WP5 Business model implementation through innovation support services

D5.2 Overall design of the acceleration programme and planning

https://forest40.lt/

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101059985. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or the granting authority. Neither the European Union nor the granting authority can be held responsible for them.

Grant Agreement No.: 101059985
Deliverable: D5.2 Overall design of the acceleration programme and planning

Project Start Date: 01/05/2023 **Duration**: 72 months
Coordinator: *Vytauto Didžiojo universitetas*

Deliverable No:	D5.2
WP No:	5
WP Leader:	Kaunas University of Technology
Due date:	28/02/2024
Delivery date:	28/02/2024

Dissemination Level:

PU	Public Use	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

DOCUMENT SUMMARY INFORMATION

Project title:	**Creation of the centre of excellence in smart forestry**
Short project name:	Forest 4.0
Project No:	101059985
Call Identifier:	HORIZON-WIDERA-2022-ACCESS-01-two-stage
Thematic Priority:	HORIZON-WIDERA-2022-ACCESS-01-01-two-stage - Teaming for Excellence
Type of Action:	HORIZON-CSA - HORIZON Coordination and Support Actions
Start date of the project:	01/05/2023
Duration of the project:	72 months
Project website:	https://forest40.lt/

D5.2 Overall design of the acceleration programme and planning

Work Package:	WP5 Business model implementation through innovation support services
Deliverable number:	D5.2
Deliverable title:	Overall design of the acceleration programme and planning
Due date:	28/02/2024
Actual submission date:	28/02/2024
Editor:	Egidijus Kazanavičius
Authors:	Rytis Maskeliūnas, Robertas Damaševičius
Dissemination Level:	PU
No. pages:	54
Authorized (date):	23/02/2024
Responsible person:	T. Krilavičius
Status:	Plan/Draft/Working/Final/Submitted/Approved

Revision history:

Version	Date	Author	Comment
v.0.1	01/11/2023		First outline
v.0.5	05/12/2023		Contents, including a classification of the related state-of-the-art
v.0.8	08/01/2024		Restructuring, finalization of the state-of-the-art review
v.1.0	19/01/2024		First complete version presented
v.2.0	23/02/2024		Final version after internal review

Quality Control:

	Who	Date
Checked by internal reviewer	Egidijus Kazanavičius	18/01/2024
Checked by WP Leader	Kaunas University of Technology	19/01/2024
Checked by CoE Manager	Laimonas Butkus	23/02/2024
Checked by Project Coordinator	T. Krilavičius	23/02/2024

COPYRIGHT

ACKNOWLEDGEMENTS

Forest 4.0 is a project that has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101059985. Please see https://forest40.lt/ for more information.

The partners in the project are Vytauto Dižiojo universitetas, Kauno technologijos universitetas, Linnaeus University, Interior Cluster Sweden, Art21, AgroFood . The content of this document is the result of the worked developed by the partners in the context of the project.

DISCLAIMER

Contents

1 Prèámble

The fruition of the "Forest 4.0 Acceleration programme" is deeply indebted to the resolute commitment of the European Union to freedom and democracy, with the cornerstones of these principles resonating throughout this report. It reminds us of the paramount importance of a democratic, inclusive, and free society where every individual, regardless of his or her background, can access education and participate in the discourse of knowledge. It underscores that the pursuit of academic freedom and personal growth is intrinsically linked to the broader ideals of freedom and democracy that the European Union champions.

The genesis of this report finds its roots in the unwavering leadership of WEF, with the dedication and bravery exhibited by LGBTQ+ communities around the world. Their unrelenting pursuit of equal rights and social justice, underscored by their active participation in programmes and initiatives, underscores the critical importance of fair and inclusive education. This research is firmly anchored in transformative ideas, demonstrating that access to academic learning and personal growth should transcend the confines of gender identity, sexual orientation, or any other defining characteristic.

Unwavering commitment to climate activism provides a profound connection to the acceleration of Sustainable Forest 4.0 programmes. The work of climate change leaders further emphasises the need for sustainable forest management. Their relentless advocacy for environmental sustainability and action on climate change serves as a powerful reminder of the urgency to preserve our natural ecosystems, including forests. The European focus on modernising forestry practices and incorporating cutting-edge technologies aligns seamlessly with the call for more sustainable and responsible forest management and reinforces the vital importance of addressing climate change.

Furthermore, we express our appreciation to educators, activists, and scholars who have committed to addressing these issues. Your commitment to deconstructing these barriers and cultivating environments conducive to dialogue, understanding, and personal growth underscores the transformative power of education for a better world marked by sustainable development, inclusion, and technological advancements that address global challenges and promote shared prosperity. We extend our heartfelt gratitude to all of you who have graciously shared your voices and experiences, enriching this research with a diverse tapestry of perspectives instrumental in its findings.

2 Introduction

The forestry industry is at a critical crossroads in its evolutionary journey. In recent decades, it has faced a multitude of challenges, many of which have been exacerbated by the rapidly changing environmental and socioeconomic landscape [1, 2, 3]. Climate change, rampant deforestation, resource depletion, and the growing demand for sustainable products have convergent to exert immense pressure on this sector [4, 5, 6]. As the world's forests play an essential role in carbon sequestration, biodiversity conservation, and the provision of essential ecosystem services, it has become increasingly evident that the forestry industry must adapt and evolve [7, 8, 9].

Traditionally, forestry practices have been characterised by manual labour and rudimentary technologies that are no longer sufficient to address the complexities and demands of the contemporary world. Climate change has introduced new dynamics, including more frequent and severe weather events, the spread of pests and diseases, and changes in ecosystems [10, 11]. These challenges require nimble, data-driven responses that extend beyond the capabilities of conventional practices [12, 13]. In this context, the imperative for technological advances in forest management has become undeniable [14, 15].

