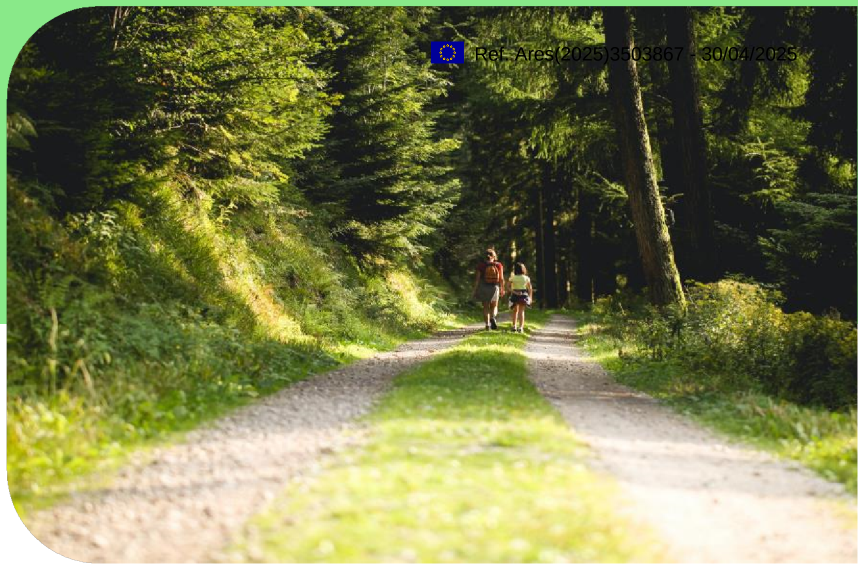

WP4 Scientific excellence and education activities development

D4.3: Sustainability of the research groups

Responsible Author: Mexhid Ferati, Linnaeus University

Funded by
the European Union
Grant agreement N° 101059985

Funded by the European Union. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Project information

Grant Agreement No	101059985
Project Acronym	Forest 4.0
Project Title	Creation of the centre of excellence in smart forestry
Type of action	HORIZON Coordination and Support Actions
Horizon Europe Call Topic	HORIZON-WIDERA-2022-ACCESS-01-01-twostage
Project Duration	1 May 2023 – 30 April 2029 | 72 months
Project Website	www.forest40.lt
EU Project Advisor	Doru-Leonard IRIMIE
Project Coordinator	Tomas Krilavičius (VMU)
Address	Vytauto Didziojo Universitetas K. Donelaicio g. 58, Kaunas LT-44248, Lithuania,
Reply to	tomas.krilavicius@vdu.lt

Document information

Work Package	4
WP Lead Beneficiary	Lnu
Relevant Task(s)	4.3
Deliverable | Version | Status	Work in progress
Deliverable Lead Beneficiary	Lnu
Responsible Author	Mexhid Ferati
Reply to	Mexhid Ferati
Deliverable type | Dissemination level[1]	Public
Due Date of Deliverable	2025-04-30
Actual Submission Date	2025-04-30
Version | Status	
Contributors	Zenun Kastrati, Fisnik Dalipi, Jimmy Johansson, Arianit Kurti, Virginija Kargytė, Gintautas Mozgeris
Reviewer(s)	Arianit Kurti, Tomas Krilavičius, Virginija Kargytė, Gintautas Mozgeris

[1] ***Deliverable type*** R: Document, report; DEM: Demonstrator, pilot, prototype, plan designs; DEC: Websites, patents filing, press & media actions, videos, etc.; DATA: Data sets, microdata, etc; DMP: Data management plan; ETHICS: Deliverables related to ethics issues; SECURITY: Deliverables related to security issues; OTHER: Software, technical diagram, algorithms, models, etc.

Dissemination level: PU – Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page); SEN – Sensitive, limited under the conditions of the Grant Agreement; Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444; Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444; Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444

Document History

Version	Changes	Date	Contributor
01	Structure of the report and initial layout	2025-04-03	Arianit Kurti
02	Scientific Roadmap of Forest 4.0	2025-04-19	Mexhid Ferati, Zenun Kastrati Jimmy Johansson Fisnik Dalipi
03	Educational Offerings as a Bridge to Research within the CoE	2025-04-19	Mexhid Ferati
04	Initial complete draft	2025-04-22	Arianit Kurti
05	Structural review	2025-04-25	Tomas Krilavičius
06	Structural review	2025-04-28	Virginija Kargytė
07	Structural review	2025-04-28	Gintautas Mozgeris
08	Structural review	2025-04-29	Arianit Kurti
09	Final version – complete draft	2025-04-29	Mexhid Ferati
10	Final version	2025-04-29	Mexhid Ferati

