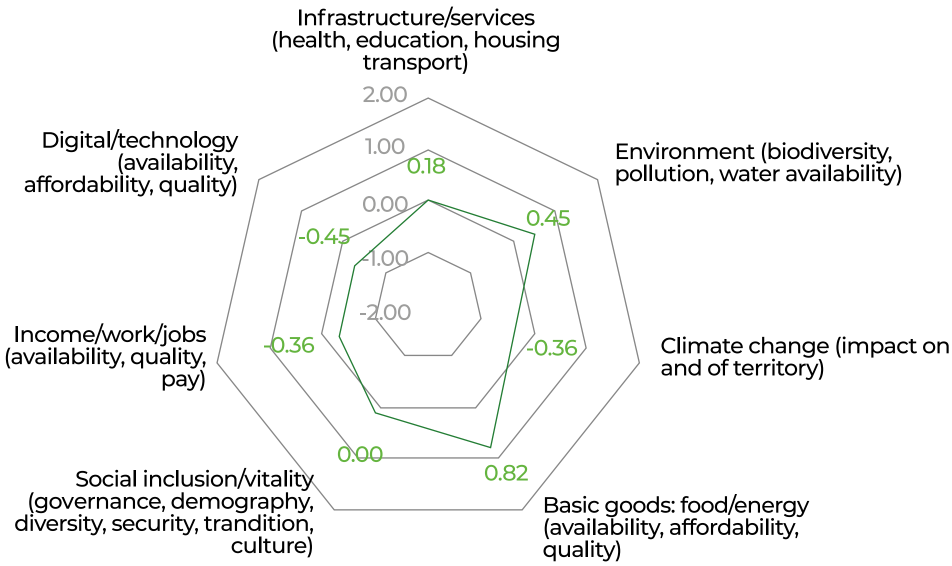
More than 40% of the EU's land area is covered by forests and other woodlands, with a major share located in rural areas. The six EU Member States with the largest forest areas are Sweden, Finland, Spain, France, Germany and Poland.

Forests are multifunctional, with an environmental, economic and social role, providing multiple benefits: ecosystem services related to soil, erosion control, water cycle, clean air, carbon storage, climate regulation, biodiversity protection; provision of recreational and cultural values; and provision of resources, in particular timber, and non-wood products. Forests are thus a source of employment, particularly in rural areas[1]. In addition to the forestry sector (forestry, wood and paper industry) having a significant role in the overall EU economy accounting for approximately 1% of EU Gross Domestic Produc (GDP), forests have also an important place in European culture.

When forestry experts were asked about the situation regarding working, living or studying in rural areas, they indicated three main issues: (i) availability, affordability and quality of technologies; (ii) availability of work, job market, income and remuneration; and (iii) the impact of climate change. The experts valued as neutral the situation of infrastructures and services (health, education, housing and transport) and the social inclusion and vitality (taking here into consideration governance, demography, diversity, security, tradition and culture). Finally, the experts appraised as relatively good the basic goods (food and energy) and the environment (biodiversity, pollution, water availability) (see Figure 1). While overall, there seems to be a similar pattern in the answers compared to their counterparts in the Agriculture and Rural Areas WGs, it is noted that the forestry experts tended to indicate worse situations in relation to environmental conditions and digitalisation development.

1 Factsheet The European Union and forests: https://www.europarl.europa.eu/factsheets/en/sheet/105/the-european-union-and-forests

Figure 1. Assessment of the development situation in the forestry sector (Base: N=11) [2]



In relation to forestry, experts outlined that there is a perceived inertia to transforming the sector, even though there are many digital developments and innovations out there with the capacity to boost important changes. However, the sector is generally recognised as still being very 'traditional' in many parts of the EU, where the take up of innovation is happening slowly. The main technological developments and digitalisation trends are taking place in the forestry sector in areas where it is clearly profitable. These include, for instance, the areas related to the monitoring of forest resources and forest health, as well as to management and early detection of biological and abiotic risks and forest fires (including geo-positioning of firefighters and real-time design of escape routes, evaluation of fire in real-time using airborne sensors, among many other applications).