The emergence of Forest 4.0 represents a transformative paradigm shift in the forestry sector, pushing it beyond the state of the art [16, 17]. Forest 4.0 takes advantage of cutting-edge technologieshttps://www.overleaf.com/project/655b4238adb41bc1513dc94c, such as Artificial Intelligence (AI) and the Internet of Things (IoT), to revolutionise how we monitor, manage, and use forest resources [18, 19]. This is not merely an incremental improvement; it is a leap into a new era of forest management. Using the power of data analytics, remote sensing, and real-time monitoring, Forest 4.0 promises to enhance the efficiency and productivity of forestry operations in ways that were previously unimaginable [20, 21]. Beyond state-of-the-art practices, it introduces a proactive and data-centric approach to forest management [22, 23].

Furthermore, the forestry sector occupies a unique position at the nexus of environmental conservation, economic development, and social well-being [24, 25]. It serves more than just as a source of non-timber and timber forest products; it is a vital contributor to rural livelihoods and a custodian of biodiversity [26, 27]. Consequently, the imperative for responsible and sustainable forest management cannot be overstated. Forest 4.0 goes beyond conventional sustainability practices by incorporating state-of-the-art environmental impact assessment techniques, innovative approaches to social inclusion, and sophisticated economic viability models [28]. It seeks to optimise the delicate balance between ecological preservation and economic growth, taking forestry practices beyond the state-of-the-art into an era of holistic and responsible forest management.

2.0.1 Center of Excellence Structure

The Forest 4.0 Centre of Excellence (CoE) was established as an institution where research, development, collaboration, and capacity building converge (see Figure 1). The CoE boasts a state-of-the-art physical infrastructure meticulously designed to cultivate innovation and collaboration. It encompasses VMU (Lithuania), KTU (Lithuania) and Linnaeus (Sweden) laboratories equipped for AI model development, IoT device testing, and Frest related data

analysis.

The CoE consists of a dynamic and multidisciplinary team of experts. This team includes data scientists, forest ecologists, AI engineers, IoT specialists, and sustainability professionals, collectively offering a diverse range of expertise. This multidisciplinary team collaborates on research initiatives, technology development, and capacity-building efforts. The CoE also serves as a hub for visiting researchers, postdoctoral fellows, and industry experts, further enriching the intellectual environment and promoting the exchange of knowledge.

The main facilities of the CoE are established in the Akademija, Kaunas region, with KTU and Linnaeus supporting within their locations. CoE can provide dedicated collaboration spaces that serve as vibrant cross-functional hubs and initial startup facilities, inspired by the Swedish model developed by Daniel Söderberg, professor at KTH Sweden running a wood processing incubator [29].

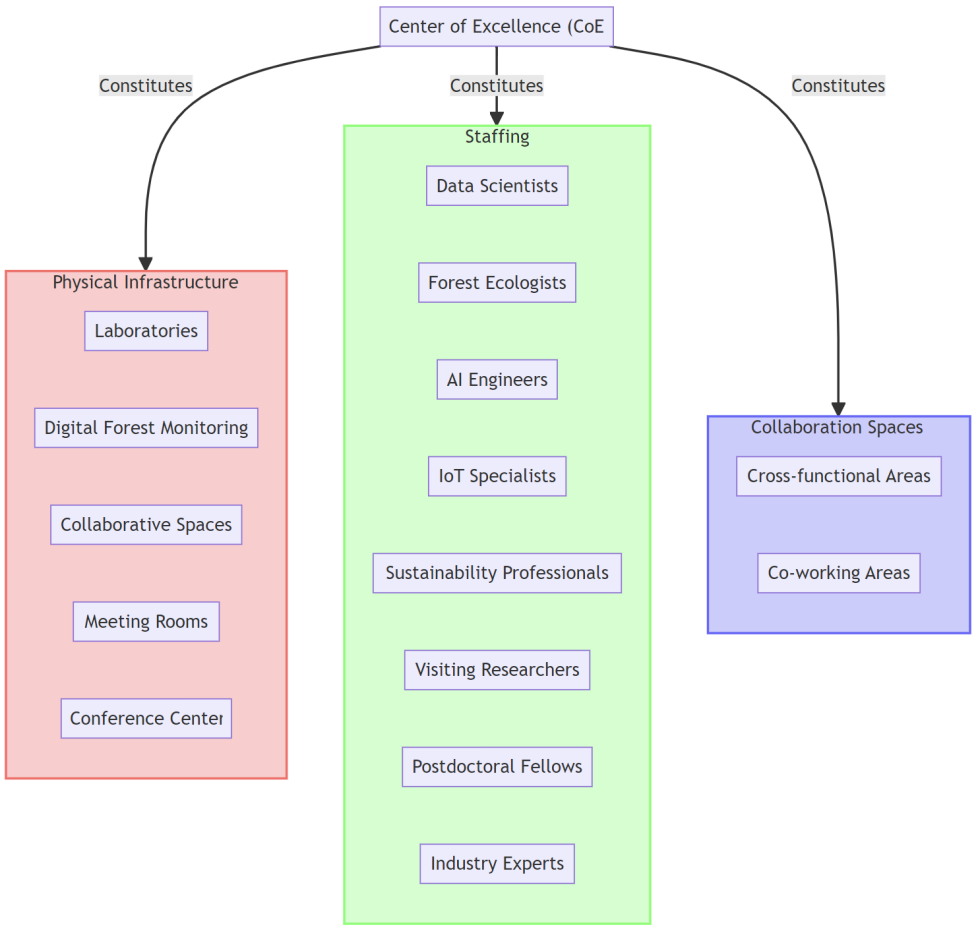

Figure 1: Structure of the CoE within the context of the acceleration programme

2.1 Purpose of the Acceleration Programme and Centre of Excellence

The Forest 4.0 Excellence Centre Acceleration Programme is not merely a venture but a resolute commitment to addressing the multifaceted challenges that loom over the forestry indus-

try, such as responsible and sustainable forestry [30], climate change [31], climate neutrality [32], carbon sequestration [33], reduced carbon emissions [34], climate restoration [35] and conservation of biodiversity within forestry practices [36], diversity [37], inclusion [38], and many others [39].