Participants	Contact
Mexhid Ferati	mexhid.ferati@lnu.se
Zenun Kastrati	zenun.kastrati@lnu.se
Jimmy Johansson	Jimmy.johansson@lnu.se
Fisnik Dalipi	fisnik.dalipi@lnu.se
Arianit Kurti	arianit.kurti@lnu.se
Virginija Kargytė	virginija.kargyte@vdu.lt
Gintautas Mozgeris	gintautas.mozgeris@vdu.lt

Executive summary

The objective of this deliverable is to outline strategies to ensure the long-term sustainability of the research groups within the Forest 4.0 CoE. The strategy is structured around four main lines of action: developing a scientific roadmap, identifying financial instruments, identifying education activities as a bridge to the research activities, and securing the required research infrastructure. To achieve financial sustainability, the plan emphasizes diversifying funding sources, including applying for research grants from EU, regional, and national agencies, undertaking commissioned research for industry and public bodies, and generating revenue from services like certification, calibration, patenting, and licensing. Educational initiatives are crucial for attracting and nurturing young talent, disseminating research findings, and engaging stakeholders, thereby ensuring the continuity of research groups. Finally, establishing a robust research infrastructure, supported by open science and open data principles, is essential for conducting cutting-edge research and creating new income opportunities. Ultimately, equipping the research groups properly is seen as vital for the CoE's success in fostering innovation and economic growth in the forestry sector.

Table of Contents

1 Introduction

Center of Excellence Forest 4.0 aims to be a transdisciplinary center that will combine expertise from multiple disciplines to offer a good overview of the immense challenges and innovative solutions it aims to achieve. The composition of the research groups as a part of CoE will be based on the developed methodology, which is based on the intersection of thematic areas and project teams. In this context, for the long-term sustainability of the research groups, the strategy forward has been based upon three lines of action:

1. Development of the scientific roadmap to ensure that CoE research expertise will be at the forefront of the latest developments
2. Identifying the financial instruments where CoE research groups can secure funding for project activities
3. Identifying the educational activities that CoE can engage in to disseminate the research insights and engage with diverse stakeholders.
4. Research infrastructure that will be required to conduct cutting-edge research and innovation activities within the CoE.

In this aspect, through a scientific roadmap, the aim is to prepare a structured plan that outlines the core areas of research where scientific insights are required. Bearing in mind the goal of CoE, we have identified four scientific areas where the research activities of the CoE are to be focused. The identified scientific areas are:

1. Human–Computer Interaction in the forestry environment.
2. Artificial Intelligence applications in forestry settings.
3. Forest data-driven support.
4. Forestry business model innovation.

The reason for this strategy for the sustainability of the research groups within CoE Forest 4.0 is to promote:

1. **Collaboration and networking** to establish strong partnerships with other research groups, institutions, and other stakeholders.
2. **Innovation and adaptability** for being able to continuously evolve research methods and approaches to remain relevant and be able to address the immense challenges within the forestry sector
3. **Funding and resources** for securing stable and diverse funding sources to support ongoing and future

In this aspect, in the lines below, we further develop our ideas when it comes to scientific roadmap, education activities, financial instruments, and research infrastructure.

2 Scientific roadmap of Forest 4.0

This section provides an overview of potential research venues that could be explored in various domains. Following the state of the art, the roadmap includes identified challenges within forestry from the Human-Computer Interaction, Artificial Intelligence, Forest Data-driven Support, and Business Model Innovation aspects.

2.1 Human-Computer Interaction within the Forestry Sector

The field of Human-Computer Interaction (HCI) explores, designs, and evaluates interfaces used by users in various domains. One such domain that could greatly benefit from HCI research and design practice is forestry. In forestry, user interfaces, particularly dashboards, are utilized to manage activities. To this end, this section proposes several potential avenues for further exploration.

2.1.1 Roles-tailored dashboards

A recent study focused on the development of a map-based dashboard tailored to the needs of the Austrian forestry sector (Atzl et al, 2019). The researchers identified four distinct user roles within the forestry domain and subsequently designed role-specific views within the dashboard to accommodate the unique tasks, responsibilities, and information needs associated with each role. This approach significantly enhanced the overall usability of the system and helped minimize media disruptions by integrating various sources of information into a single, coherent interface.