Digitalisation has a lot of potential in relation to forest monitoring, management and certification, mapping forest resources and services, and opening new value chains, which would help to support decision making and improve competitiveness.

On the other hand, the experts indicated that the challenges related to implementing digitalisation are both economic and social. In particular, they outlined issues related to the disappearance of the traditional jobs in the sector, mainly those characterised by the use of manual labour, while at the same time, there is an increased demand for skilled workers - a rather scarce resource in many rural areas. Managing this transition in a way that brings benefits to rural areas and the sector becomes critical. Another relevant issue outlined is the lack of internet – including access to a decent quality – in most European mountain areas. This reduces the competitiveness of the forest-related businesses that operate in these areas. It is further exacerbated by insufficient training opportunities for forest employees in the use of new technology, and in some cases a reluctance towards embracing new technologies. This outlines the importance of embarking into multi-actor processes for digitalisation, starting from the recognition of needs and design actions that are commonly agreed, accepted and recognised by all actors involved.

Finally, experts stressed the danger that digitalisation can create by providing distorted information about the realities of forest, which can mislead decision-making processes. With enhanced digitalisation, there is more quantitative information available about forests, mainly about their biophysical states. However, forests also play an important role in fulfilling societal demands, which in many cases can be captured with qualitative measurements. Hence, decisions solely based on information from technologies may be misleading and not address the real needs of the population living in mountain areas, thus creating a general mistrust.

2 Expert responses were ranked between -2 to 2 (Very bad: -2; Bad: -1; Neutral: 0; Good: +1; Very good: +2)

3. Identification of key digital game changers for the forestry sector

Digitalisation is the greatest game changer available to forest science and technology.

When thinking about digital game changers, it is important to note here that there is a close link between digital technologies - and tools using these technologies - and so-called application scenarios. An application scenario can be defined as the context in which a given goal can be accomplished by using digital tools. In DESIRA, application scenarios have been built by grouping digital tools according to the function they serve. In the Synthesis Report on the Inventory and Taxonomy of Digital Game Changers an overview is given of technologies which are considered as potentially game changing for agriculture, forestry and rural areas (see Table 1).

The experts consulted in this exercise outlined in particular that digitalisation offers a great opportunity to enhance the competitiveness of the forestry sector and contribute to the sustainability of forest resources. Digital technologies can be applied in many different scenarios. Some of these are: i) forest management, monitoring and decision making; ii) land-use and land changes monitoring; iii) precision forestry; iv) traceability of forest resources; and v) business support and innovation.

A relevant case where digitalisation can change the game for the forestry sector concerns illegal imports of timber and forest resources. European Union Timber Regulation (EUTR 995/2010) - a compulsory EU normative instrument - was put in place to minimise the risk of introducing forest based material from illegal sources, which is estimated to be at least 20% of the total timber imported into Europe. Digitalisation can support the implementation of the EUTR by all EU Member States and help those that are lagging behind in its full adoption. The application of digital technologies for the traceability of forest resources, from origin to end-use, offers enormous potential to support the sector and further contribute to global sustainability, enhancing European value chains, and fighting corrupt practices associated with illegal imports.

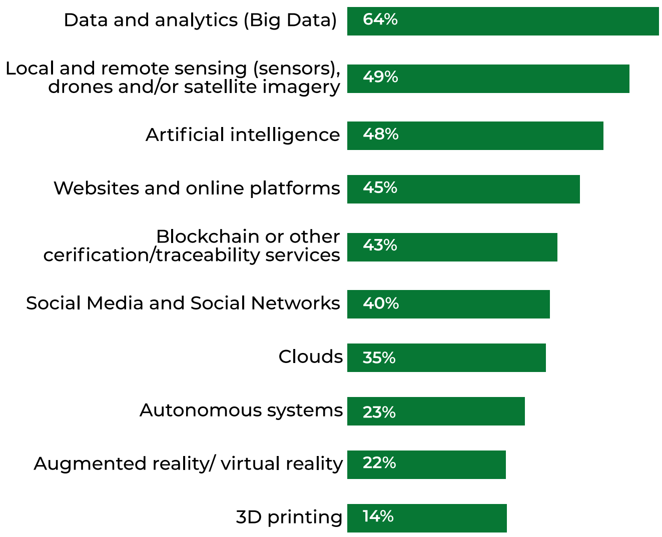
Table 1. Potentiality of game-changing digital technologies