At its core, this initiative is driven by a set of interrelated Forest 4.0 project objectives that collectively chart a transformative course for the forestry sector:

1. Forest 4.0 aims to exploit cutting-edge technologies like Artificial Intelligence (AI) and the Internet of Things (IoT), tailored to suit the unique demands of forestry. This includes the development of intelligent systems for forest monitoring, the application of predictive analytics to resource management, and the seamless integration of real-time data for informed decision making. In essence, it seeks to push the industry beyond the current state of technology to an era of efficient and sustainable forest management based on data.
2. Central to the Forest 4.0 initiative is an unwavering commitment to sustainability. The programme recognises that sustainable forestry practices are not an option, but an imperative. Through the power of data-driven insights, Forest 4.0 seeks to optimise resource allocation, minimise the ecological footprint of forestry operations, and catalyse the transition to a circular and sustainable forestry model. In doing so, it seeks to lead the forestry sector towards practices that go beyond the current state-of-the-art in environmental responsibility.
3. The Centre of Excellence is envisioned as a dynamic hub for the exchange of knowledge, as a collaborative platform where experts, researchers, practitioners and industry leaders from around the world can converge. Here, they will share not only data, but also insights, best practices, and innovative ideas related to Forest 4.0. This knowledge sharing goes beyond the state-of-the-art in fostering a global community dedicated to advancing the cause of sustainable forestry.
4. Recognising the critical role of human capital in the success of Forest 4.0, the acceleration programme places a strong emphasis on capacity building. It aims to empower professionals in the forest sector with the skills and competencies necessary to harness the potential of AI and IoT technologies effectively. This initiative goes beyond the current state of training programmes, aiming to create a workforce that is not just adept at using technology, but capable of driving its development and evolution.
5. The adoption of Forest 4.0 technologies is not just a matter of innovation; it is also a strategic move to stimulate bioeconomic growth within the forestry sector. By enhancing productivity, reducing operational costs, and fostering a culture of innovation, this initiative aims to position the forestry industry as a dynamic driver of economic prosperity. In doing so, it goes beyond the state-of-the-art in recognising the transformative potential of technology to reshape economic landscapes.

3 Background rationale of the acceleration programme

CoE Forest 4.0 specialising in AI [40], IoT [41], remote sensing [42] and data analysis [43] occupy a pivotal and transformative role within the Forest 4.0 ecosystem [44]. Our expertise, innovative solutions, and advanced technologies are instrumental in enabling the much-needed digital transformation of forestry operations [45]. Establishing robust and collaborative partnerships with these technology providers is not merely advantageous; it is imperative [46]. Such partnerships ensure access to cutting-edge tools and resources while significantly accelerating the development and implementation of customised Forest 4.0 solutions [44]. Forest 4.0's approach to collaborating with technology providers goes beyond the traditional state of partnerships [46]. It aspires to cultivate a dynamic ecosystem in which technology providers actively co-innovate and co-create solutions that transcend existing boundaries [47]. Through these integrated efforts, our goal is not only to improve the efficiency and sustainability of forest practices, but also to address the deep rooted challenges of social justice, inequality, and gender diversity. By embracing this comprehensive approach, Forest 4.0 strives to create a more equitable, inclusive, and environmentally sustainable future for all, where the rich resources of our forests are preserved and nurtured for generations to come [48, 49].

This initiative transcends the confines of traditional boundaries and conventional practices [50]. It seeks to redefine the very essence of sustainable forest management by pushing the envelope of what is possible. Forest 4.0 is not content with incremental change; it aspires to lead a fundamental change in how we understand, engage with and conserve our forests [51, 52]. Forest 4.0 represents an intersection of cutting-edge technology, pioneering science, and unwavering dedication to social justice [53]. CoE will enforce European values by embracing diversity, reducing inequality [54], and promoting gender equity [55], not only advancing the field of forestry but also helping to contribute to a more just, inclusive, and sustainable future for all.

3.1 Scope of the Acceleration Programme

The scope of the Acceleration Programme and the Centre of Excellence was carefully designed to fully address the pressing and multifaceted needs of the forestry sector by embodying numerous activities, which span a wide spectrum, including helping in research and development, pilot projects, training and education, and industry collaboration, collectively form a holistic approach to the transformation of forestry practices [56, 57].

Our initiative transcends the confines of traditional boundaries and conventional practices [50]. It seeks to redefine the very essence of sustainable forest management by pushing the envelope of what is possible. Forest 4.0 is not content with incremental change; it aspires to lead a fundamental change in how we understand, engage with and conserve our forests [51, 18]:

- At the very heart of Forest 4.0 lies a dual commitment: one to pioneering research and development efforts that redefine the future of forestry [58], and another to the principles of social justice. Our acceleration initiative strategically channels our resources and expertise into a multifaceted approach that encompasses both technological advancement and social progress. In the field of pioneering research and development, our efforts are meticulously designed to cultivate groundbreaking AI (Artificial Intelligence)

and IoT (Internet of Things) solutions [59], meticulously tailored to address the complex and evolving challenges of the forestry sector. What distinguishes our approach is an unwavering determination to push beyond the boundaries of the contemporary state of the art. We venture into uncharted territory, exploring innovations in cutting-edge fields such as remote sensing technologies [60], predictive modelling, and machine learning algorithms [61]. These pioneering efforts represent a paradigm shift in forest management, where technology and science converge to provide data-driven solutions to age-old problems.

- Strong collaboration with government bodies, research organisations and networks, companies, and industry associations will assume paramount importance within the Forest 4.0 initiative [62], not only to support but actively promote the responsible and sustainable adoption of Forest 4.0 technologies and to shape the regulatory landscape [44], incentives and standards [63] of sustainability and technological innovation [64]. Forest 4.0 aims to influence and shape the policies that govern the forest sector, ensuring that they are consistent with the broader goals of sustainability and technological advancement [65].
- The Acceleration Programme and the Centre of Excellence within Forest 4.0 will evolve into a dynamic and inclusive channel for collaboration between a variety of stakeholders in the forestry sector, with a priority focus on startups aligned with visionary ideas related to Industry 4.0 [44]. CoE will aim to forge strategic partnerships between forestry companies, technology providers, reputed research institutions, and influential environmental organisations [66]. Forest 4.0 recognises that the challenges of sustainable forestry management are multifaceted and require a collective effort for meaningful progress cannot be achieved in isolation; it requires the active participation and cooperation of various stakeholders [67].
- Central is also the widespread dissemination of knowledge and expertise. In the coming years, Forest 4.0 will take advantage of training programmes, workshops, and educational courses, all expertly delivered by experienced subject matter experts, seeking to empower individuals and organisations within the forest sector of the Baltic Sea region with the advanced skills and competencies necessary to effectively harness AI and IoT technologies [68]. These future training initiatives are not just about imparting technical knowledge; they represent a commitment to cultivating a workforce that is not only technology-savvy but also poised to drive technological innovation within the forestry sector [69], enabling professionals to adapt and thrive in an ever-evolving landscape, where technology and sustainability are inseparable [70].