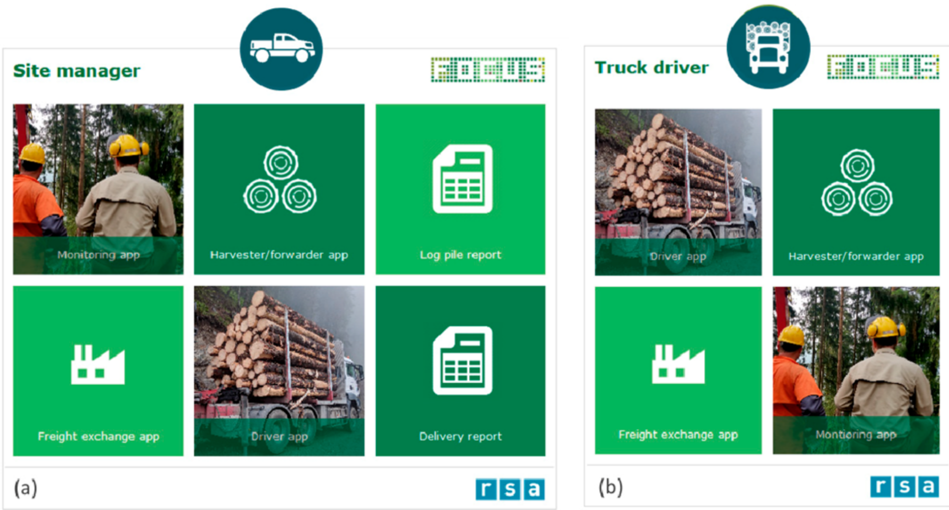

Figure 1. A look at the dashboard from the perspective of two roles: site manager and truck driver (Atzl et al, 2019).

Building on this idea, a similar approach could be explored and adapted to suit our specific context and user needs, specifically within Forestry 4.0 stakeholders. By identifying relevant user roles within our domain and designing tailored views for each, we may be able to improve the effectiveness and efficiency of our system, while also addressing potential usability challenges and reducing fragmentation across different tools and platforms.

2.1.2 Integration of Traditional Practices within Forestry with Digital Tool

Forestry workers have traditionally relied heavily on hands-on experience, practical knowledge passed down through generations, and a strong sense of intuition developed through direct engagement with the natural environment. This deeply rooted, experiential approach has shaped not only how forestry tasks are performed but also how decisions are made in the field. As a result, introducing digital tools into this context presents notable challenges, particularly when these tools are perceived as replacing rather than supporting the established ways of working (Krifter, 2021).

To ensure successful adoption, it is essential that digital solutions are designed to complement and enhance these core values rather than disrupt them. This means creating tools that respect the expertise of forestry professionals, align with their workflows, and build on their intuitive knowledge, rather than attempting to override it with overly rigid or unfamiliar systems.

Furthermore, while digital tools can offer valuable opportunities for improving communication, data sharing, and collaboration, especially across geographically dispersed teams, it is important to strike a careful balance. The benefits of enhanced human interaction and networking through digital platforms should not come at the cost of diminishing the traditional values and practices that define forestry culture. Instead, digitalization efforts should aim to bridge the gap between tradition and innovation, fostering tools that support both the practical realities of forestry work and the evolving demands of a connected, data-driven world.

2.1.3 Context-aware Forestry Interfaces

Forestry professionals often work in highly dynamic and variable environments where conditions can shift rapidly due to weather changes, seasonal cycles, terrain variability, or unforeseen ecological events. Their tasks may range from field assessments and equipment management to environmental monitoring and decision-making, each requiring specific information at different times and locations. This complexity presents unique challenges for the design of digital tools, particularly dashboards intended to support fieldwork and decision processes.

To address these challenges effectively, dashboards should be designed with adaptability in mind. By incorporating contextual awareness, such as real-time location data, current environmental conditions (e.g., weather, soil moisture, forest health indicators), and the specific tasks being performed, dashboards can present relevant, timely, and actionable information. This level of contextual adaptation not only streamlines the user experience but also significantly enhances the usability and effectiveness of the tool in supporting day-to-day operations (Liu et al, 2024).

Such adaptive dashboards can help reduce cognitive load, minimize unnecessary information, and provide forestry professionals with precisely what they need when they need it. Ultimately, this approach aligns the digital interface with the dynamic nature of forestry work, fostering greater efficiency, situational awareness, and trust in digital solutions among professionals in the field.

2.2 Artificial Intelligence applications in the forestry sector

The forestry sector is undergoing a significant transformation as advancements in artificial intelligence (AI) and digital technologies (DT) open new avenues for precision management, operational efficiency, and environmental stewardship. As the industry transitions from traditional practices to technology-assisted solutions, the concept of Forestry 5.0 emerges. This evolution is inspired by the principles of Industry 5.0 and focuses on human-centricity, resilience, and sustainability. Human-centered AI plays a key role in modernizing forestry operations.

Forestry 5.0 envisions the integration of AI-driven predictive analytics, automation, and precision management systems into forest operations. Its primary objective is to support and enhance the roles of forestry professionals rather than replace them. This ensures that AI systems remain trustworthy, transparent, and aligned with human expertise and decision-making processes.

Human-centered AI promotes safe, secure, and reliable interactions between technology and forestry workers, addressing the unique complexities of natural environments. This approach positions AI not as an isolated tool but as a collaborative partner in sustainable forestry management.

As highlighted by the research work by Holzinger et al (2024), bridging the gap between Industry 5.0 and Forestry 5.0 requires developing AI systems capable of operating in dynamic, data-scarce, and ecologically sensitive contexts. These systems should prioritize human oversight, safety, and environmental ethics while delivering operational benefits.