Digital technology	Short description	Potential positive impact in forestry
Data analytics	Techniques to extract information from data (Big Data)	Information from sensed data to support decision-making
Artificial intelligence (narrow AI)	Umbrella term for machine learning and machine vision techniques, Natural Language Processing (NPL), robotic automation	Decision support and management system; planning and simulation
Social media and social network & web-based technology	Web-based tools and social tools for interaction or access to services	Access to online services and connection with the market
Local and remote sensing	Sensing capabilities available remotely (aerospace solutions) or in close proximity (in the field)	Advanced monitoring capabilities applied to trees to monitor physiological parameters, growth, and other
Cloud / edge computing	Storage and computing resources available remotely (cloud) or in close proximity (edge)	Provision of remotely deployed services; better support to real-time sensitive scenarios
Distributed ledger (DL) (in some cases also referred to as blockchain)	Distributed and replicated database without central authority. If data are stored in immutable blocks cryptographically linked, the DL is known as blockchain	Traceability and smart contracts; insurances
Augmented reality / virtual reality (AR/VR)	Extended reality (XR) techniques for human-machine interaction (often through wearables)	Educational purposes; easily accessible visual information
3D printing	Production of 3D objects through a printing-like process	Design and printing of custom parts and small equipment
Autonomous systems and robotics (integrated systems using several technologies altogether)	Integrated systems using several technologies altogether to achieve simple to complex (semi-) autonomous behaviours	Semi and fully autonomous systems for forestry (cutting, loading, harvesting, yarding)

Source: Adapted from bacco *et al.*, 2020

The forestry experts consulted also outlined some of potential technologies with that can bring change and facilitate a more sustainable future for the forestry sector in 2040. In this respect, the four most prominent technologies mentioned are (in the order of relevance): i) Data and analytics (Big data); ii) Local and remote sensing; iii) Artificial Intelligence; iv) Websites and online platforms (see Figure 2).

Figure 2. Most relevant technologies that could shape the future of rural areas in 2040 in relation to forestry sector (share of mentions N=11)



The relevance of each type of technology varies depending on the specific application scenario and how it is being implemented. For instance, Data and analytics (Big data) is observed in many application scenarios in the forestry sector, combining **local and remote sensing**, and **artificial intelligence** (AI). Despite the wide analytical power of these systems, they cannot run autonomously and humans are still required to interpret the results and to take the right decision. Technologies also observed in use are sensors applied to trees to monitor the health of forests, **HAPS (High Altitude Pseudo-Satellites)** applied in the management of natural resources, **Remote sensing and LIDAR (Laser Imaging Detection and Ranging) technologies** detecting changes in land use, web platforms for knowledge communications and interface with technologies, and **Social media** to share information.

The following section provides examples of application scenario of some of the above mentioned technologies, which were collected and assessed by the DESIRA project for the Inventory and Taxonomy of Digital Game Changers.

4. Examples of application scenarios

The **application scenarios** and specific contexts in which game changing technologies might affect the future of rural areas can be categorised in the **following core thematic categories**: (i)forest management, monitoring and decision-making; (ii) land-use and land use change monitoring;(iii) precision forestry; (iv) traceability of forest resources; and (v) business support and innovation.

4.1 Forest management and decision-making

TREEMETRICS Forest HQ -a sustainable, innovative and dynamic forestry method

TREEMETRICS - Internet of Trees, is a Forest Management and Information System (FMIS) digital solution embodied in a cloud-based management platform that offers the possibility of centralising all the data collected from the different devices used in forestry. It all communicates together in real-time over multiple locations. This technology makes forest management simpler and more precise, thanks to digital data capture and integrated systems. Forest HQ is divided into three modules: manage (integrating all the LIDAR, drone, satellite imagery and Geographic Information System (GIS) data collected); measure; and harvest.