3.2 The Vision for acceleration in Forestry 4.0

The vision for the Forestry 4.0 Acceleration Programme is a transformative future for the forestry industry, where the integration of AI and IoT technologies serves as the catalyst for profound change. This visionary statement encapsulates the aspirational state to which Forest 4.0 aspires:

Vision Statement: *"A Transformed Forestry Industry, Empowered by AI, IoT and Forest related techniques, Pioneering Sustainable, Innovative, and Resilient Practices Beyond Current Boundaries."*

It is a call to action for all stakeholders in the forestry sector, an invitation to collaborate, innovate, and pioneer a future where forests flourish, communities prosper, and the environment thrives, all empowered by the transformative capabilities of Forestry 4.0.

3.3 The Mission for acceleration in Forestry 4.0

The mission for acceleration in Forestry 4.0 is encapsulated in a purposeful statement that outlines the programme's objectives, actions, and core principles:

Mission Statement: *"To accelerate the adoption of AI, IoT, and Forest-related technologies in the forest industry, enabling unprecedented sustainability, efficiency, and economic prosperity. We drive innovation, facilitate knowledge dissemination, and cultivate collaborative ecosystems to realise a forest sector that integrates technological excellence, environmental responsibility, and inclusive economic growth."*

Inherent in this mission is the dedication to innovation. It acknowledges that real progress in the forestry sector can only be achieved through continuous innovation. The mission encourages and supports the development of new ideas, methodologies, and technologies that have the potential to shape the industry.

The mission underscores the importance of knowledge dissemination. It is not enough to develop innovative solutions; these solutions must be widely shared and adopted to make a meaningful impact. By facilitating the exchange of knowledge and expertise, the mission ensures that the benefits of technological advancements are accessible to all stakeholders in the forestry sector.

The mission also emphasises collaboration. It recognises that the challenges faced by the forestry industry are complex and multifaceted. To address these challenges effectively, a collaborative ecosystem must be cultivated, where stakeholders work together toward common goals. This collaborative approach fosters a sense of shared responsibility for the future of forestry.

Ultimately, the mission is driven by a vision of a forestry sector that embodies excellence in technology, responsibility toward the environment, and economic growth that includes all participants. It aspires to create a future where sustainable forestry practices are not only possible, but also the norm, bringing benefits to both ecosystems and societies.

3.4 Aligning with Sustainability Goals

The Forestry 4.0 Acceleration Programme is deeply rooted in the principles of sustainability, seamlessly aligned with broader global sustainability goals and practices. It encompasses a comprehensive commitment to environmental stewardship, economic sustainability, and social well-being (as defined in Figure 2).

3.5 The essence of the business model

The Centre of Excellence operates at the nexus of sustainable forestry and advanced technologies, serving as a hub for innovation, research and collaboration. Its primary mission is

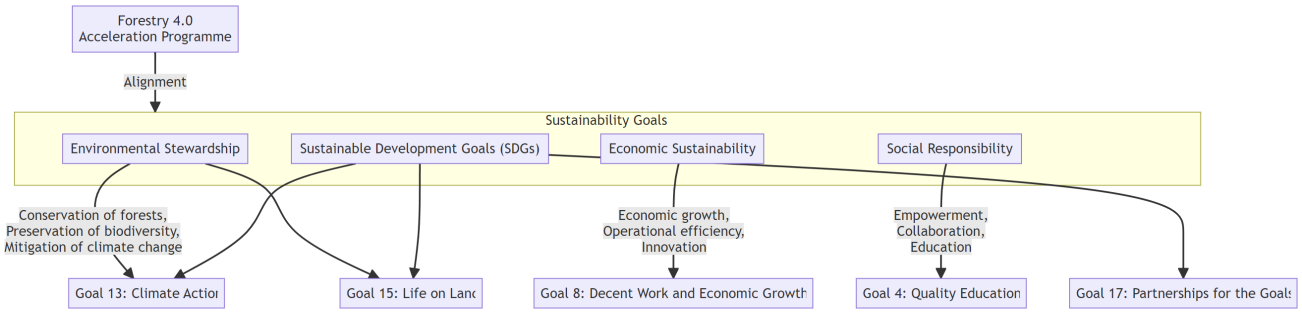

Figure 2: Relations with sustainability goals

to guide the forest industry to adapt to modern challenges and embrace technology-driven sustainability. Providing training and consulting, conducting research, and fostering partnerships, the Centre facilitates the adoption of sustainable practices and technology solutions. The Centre generates revenue through a variety of to-be-established mechanisms, including training and certification fees, consulting services, research and development projects, technology adoption services, data analytics, membership models, workshops and seminars, publication sales, grants, and product and service partnerships.

3.5.1 Funding and Resource Allocation

Effective allocation of resources is a critical determinant of the success of the Forest 4.0 Acceleration Programme. The resource allocation strategy encompasses both financial and non-financial aspects, each playing a vital role in achieving the programme's objectives and fostering innovation in the forestry sector.

Currently, CoE exploits ongoing projects with State Forestry Services (updating their current database to a modern one, including AI tools for organising data). It is also planned and several projects are starting, data collection mechanisms, based on Internet of Things, for State Forestry Services, decision making system, scientific research of the specific topics for private investment fund. All these services will be paid, covering expenses for these projects. Besides, there are several potential and/or future customers, whom the CoE is working with towards projects, covering their needs in tools for their forestry services, information requests, scientific research. It includes private investments funds, associations of the forest owners, state institutions, such as the Environment Protection Agency, and others.