The deployment of AI technologies in forestry is accompanied by a range of challenges that must be systematically addressed:

1. **Logistical constraints** - The remote and expansive nature of forest areas complicate infrastructure deployment, data connectivity, and equipment maintenance.
2. **Infrastructural limitations** - Small-scale foresters cannot afford the high-cost AI solution. Also, reliable digital infrastructure is often lacking in forested regions, requiring innovative solutions like edge computing and decentralized data processing.
3. **Environmental sensitivities** - Balancing technological intervention with nature conservation remains critical, ensuring that automation and monitoring practices do not disrupt ecological integrity.
4. **Worker safety** - Human-centered AI should contribute to safer working conditions by automating high-risk operations and providing real-time environmental data to field personnel.

Successfully navigating these challenges is essential to unlocking the potential of AI in forestry while upholding sustainability and ethical responsibilities.

Another innovation of great importance for forestry is the deployment of lightweight AI models on edge devices such as drones and Internet of Things (IoT) sensors. Edge AI processes data locally within the forest environment, reducing latency, minimizing dependence on central servers, and enabling immediate, actionable insights.

AI-powered edge devices provide significant advancements in environmental monitoring and management and could have several promising applications such as:

1. **Wildfire detection and monitoring** - AI-equipped drones and sensor networks can detect early signs of wildfires, enabling prompt interventions and mitigating damage (Ramadan et al, 2024).
2. **Tree health and disease monitoring** - Real-time analysis of sensor and image data allows for the early identification of pest infestations, nutrient deficiencies, and diseases, facilitating targeted responses (da Silva et al, 2022).
3. **Forest inventory and biomass estimation** - Automated data collection and analysis enhance the accuracy of inventory assessments, informing sustainable harvesting plans and carbon stock evaluations (Sue et al, 2025).

The integration of these AI applications not only helps in improving operational efficiency but also contributes to long-term conservation goals by providing precise, data-driven insights for forest management.

2.3 Forest Data-driven Support

The integration of data-driven technologies in forestry is revolutionizing the way forest management and policy development are approached. Connected to the forest and wood value chain, the European Union Deforestation Regulation (EUDR) highlights the importance of tracking forest resources from the forest to industry and beyond. This regulation aims to ensure that products consumed within the EU do not contribute to deforestation or forest degradation worldwide. This regulation is part of a broader effort to reduce greenhouse gas emissions and biodiversity loss, promoting the consumption of deforestation-free products. From a sustainability perspective, policy development must align with business development. By integrating diverse sustainability data at the local level, stakeholders can enhance the competitiveness of wood-based resources while ensuring that forestry practices align with sustainability goals. However, as mentioned, the traditional forest industry involves people, and the changes related to digitalized procedures must align with changing occupational roles (Hultman et al, 2024).

The future introduction of Digital Product Passport (DPP) and connected Ecodesign for Sustainable Products Regulation (ESPR) is pivotal in advancing sustainability within the forestry, wood, and furniture industries. The DPP provides each product with a unique digital identity. This transparency allows consumers to make informed, sustainable choices and helps manufacturers comply with regulatory requirements. The ESPR sets design requirements to ensure products are sustainable and circular, reducing waste and environmental impact.

In the forestry and wood industries, the DPP can track the origin, materials, and ecological impact of wood products, ensuring they meet sustainability standards. For the furniture industry, the DPP can facilitate future efficient product refurbishment, recycling, and resale, enhancing competitiveness and market resilience. By integrating sustainability data throughout the value chain, the DPP and ESPR support better decision-making and compliance with sustainability goals. Initiated Innovative projects under the umbrella of Forest 4.0, such as Gaya (Eriksson and Bergh, 2022) developing to Gaya++, and forest sound classification (Qurthobi et al, 2025) and advancements in digital product passport in Lithuania as well as forest resource information systems utilizing laser scanning are paving the way for more sustainable, precise and efficient forest management. In Lithuania, the integration of National Forest Inventory (NFI) plots and silvicultural interventions provides a robust starting point for analysis tools. Similarly, the SweFor model of the Swedish forest sector introduced in Lithuania offers projections on forest use under various conditions, contributing to better forest management practices.

Forest 4.0 research groups connect on-going work on developing tools with a holistic approach to support forest-based industries in fulfilling sustainability targets and simultaneously improving competitiveness of forest-based sector.

2.4 Forestry Business Model Innovation

Business model innovation has become an essential driver of competitiveness and sustainability in the forestry sector, particularly as the industry faces mounting pressures from climate change, global competition, and evolving regulatory demands. Recently, the integration of digital technologies and the emergence of new governance frameworks have begun to reshape the very foundations of how forestry enterprises create, deliver, and capture value.