More information

Silvismart - efficiency portal for forest operations

Silvismart is a cloud system able to store and analyse data collected from the field in forestry operations. Collected data can be of different types, such as that coming from machines, electronic submission procedures, performance data, available natural resources, environmental data, and so on. Thus, the dataflow is digitalised, and the forest owner is in control of his/her data. Data can be shared with other interested or involved actors. The main rationale of such a system is to ease the management of daily operations in forestry. It will enable the collection of data into a central repository, its analysis, and the extraction of useful information for machine operators, forest owners, and forest managers.

More information

Leśnik+: a new application for forest management in Poland

Leśnik+ is a newly-developed forest management software application, based on the Android system, which enhances timber recording in forestry management practices. Implemented by State Forests in Poland in September 2019, as part of a strategic project on mobile technologies, it replaced the former "Leśnik" based on Windows Mobile. The application supports forest professionals by providing an overview of forest areas, in performing the necessary documentation, and in planning forest cultivation. Leśnik+ offers a field mapping service, general inventory management, and a full timber turnover documentation function. All data can be conveniently recorded from the office or from the forest.

More information

Other example: FRESh LIFE – demonstrating remote sensing integration in sustainable forest management.

4.2 Land-use and Land use change monitoring

20trees: creating forest intelligence with AI

20tree.ai uses a combination of artificial intelligence (AI), high-quality and high-resolution optical satellite imagery and radar data, and (cloud) computing power to generate forest intelligence. Using a type of AI called machine learning, algorithms are created to 'learn' from experience. For example, in the case of deforestation, the algorithm is fed with many cases of deforested areas, and it learns what deforestation looks like. In this way, the machine learning algorithm can detect deforestation patterns and predict high risk areas. It even makes it possible to detect patterns that cannot be spotted by humans yet. The global daily availability of satellite data combined with AI and complex data poses a potent technology for understanding natural and human induced phenomena affecting forests.

More information

Monitoring forests through remote sensing in La Rioja (Spain)

This project uses satellite data and LiDAR scans to create a highly detailed 3D model of the trees in the area, but also of shrubs and undergrowth. The project Forest-Lida Rioja has prepared a regional forest inventory and has elaborated 'fuel maps' as a basis for forest management and forest fire preventive work. In addition, the project has studied the evolution of the poplar groves in the region and wood supply potential. The project also includes technical training on the products generated and their use for interested professionals.

More information

Wildfire Analyst - software designed to support initial fire situations

The software integrates real-time weather information with advanced modelling to simulate and calculate wildfire behaviour and provide instant information to support real-time decision-making. It uses geo-technologies and advanced analytics based on remote sensing: satellite and LiDAR. In addition, it includes a dashboard and mobile devices.

More information

4.3 Precision forestry

Intelligent biomass analyser (IBA) – determining the key characteristics of biomass

It is a tool for non-destructive classification of biomass into different quality groups. The IBA product is still a prototype, but it has many promising applications relating to renewable resources. The tool obtains information from a relevant volume of biomass using the electrical impedance spectroscopy (EIS) technique. The IBA process combines the EIS technique with robotics and artificial intelligence (AI). It includes investigations of combining IBA sensors with commercial industrial robots.

More information

4.4 Traceability of forest resources

RDIF Sundog - Ultra high frequency tags for rough wood surfaces

Radio Frequency Identification (RFID) tags are small, low-cost objects that can be attached to materials and products to identify and track them throughout their lifecycles. However, some surfaces, like rough wood, do not allow the use of classical adhesive tags. Thus specific solutions have been developed to allow easy and fast tagging of rough wood surfaces. Data from Ultra High Frequency (UHF) RFID tags can be collated using special trackers. Each tag contains unique information about the object it is attached to, such as timber or lumber, pallets, utility poles, and railway sleepers. To read the tag, an RFID reader is required, and the tag must be close to the reader (typically less than one metre), but UHF tags with high reading range can be detected at larger distances (five to seven metres).