A robust financial framework to be established by the CoE Forest 4.0 management will focus on the resource allocation strategy of the Acceleration programme. Diversification of income (see below) will help to ensure that the necessary funding is available to support the various components of the Acceleration Programme. Key elements of the financial resource allocation strategy include:

- Substantial financial resources will be allocated from the funding part of the Lithuanian government to fund research and development initiatives.
- Funding will be allocated for pilot projects in real-world forest environments, aimed at testing and validating Forest 4.0 technologies before full-scale deployment.

- The recruitment and retention of skilled professionals is paramount, therefor financial resources are allocated to attract top talent in fields such as AI, IoT, and forestry techniques.
- Comprehensive training programmes require financial resources for curriculum development, instructional materials, and the facilitation of workshops and seminars. These programmes will help equip teams of Acceleration programme participants with the skills needed to effectively use Forest 4.0 technologies.
- Investment in cutting-edge technology infrastructure is another area CoE aims to actively improve and make available to programme participants. This includes the acquisition of hardware, software, and cloud computing resources necessary for data analytics, remote sensing, and Forestry measurement and analysis tools, and potentially even the participation of third-party companies as lab providers.
- To promote awareness and adoption of Forest 4.0 technologies, financial resources are allocated for outreach campaigns to attract not only the participant to the programme, but also investment to cover key topics. These campaigns can involve marketing, educational materials, and public relations efforts.

Non-financial resources play an equally significant role in the resource allocation strategy. These resources include:

- Collaboration with NGOs, industry, research institutions, involvement in networking (see section 5) often involves in-kind contributions. These can include access to specialist equipment, technology expertise, and research facilities.
- Pilot projects require access to forested land for testing and validation. CoE has operating rights to numerous forest parks in Lithuania.
- Data as a valuable non-financial resource and the CoE plans a lot of its activities about data collection and managements. Furthermore, existing agreements for data sharing with research institutions, government (state) agencies, and technology providers facilitate the collection of crucial datasets for AI and IoT applications.
- Collaborative agreements with technology providers offer access to their specialised expertise, helping to ensure that Forest 4.0 technologies are developed and implemented effectively.

To augment its financial resources, the Acceleration Programme actively seeks grant opportunities from a variety of sources. Grants serve as catalysts for specific projects and initiatives within the programme, as securing grants from government agencies, private foundations, companies and relevant international organisations (see section 5), operating startup incubators and accelerators (see section 3.5.3) will help to improve the programme's ability to drive innovation in forestry sustainably and responsibly.

3.5.2 Potential Revenue streams

In pursuit of revenue generation, the Forest 4.0 Centre of Excellence will strategically employ a blend of well-established business practices and research-supported methodologies (see Table 1).

Table 1: Revenue Generation Mechanisms and Business Practices

Revenue Mechanism	Business Practice and Reference
Training and Certification Fees	The implementation of a tiered pricing structure, informed by a comprehensive analysis of the depth and breadth of the course, has been observed as an effective business practice in the context of professional development [71]. Industry-specific research (underscores the tangible benefits of certifications, revealing that professionals with AI-related and IoT certifications typically command an income premium of approximately 15% [72, 73].
Consulting Services	Best practice dictates the utilisation of case studies and white papers as instruments to highlight the demonstrable impact of consulting services on forestry companies [74, 75]. A client satisfaction survey, coupled with transparent sharing of results, aligns with industry standards and offers empirical evidence of the value provided [76]. In particular, the research by Pinto et al. further underscores the substantial return on investment in consulting services, often exceeding 100% [77].
Research and Development Projects	The strategic presentation of successful projects and partnerships, which are well-documented in annual reports, serves as a key business practice [78]. Such showcases exemplify the positive influence of innovations on sustainability and profitability, thus strengthening the appeal to stakeholders [79]. In particular, statistics indicate that companies investing in research and development activities tend to outperform competitors by an average annual growth rate of 2.2% [80].
Technology Adoption Services	Research and best practices highlight the value of publishing success stories related to forest companies that have adopted technology solutions [81]. In addition, bundles of training and technology solutions are considered prudent business practice, which improves the overall efficacy of the adoption process [82]. Research by Schweikl et al. reveals that investment in technology training is associated with a substantial increase in employee productivity, which is approximately 24% [83].
Data Analytics and Insights	Regular publication of industry reports, founded on data analytics, emerges as a well-established business practice within the Centre [84]. Such reports elucidate how data-driven decision-making results in cost savings [85]. In particular, research by Bechtsis et al. underscores that data-driven enterprises tend to exhibit 6% higher profitability than their non-data-driven counterparts [86].
Membership Models	Well-defined benefits packages for members, complemented by annual satisfaction surveys, are instrumental in affirming the value of membership [87]. Membership models, as a best practice, have consistently demonstrated the potential to improve customer retention rates by approximately 10% [88].
Workshops and Seminars	The use of feedback from participants to iteratively improve the quality of workshops and seminars is consistent with best practice [89]. The establishment of an annual flagship event is consistent with industry standards and has been found to provide unique value [90]. Leonard-Barton et al. report that 94% of event creators believe that in person events offer a distinctive and irreplaceable dimension to knowledge dissemination [91].
Affiliate collaboration	Robust promotion of affiliation via targeted marketing campaigns and the implementation of an affiliate programme are sound business practices [92]. Affiliate programmes can produce, on average, 16% of online orders, indicating its relevance and value within revenue generation strategies [93].
Grants and Funding	The presentation of success stories related to grant acquisition, coupled with their instrumental role in advancing the Centre's mission, aligns with established practices [94]. It should be noted that organisations that secure grants have reported an increase in revenue [95].
Product and Service Partnerships	Best practices in partnerships endorse highlighting tangible successes in annual reports, accentuating the positive impact on forestry companies [96]. Revenue-sharing agreements, when structured effectively, are associated with a substantial increase in partner satisfaction, potentially reaching 50% [97, 98].