The strong market competition and the imperative for sustainable management have compelled forest owners and enterprises to seek novel approaches, with business models now recognized as integral tools for strategic innovation and long-term viability (Pek, Riedl and Jarsky, 2017). The extended CANVAS model, for instance, has shown to be a useful tool for assessing opportunities and strengths in small factories, emphasizing the importance of adding qualitative insights to numerical data for a complete view of the industry.

Within the context, the Forest 4.0 initiative exemplifies the sector's digital transformation, leveraging advanced technologies such as AI, IoT, and blockchain to promote both scientific excellence and educational development in forestry. A central innovation in this transformation journey is the adoption of Digital Product Passports (DPPs). DPPs, underpinned by blockchain technology, offer a secure and decentralized means of recording and sharing data about the lifecycle of forest products— from harvest to end user. This enables traceability and compliance with legal, environmental, and social standards, which are increasingly demanded by both regulators and consumers (Damasevicius et al., 2024). In the furniture sector, for example, DPPS are used to document the provenance, carbon footprint, and sustainability credentials of wood products, thus enabling differentiation in the marketplace and supporting premium pricing for certified goods (Dalipi et al., 2024).

The implementation of DPPs is closely linked to advances in data governance. As the volume and sensitivity of forestry data grow, ranging from geospatial monitoring to transaction records, robust frameworks for data sharing, privacy, and interoperability become of paramount importance (Ducuing and Reich, 2023). Forest 4.0's approach emphasizes open data ecosystems, where academic, public, and private stakeholders collaborate to develop smart solutions for challenges such as biodiversity monitoring and supply chain optimization. However, this also raises new challenges around data security and the need for clear legislative and technical standards.

Traceability is also becoming a cornerstone of business model innovation in forestry. Effective traceability systems not only help demonstrate compliance with sustainability requirements but also enhance transparency and accountability across the value chain. Technologies such as RFID tagging, IoT sensors, and blockchain-based ledgers enable real-time tracking of timber and wood products, reducing the risk of illegal logging, improving logistics, and facilitating circular economy practices, such as product reuse. Additionally, being able to trace the source of timber is now seen as crucial for ensuring that forest resources are managed properly, helping to meet regulations and stand out in the market (Stauble et al., 2022).

In summary, business model innovation in the forestry sector is being propelled by the convergence of DPPs, advanced data governance, and traceability-enabling systems. These innovations not only enhance operational efficiency and regulatory compliance but also open new avenues for value creation and stakeholder engagement. As the forestry domain continues to evolve, the integration of these solutions and frameworks will be critical to achieving both economic competitiveness and sustainability, aligning with European and global sustainability agendas.

3 Educational Offerings as a Bridge to Research within the CoE

Within the framework of the CoE, education is envisioned not only as a core activity but as a strategic bridge connecting academic knowledge, research innovation, and societal impact. One of the key aims of the educational offerings within the CoE is to ensure the long-term sustainability and vitality of its research groups. This is achieved by creating structured opportunities to attract, engage, and nurture young talents who represent the future of the research community.

To this end, the CoE will continue to offer a portfolio of brief yet intensive courses, targeting motivated students and early-career professionals with a strong interest in the research themes addressed by the center. These educational interventions will serve a dual purpose. Firstly, they will function as a hunting mechanism, allowing research groups to identify and connect with promising individuals who may later be integrated into ongoing or future research projects. Secondly, they will act as an entry point for participants to immerse themselves in the research culture of the CoE, fostering early awareness of research careers and contributing to the talent pipeline necessary for sustaining research excellence.

Furthermore, these educational initiatives will enhance the CoE's capacity for executive education and professional development, creating opportunities to share cutting-edge research insights with industry practitioners, public sector stakeholders, and other academic partners. This bidirectional exchange will not only strengthen ties between academia and society but also offer researchers valuable perspectives on applied challenges and emerging trends within their fields.

For instance, as part of our international collaboration initiatives, we have recently prepared and offered a Blended Intensive Program (BIP) focused on *Data Analytics and Visualization*. This short but intensive course was designed to provide students with practical and theoretical knowledge in the field of data analytics, and it is worth 3 ECTS credits.

The course content included key foundational elements such as data cleaning, exploratory data analysis, and various visualization techniques. Students gained knowledge on how to apply descriptive statistics and use visualization tools to interpret and communicate data-driven insights effectively. The program combined online learning with a one-week period of physical mobility to VMU in Lithuania, offering a rich and engaging learning experience. The course attracted and was followed by twenty students from educational institutions in Estonia, Letonia, Sweden and Lithuania.

In summary, the educational offerings within the CoE will play an important role in ensuring the continuity and renewal of research groups, positioning education as a dynamic interface where knowledge transfer, talent development, and research innovation intersect. Through these efforts, the CoE will cultivate a sustainable, inclusive, and forward-looking research environment capable of addressing both current and future societal challenges.