More information

NIRwood – smart and transparent timber trading

NIRwood aims to provide the timber market (producers, traders, manufacturers, transformers and environmental authorities) with a reliable, precise, quick and affordable tool to ensure that their wood products are of the type and quality they expected, avoiding fraud and illegalities. NIRwood's objective is the creation of a big timber spectral database, which will include NIR (Near InfraRed) spectra from protected tree species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as well as most commercial species.

More information

Other examples: Use of bar codes to define timber quality on forest sites, before selling to customers to prevent corruption in the timber trade (changing quality classes when selling).

4.5 Business support and innovation

Forests e-marketplace

This tool brings the forestry sector together through an e-marketplace. With the help of a new online service, all the timber available in Finnish private forests can be sold in one place. The aim of the e-service is to get the timber onto the market and attract even the more passive forest owners, often living in cities, to sell some of their timber. The number of such Finnish forest owners is estimated at tens of thousands. More timber is needed because of the new investments in the forest industry.

More information

New digital business from data and wood fibre process innovations

Digitalisation of the forest industry can facilitate new digital businesses from data and wood fibre process innovations. With COMOS software, Siemens can carry out integrated plant asset management projects over the entire industrial lifecycle.

More information

5. Recommended actions to make the best out of digitalisation

EU forest-related policies and the Long-Term Vision for Rural Areas must reflect that rural areas are prone to natural hazard impacts and that sustainably managed forests contribute to increased resilience of rural livelihoods and landscape features.

Healthy and resilient forests will contribute to the improvement and support of the resilience of rural areas, and will also contribute to the provision of the numerous goods and ecosystem services expected by society. As they grow, EU forests deliver on biodiversity, water quality (for drinking purposes), carbon sequestration, wood and non-wood forest products, and recreational and spiritual spaces, among other key services. Furthermore, EU forests in rural areas have a long-term role to play in contributing to the UN SDGs or EU climate neutrality goals.

Following the impacts of COVID-19 on the EU economy, the European forestry sector can contribute to the recovery of Europe's economy and in particular for rural areas. For this, the experts highlighted the crucial role that digitalisation should play in the long-term vision, hence acknowledging the vital contribution that digital tools can provide to boost innovation, jobs and value creation to sustain vibrant rural areas.

The assessment of preliminary findings from DESIRA and the contributions of the experts consulted led to the identification of the following actions:

- Acknowledge the commitment of European forest owners and forest managers to sustainable forestry and target support to boost digitalisation in the sector enhancing competitiveness and contributing to the sustainability of forest resources. The forest manager should be placed at the core of the long-term vision, if we aim to ensure that civil society benefits from forest ecosystem services (FES).

- Digital technologies should give an answer to the real demand of the sector, and in particular, in those specific activities within the forestry sector that are not technologically advanced at the moment. It is essential to build 'bridges' between forestry stakeholders and digital experts so as to boost a co-development process adapted to the sector's needs and which directs efforts towards solving the problems.

- Bring technologies closer to the more 'traditional' forestry stakeholders, as digitalisation is still a distant reality for many in the sector. Turn these technologies into simple products that can really provide benefit to landholders, like traceability tools, e-marketplaces, land use planning, etc. User-friendly interfaces that will boost uptake. Targeted communication to forestry professional about the benefits of digitalisation in the sector will increase trust and willingness to learn and implement new technologies. Information actions, demonstration projects or digitalisation business-to-business (b2b) actions can enhance the sector's confidence in digitalisation.

- Digital technologies need to be transparent, accessible, and straightforward. Communicate and illustrate the trade-offs of digitalisation and the various technologies, highlighting winners, losers and, when relevant, opponents.

- Carry out actions to improve the capacities and skills on digital technologies, through training programmes for technicians, maintaining trained staff and providing space for their further development. In addition, foster digital skills among the rural youth in education centres.

- Foster and support digitalisation at different levels and for different types of users, including local and large scale forest owners, policy-makers, businesses, scientists and citizens, with innovation and job diversification, and education courses (at universities and schools) on digitalisation in rural areas.

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