3.5.3 Exploiting existing accelerator training programmes

Within the Acceleration Programme, the incubation process plays a vital role in nurturing the growth of start-ups and entrepreneurs of forest technology. The programme will offer a dedicated physical workspace within the Centre of Excellence, located in established premises in Akademija, Kaunas region, creating an environment conducive to innovation and collaboration. Startups benefit from access to cutting-edge forest technology infrastructure, research facilities, and a network of like-minded individuals and organisations.

The Acceleration Programme will actively seek funding opportunities through collaborations with venture capital firms, angel investors, and public-private partnerships. This proactive approach ensures that start-ups have the capital necessary to drive their Forest 4.0 initiatives from concept to market.

Mentoring is another cornerstone of the startup incubation process, leveraging the expertise of seasoned professionals and industry veterans. Startups must be paired with mentors who provide guidance, share industry insights, and offer strategic advice. These mentoring relationships are designed to accelerate the development of forest technology companies, en-

hance their market readiness, and foster long-term success.

As there are many existing accelerators operating within forestry related fields, it is logical to attract and exploit these existing funding sources and business training programmes, operating in the Baltic Sea region, so the CoE itself could focus on its more primary tasks within the acceleration programme. Tables 2 and 3 summarise such initiatives operating within the fields of Forestry related subjects.

Table 2: Review of Existing Accelerating intiatives

Accelerator programme	Focus	Services	Partnership
Forestry Accelerator - Vermont, USA	This accelerator is focused on companies looking to develop markets in northern New England and addresses challenges the regional industry faces.	It provides companies with expert advice and tools to build a market-validated business case, model, and operating plan. Services include a rigorous commercialisation curriculum, coaching, webinars, panels, and connections with industry experts, customers, and suppliers.	The accelerator partners with ecosVC to provide companies with access to their comprehensive commercialisation curriculum and years of experience supporting startups and innovation.
Forest Business Accelerator - RISE, Sweden	This accelerator is focused on companies from all over Sweden who want to develop and exchange their forestry concepts and sustainable technologies. It is looking for sustainable business ideas where the focus is on forests, and it is open to cross-fertilisation with other industries and areas.	The programme includes seven months of business development, working together towards commercialising and internationalising companies' products or services in larger markets. It is based on set goals, business models, and strategies.	It is a collaboration between SCA, IBM, RISE, and BizMaker.
Forest Business Accelerator - BizMaker, Sweden	This accelerator focusses on enabling successful exchange between SCA Forest Products and entrepreneurs, emphasising the link between the forest industry and digitalisation. It aims to create a seed bed for transformational innovations by bringing entrepreneurs and the forest industry together.	Provides a platform for developing and commercialising concepts, focussing on creating new products and businesses where extremely fast decisions are part of everyday life. It aims to open doors to new and interesting dialogues, relationships, and collaborations.	It is a forestry-focused accelerator with a direct link to digitalisation, created in collaboration with BizMaker and IBM.
Terra-formation Accelerator	This accelerator is the first carbon-funded forest accelerator focused on biodiversity. It focusses on native biodiverse restoration that creates community benefits and is open to forest restoration teams around the world, specifically targeting organisations focused on tropical or subtropical reforestation projects and communities.	Offers a range of services including funding planting costs, coordinating forward carbon sales, developing sustainable business models, providing software solutions and training for monitoring progress, offering a free feasibility study to assess projects' carbon potential, and more. It also facilitates project verification with third-party top-tier verifiers and connects projects to carbon credit buyers.	It has a global team of foresters, scientists, technologists, experienced carbon market strategists, and creative communicators ready to help projects succeed.
SilvaTech Accelerator - Startup Wise Guys, Latvia	SilvaTech was designed to promote innovation and efficiency within the forest sector, with the aim of helping entrepreneurs complete the journey from ideation to building tech products that bring forest solutions and potential collaboration to the client, Joint Stock Company Latvia's State Forests.	It is an 8-month-long hybrid (online & offline) acceleration programme carried out in 4 stages covering everything from idea shaping to building a market-ready solution. Provides effective project management, event production, accelerator programme content, as well as branding and communication.	It is a collaboration with the Joint Stock Company of Latvia's State Forests and Startup Wise Guys, who were the selected winner of the procurement to carry out this tailor-made solution.
Acceleration Programme for Forest Restoration Initiatives - PAR, Brazil	The programme has a differentiated approach that supports native vegetation restoration initiatives (ARR projects) through economic and financial incentives, especially those from the voluntary carbon market. It aims to expand the planted area and the positive climate impacts of the actions.	The programme allows for a gain in scale of initiatives by grouping projects, simplifying the processes necessary for carbon certification, relieving the project proponent, eliminating costs, and minimising the respective risks. The financial incentive is carried out per hectare depending on the accumulation of biomass and, respectively, the increase in carbon stocks.	
AFRY Forestry - Europe	AFRY is a European leader in engineering, design, and advisory services, with a global reach, focused on accelerating the transition to a sustainable society. It seems to have a broad focus, including infrastructure, industry, energy and digitalisation, creating sustainable solutions for future generations.	AFRY X is a digital leader and powerhouse in the industrial Internet of Things, Artificial Intelligence, design, and cybersecurity. However, specific services related to forestry acceleration are not explicitly mentioned in the accessed content.	The organisation consists of 19,000 dedicated experts working toward creating sustainable solutions in various domains.
ForestTech Accelerator - Russia	The accelerator seems to focus on the acceleration and piloting of innovative solutions in the field of the forestry industry. It aims to invest in new technologies and solutions and help businesses adapt to the forestry industry and scale significantly.	Specific services or offerings of the accelerator are not explicitly mentioned in the accessed content.	
Future Forest Accelerator - Germany	This accelerator is part of Europe's first accelerator for forest and climate, focussing on startups connected to forest and climate. It aims to support innovations in the forest, wood, and climate tech areas, particularly those in the preseed and seed stage with an existing prototype or business model. Thematic pillars are Smart Forestry, Ecosystem Services, and Climate Solutions.	The accelerator offers custom-made access to mentors, experts, potential investors, and implementation partners. It provides a network of over 40 mentors and attractive partners to optimise solutions, and organises pilot projects and initiates strategic partnerships for successful brand entry.	
Forest Business Accelerator - SCA, Sweden,	SCA's Forest Business Accelerator merges forest development with digitalisation and entrepreneurship. It is designed as a joint venture to cooperate with startups, with the aim of building new relationships and initiating cooperation that contributes toward the renewal of the industry.	The accelerator programme offers tailored business coaching for commercialisation and internationalisation.	It is a collaboration between the Bizmaker business incubator, SCA, IBM, and RISE through the Biorefinery Cluster.
RedZone by SAES - Italy	RedZone is a high-tech hub for startups in materials science, offering a customised programme for scientists, engineers, and inventors. It aims to develop the materials of tomorrow, side-by-side with the most brilliant startups, focussing on areas like cosmetics solutions, advanced packaging, sensing materials, functional additives, biomaterials, smart packaging, and carbon capture materials.	The programme is structured in two phases, with the first phase focussing on Proof of Concept or Initial MVP and the second phase aiming to launch MVP in partnership with SAES. Provides professional support, open laboratories, and investment during the second phase.	
Forest Landscape Sustainability Accelerator - BirdLife	This accelerator is focused on forest conservation and is modelled on start-up incubators in the tech sector. It aims to develop and elevate successful conservation enterprises and build innovative funding models that change the way businesses, governments, and society value forests. It seeks to create economic value for forests while maintaining them and to attract private finance with the right incentives.	The accelerator selects Sustainable Finance Initiatives posed by BirdLife Partners that have high potential to conserve forests and draw in income for the Partner and local communities. Provides targeted seed funding, technical mentorship, and profile raising to start and scale up these initiatives.	The accelerator is an initiative of Trillion Trees, a joint venture comprising BirdLife, WCS, and WWF, representing over 100 forest landscape programs.