4 Financial Instruments

For the longevity of the research groups within the CoE Forest 4.0, there is a need for diversifying funding sources. In this aspect, as a part of our analysis, we have identified a couple of lines of activities that can generate revenues for CoE Forest 4.0 research group.

4.1 Research funding application

The research funding applications are primarily focused on researcher-initiated ideas that are aimed toward a specific funding agency. In this aspect, the CoE will target international calls within EU programs for research and innovation activities, regional funding agencies within the Nordic and Baltic region as well as national funding agencies in Lithuania. Through increased competencies, CoE researchers should be able to maintain a steady track record to secure a sizable part of the budget within this funding instrument.

Within Horizon Europe, relevant funding opportunities are present in Pillar 1 “Excellent science” (e.g., Doctoral Networks under Marie Skłodowska-Curie Actions) and in Pillar 3 “Innovative Europe” (e.g., European Innovation Ecosystems). Meanwhile, relevant Clusters under Pillar 2 are “Food, Bioeconomy, Natural Resources, Agriculture and Environment”, “Climate, Energy and Mobility”, “Digital, Industry and Space”, “Civil Security for Society”. Moreover, Lithuania is involved in ongoing co-fund action “European Biodiversity Partnership: Biodiversa+”, and new “European partnership: Forests and Forestry for a Sustainable Future” is expected.

4.2 Commissioned Research

Another line of activities that should be able to secure revenues for the research groups at CoE is also commissioned research activities. These activities will constitute the provisioning of the research expertise to industries and companies for a commission. This will be primarily on the applied research projects where expertise from research groups will be utilized to address an immense problem/challenge faced by a company/industrial partner. Furthermore, as a part of this line of work, we expect smaller projects for the provisioning of professional and independent opinion on issues of relevance for diverse governmental and other public agencies.

4.3 Other revenue sources

Other lines of revenue for research and innovation activities will also include services related to certification and calibration of diverse instruments, patenting and licensing incomes from diverse software solutions. Furthermore, as prior identified in deliverable 5.3, another source of funding will be diverse financial instruments designed to foster innovation and business growth through different startup programs.

5 Research Infrastructure of CoE

In order to fulfill its mission and for long term stability of the research groups of the CoE there is a need to establish a sustainable research infrastructure in place. This infrastructure is purchased or in the process to be purchased, and it will be used to expand the functionality of the current operational solutions used at VMU. The research infrastructure will enable the CoE to generate new sources of income such as certification, calibration, licensing and patenting. The equipment purchase has been done having in mind the identified research directions presented in the previous deliverables. These topics represent instances of the suggested scientific roadmap and are depicted in the figure 2.

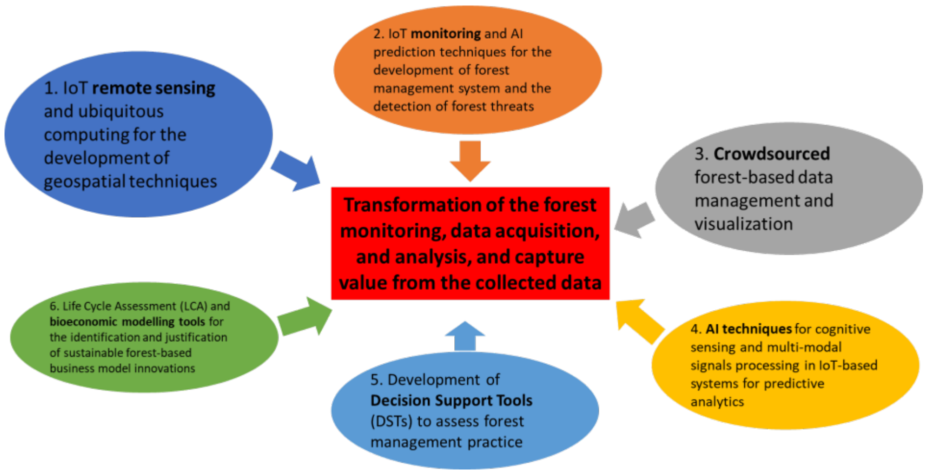

Figure 2. Main research and development directions of the CoE.

The equipment related to topic 1 (IoT remote sensing and ubiquitous computing for the development of geospatial techniques) is supposed to expand the functionality of the research infrastructure already available and used at VMU (Fig. 3).