On the basis of the analysis of the various forestry accelerator programmes, several common

Table 3: Review of Existing Accelerating initiatives (continued)

Accelerator programme	Focus	Services	Partnership
Forestry Accelerator 2023 - USA	This is a four-month programme open to North American start-up, preseed and seed stage companies that are commercialising new and improved products, services and technology in the forest industry. It focusses on supporting companies in areas such as products that use low-grade wood, technology that improves forest industry operations, and products or services that increase the use of wood heat or energy or improve its efficiency.	The programme provides forest start-ups with connections to industry experts, customers, suppliers, partners, pilots, investors, and industry leaders, and a comprehensive commercialisation curriculum. It includes both virtual and in-person components, with companies receiving financial support to make two trips to Vermont's Northeast Kingdom to connect with other cohort members and industry leaders.	It is developed by Do North Coworking and is facilitated by ecosVC, who brings decades of experience working with companies to commercialise and launch new technologies.
Seed to Carbon Forest Accelerator - Terraformation	Terraformation has launched the world's first carbon-funded forest accelerator focused on biodiversity. The Seed to Carbon Forest Accelerator supports early-stage forestry teams in launching biodiverse reforestation projects to produce verified high-quality carbon credits. It aims to unlock forest carbon revenue for forestry projects.	The accelerator offers a feasibility study to assess projects and their ability to grow into full-scale carbon projects, training on critical topics ranging from seed collection to sustainable business models, and carbon markets, and infrastructure like seed banks and nurseries.	
Forest Starter – Forest Tech Acceleration Programme	Forest Starter is designed to support the innovation and internationalisation of companies with the aim of building a more sustainable future. It propels forest technology into the future, focussing on discovering and helping the next generation of forest technology-focused startups. The programme aims to integrate the processes and mechanisms of the tech start-up culture to achieve long-term success.	It is a two-week accelerator programme that supports everything from idea creation to the creation of an entry-level solution. It provides participants with access to the business and forestry experience of mentors from different organisations, as well as forestry data and insights to help address the current challenges of one of the largest forestry players in the region.	The programme is created by Startup Leiria, together with Entrepreneurship and Innovation Hubs: Sampo (Finland), BizMaker (Sweden), Patras Science Park (Greece), and Arca (Italy).
Forest Carbon Accelerator - Form International	Treevive is an initiative of Form International designed to accelerate private sector climate finance for the long-term conservation, restoration, and sustainable management of tropical forest landscapes. It aims to protect biodiversity, set local value chains in motion, and improve the livelihoods of the local population. The initiative is crucial to combating global climate change and preventing biodiversity loss, focussing on areas that are essential, yet underfunded.	Treevive works to bridge the existing gap between forest landscape projects that wish to receive carbon financing and businesses and investors who want to fund these types of projects. It offers technical assistance and (pre)financing for forest landscape projects and connects these projects to investors and buyers of quality forest carbon credits.	
The Silicon Forest – Oregon, USA	The Silicon Forest provides a directory of accelerators and incubators in Oregon, focussing on various sectors including technology, bioscience, green startups, and more. It is not specifically focused on forestry but includes accelerators that support sustainable solutions and cleantech startups.	The listed accelerators and incubators offer various services, including mentoring, support for innovation and entrepreneurship, and assistance to early-stage startups.	
StartUp Lab – Wake Forest University, USA	StartUp Lab is Wake Forest University's startup accelerator, focused on helping students develop concepts into ventures through access to mentors and seed capital. It is not specifically focused on forestry but supports a range of ventures, including those aimed at sustainability and innovation.	The accelerator provides key resources necessary to launch a venture, including mentoring, where StartUp Lab connects high-potential entrepreneurs to accomplished mentors who have founded successful ventures and to industry-specific mentors with domain, legal, and business expertise.	
Forestry Accelerator Programme in North America	This accelerator focusses on companies looking to develop markets in northern New England and working to solve the challenges of the regional industry. It targets products that use chips, dust, resins and other by-products and low-grade wood, technology that improves forest management, sales, safety, and other operations, and products and processes that develop and improve advanced wood heat, fuels, and energy.	The programme, in partnership with ecosVC, provides companies with access to a comprehensive commercialisation curriculum and years of experience supporting startups and innovation. It offers a rigorous commercialisation curriculum, coaching, webinars, panels, and connections with industry experts, customers, and suppliers.	
The Forest Business Accelerator - Biosorbe	Biosorbe was one of the startups in the Forest Business Accelerator, which aims to enable entrepreneurs to verify and develop their solutions in close collaboration with industry leaders operating on a global market. It seems to focus on fostering innovations and solutions that can be integrated and beneficial to the forestry industry.	The accelerator provides an environment where startups can develop and verify their solutions with the collaboration of leading companies in the industry.	
The Land Accelerator – World Resources Institute	The Land Accelerator focus on landscape restoration, which creates environmental and economic benefits by revitalising ecosystems and rural communities. It aims to make degraded land healthy again, boosting agricultural yields, creating jobs, and fighting climate change. The programme targets rural areas where producing agricultural commodities on restored land is cost-effective.	The accelerator offers online and in-person boot camps and personalised mentorship, empowering entrepreneurs to pitch impact investors and sell their products more effectively. It fosters entrepreneurialism and provides a cost-effective approach to restore and develop rural areas around the world.	
The Forest Business Accelerator - BizMaker	The Forest Business Accelerator focusses on enabling entrepreneurs to develop and commercialise concepts outside of what large companies like SCA Forest Products invest in. It emphasises the link between the forest industry and digitalisation, with the objective of creating a seed bed for transformational innovations by bringing entrepreneurs and the forest industry together.	The accelerator serves as a platform for successful exchange between SCA Forest Products and entrepreneurs, opening doors to new dialogues, relationships, and collaborations. It is designed to shape an optimal structure and culture for the development of brand new products and businesses where extremely fast decisions are part of everyday life.	The accelerator is a collaboration between SCA Forest Products, BizMaker, and IBM, focussing on creating new opportunities for the future by combining the forest industry and digitalisation.
Forest Valley	Forest Valley is committed to driving climate change solutions through innovative approaches in the production of goods and services. It is dedicated to combating climate change by championing innovation in the production of goods and services, focussing on creating sustainable and environmentally friendly solutions.	Specific services and benefits provided by the accelerator are not detailed in the available content, but given its focus, it likely supports startups and initiatives aimed at developing sustainable and innovative solutions to combat climate change.	It collaborates with the AWS Emerging Technologies Accelerator, which may provide startups with access to AWS Activate Credits and connections to leading VCs.