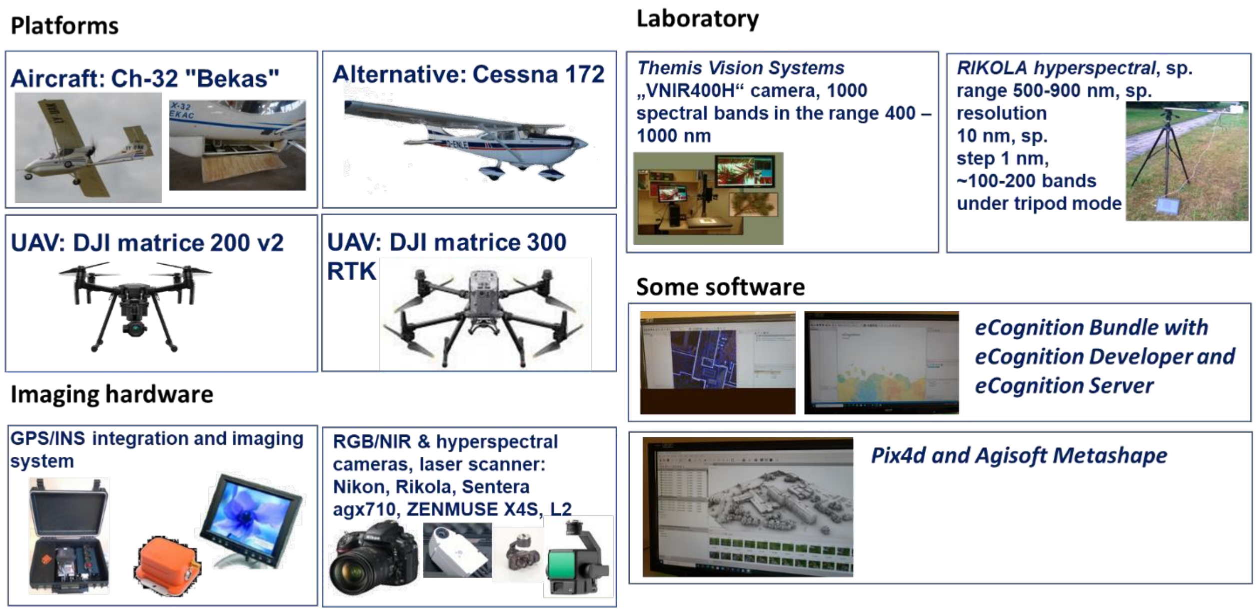

Figure 3. Remote sensing equipment currently available at VMU and supposed to expand within Forest 4.0.

Furthermore, the list below represents the ongoing and planned purchases of the equipment to complete the research infrastructure (manufacturer and models are optional, as the equipment will be purchased following the open procurement procedures and may be different):

1. Mobile laboratory on the base of 4x4 MB Vito, equipped with Themis Vision camera, transporting samples, all imaging equipment, drones, reflectance panels, also installing a laser scanner. Currently we are working with the installation of the equipment, and the mobile laboratory is expected to be operational shortly.
2. Long-range laser scanning and hyperspectral imaging system for manned aircraft: option Riegl VUX-240 lidar, Applanix AP+30 AV GNNS/IMU, Sensor controller, software, aviation container for Cessna, including SWIR hyperspectral camera: option SPECIM AFX17 hyperspectral system with associated software. Currently installed equipment includes: A multi-sensor system, including a RIEGL VUX 18024 laser scanner, Rikola VNIR and Specim-AFX17 SWIR hyperspectral scanners, and a Nikon D800E modified color-infrared camera, was installed on a Bekas X32 manned ultralight aircraft using a custom-designed aviation container mounted beneath the cockpit. The AISPECO Robincop flight management system integrates all sensors. Furthermore, we are working with the pilot training and development of container planned for Cessna 172 (this option is under consideration, however, outside Forest 4.0 budgets)
3. Short-range laser scanning system for UAV: option RECON-XT laser mapping system with a backpack and vehicle mounting option. This equipment is now fully operational, including SLAM.
4. Specialized software in use for more than one year, for processing specific data, e.g., TerraSolid software, LAStools.

The equipment best fitting the objectives of topic 2 (IoT monitoring and AI prediction techniques for the development of forest management system and the detection of forest threats) will much be coordinated with the tools and solutions concentrated at VMU's Aukštaitija station of integrated monitoring, to strengthen the performance of its long-term forest ecosystem monitoring and modelling platform. The following equipment is purchased, or its procurement is underway for full integration within research infrastructure.

1. A set of equipment for measuring the greenhouse gases is in place and the staff training is underway.
2. A set of equipment for investigating chemical air properties is now under the public procurement
3. Eddy Covariance tower and installation for carbon flux measurements is being discussed but its operations might be ready at a later stage of the project.
4. Mobile towers for GHG flux measurements under different forestry conditions
5. Equipment for demonstration of eco-physiological processes in forest ecosystems is now purchased.

IoT platform for new forestry-related data collection in the whole life cycle of the forest and related products (topic 3) is associated with purchasing the following or compatible equipment: IoT control platform LORIOT (SaaS), GW Loric One gateways and monitoring devices.

New equipment which is allocated to topic 4 (AI techniques for cognitive sensing and multi-modal signals processing in IoT-based systems for predictive analytics) is expected mostly to support all the data storage and related AI research. It includes a data storage platform, a GPU computation cluster, and a CPU computation cluster.

No specific equipment is planned to support topic 4 (Development of Decision Support Tools (DSTs) to assess forest management practice).

Topic 6: Life Cycle Assessment (LCA) and bioeconomic modelling tools for the identification and justification of sustainable forest-based business model innovations will be supported with:

1. Software infrastructure in terms of SimaPro Power
2. System to investigate, model, and demonstrate the greenhouse gas emissions from forest soils, biomass, and waste is currently running and operations.

6 Summarizing remarks

The CoE agenda should be enhanced through the development of a well-defined scientific roadmap that addresses key areas such as dashboard design and usability, the application of artificial intelligence within the forestry sector, data-driven decision support systems, and business model innovation tailored to the forestry domain. To foster long-term impact, the CoE should also integrate an educational program as a sustainable component of its research and innovation strategy, ensuring the continuous development of skills and knowledge within the sector. In addition, the financial framework supporting the CoE should be diversified and resilient, incorporating multiple funding instruments to secure the Centre’s sustainable growth, operational continuity, and the upkeep of a competitive, state-of-the-art research infrastructure. This holistic approach would position the CoE as a dynamic hub for scientific advancement, capacity building, and innovation within forestry.

References

Atzl, C., Scholz, J., Vockner, B., Mittlböck, M., & Knoth, L. (2019). Role-Tailored Map Dashboards—A New Approach for Enhancing the Forest-based Supply Chain. *ISPRS International Journal of Geo-Information*, *8*(1), 41. https://doi.org/10.3390/ijgi8010041

da Silva, D.Q., dos Santos, F.N., Filipe, V., Sousa, A.J., Oliveira, P.M. (2022) Edge AI-Based Tree Trunk Detection for Forestry Monitoring Robotics. Robotics, 11, 136.

Dalipi, F., Kurti, A., & Ferati, M. (2024). Append: a blockchain-based model of digital product passport for furniture industry. In 11th International Conference on Human Interaction and Emerging Technologies (IHIET-AI 2024) (Vol. 120, pp. 95-103).

Damaševičius, R., Mozgeris, G., Kurti, A., & Maskeliūnas, R. (2024). Digital transformation of the future of forestry: an exploration of key concepts in the principles behind Forest 4.0. Frontiers in Forests and Global Change, 7, 1424327.

Ducuing, C., & Reich, R. H. (2023). Data governance: Digital product passports as a case study. Competition and Regulation in Network Industries, 24(1), 3-23.

Eriksson, O. Bergh, J. (2022) A Tool for Long-Term Forest Stand Projections of Swedish Forests, Forests 13(6) p.816.

Holzinger, A., Schweier, J., Gollob, C., Nothdurft, A., Hasenauer, H., Kirisits, T., Häggström, C., Visser, R., Cavalli, R., Spinelli, R., & Stampfer, K. (2024). From Industry 5.0 to Forestry 5.0: Bridging the gap with Human-Centered Artificial Intelligence. Current Forestry Reports, 10, 442–455.

Hultman, H, Woxblom, L Nordström, M (2024) Digitaliserad arbetsvardag i skogsbruket – en intervjustudie med virkesköpare och skogsinspektorer (in Swedish) SkogForsk, arbetsrapport 1210-2024.

Krifter, K. (2021). Digitaler Wandel in der Forstwirtschaft: eine Chance, die Kernwerte zu stärken. Schweizerische Zeitschrift fur Forstwesen, 172(4), 212-215.

Pek, R., Riedl, M., & Jarský, V. (2017). Innovative approaches in forest management- the application of a business model to designing a small-scale forestry strategy. Journal of Forest Science, 63 (9).

Qurthobi, A., Damaševičius, R., Barzdaitis, V., and Maskeliūnas, R. (2025) Robust Forest Sound Classification Using Pareto-Mordukhovich Optimized MFCC in Environmental Monitoring. IEEE access, 2025, Vol.13, p.20923-20944

Ramadan, M. N.A., Basmaji, T., Gad, A., Hamdan, H., Akgün, B. T., Ali, M. A.H., Alkhedher, M., Ghazal, M. (2024). Towards early forest fire detection and prevention using AI-powered drones and the IoT, Internet of Things, Vol 27, 101248.

Stauble T., Nogueron R., Knorr-Evans M., Schneider T. (2022). Timber traceability: A Diagnostic Tool for Practitioners and Policymakers. World Resources Institute. Available online at https://doi.org/10.46830/wrirpt.21.00067.

Su, Y., Wu, Z., Zheng, X., Qiu, Y., Ma, Z., Ren, Y., & Bai, Y. (2025). Harmonizing remote sensing and ground data for forest aboveground biomass estimation. Ecological Informatics, 86, 103002.

List of Figures