characteristics can be identified. These reflect a shared goal among the forestry accelerator programmes to foster innovation, sustainability, and entrepreneurship in the forest sector, contributing to environmental conservation and economic development:

- Most programs are focused on sustainability, environmental conservation, and innovative solutions to combat climate change, emphasizing the development of eco-friendly technologies and practices.
- The programmes offer a variety of services, including mentoring, coaching, technical

assistance, and access to resources and expertise, to support the development and commercialisation of innovative solutions.

- Many programmes provide financial support in the form of grants, investments, or (pre-)financing to help startups develop their concepts and bring them to market.
- Collaboration with industry leaders, experts, and other startups is a key component, providing participants with opportunities to form partnerships, receive feedback, and access new markets. Opportunities to network with potential investors, mentors, and industry experts are often provided to help start-ups grow their businesses.
- Programmes typically have an application and selection process to identify startups with high potential and innovative solutions.They often look for startups that address real customer problems in growing markets and have scalable and sustainable business models.
- Although all are related to forestry, the areas of interest are diverse, ranging from land restoration and forest management to advanced materials science and digital solutions for the forestry industry.
- The programmes are spread across different regions around the world, indicating a widespread interest and a need for innovation and sustainability in the forestry sector.
- They support startups at various stages of development, from early-stage to more established companies, helping them to scale and commercialise their innovations.
- Many programmes offer educational resources, workshops, and training sessions to improve the skills and knowledge of participating companies.
- Accelerators often help validate the market, access and commercialise products, helping startups refine their business models and strategies for market entry.

3.6 Training and Capacity Building

The development of skills and capacity is a fundamental pillar of the Forest 4.0 Acceleration Programme. CoE adopts a comprehensive and versatile approach to skill development, recognising the diverse levels and backgrounds of its participants. Several methods are employed to cultivate expertise in AI, IoT and Forest-related techniques:

- The program will offer a series of structured training modules covering foundational to advanced concepts in AI, IoT, and forest related subjects. These modules will be designed to provide participants with a solid theoretical understanding of these technologies.
  - Participants will receive in-depth training in the latest AI, IoT and forest related disciplines. These modules will explore cutting-edge research and applications specific to forest, such as image recognition for tree species identification and predictive modelling for forest growth. Training will also cover state-of-the-art IoT sensor technologies, focussing on environmental monitoring, wildlife tracking, and equipment automation. Participants will learn to deploy and manage advanced

sensor networks that provide crucial real-time data for sustainable forest management.

- Practicality is the key to skill development. Immersive workshops will be organised to allow participants to apply their knowledge in hands-on settings. The workshops will cover various use cases and scenarios relevant to forestry applications.
  - Workshops will simulate real-world scenarios where participants use AI algorithms to assess forest health based on drone-collected imagery, including early detection of pest infestations and disease outbreaks. Hands-on sessions will involve the deployment of IoT sensors in a forest environment, the configuration of data collection parameters, and the guarantee of secure data transmission and storage. We will also aim to familiarise participants through the process of integrating blockchain into existing supply chains, ensuring transparent and tamper-proof tracking of forest products from the origin to the consumer.
- Webinars will provide an interactive platform for participants to engage with experts and fellow learners. They will facilitate discussions, Q&A sessions, and the exchange of insight and best practices.
  - Webinars will focus on advanced AI model optimization techniques, discussing transfer learning, federated learning, and model interpretability as well as other related subjects on IoT and Forestry data processing. Participants will engage in live model tuning exercises. The interactive sessions will cover real-time data analysis using IoT-generated data, focussing on anomaly detection, predictive maintenance, and ecosystem monitoring.
- Learning by doing is another fundamental principle to be employed within CoE labs. Practical sessions will enable participants to work directly with technology tools and platforms. These sessions will reinforce theoretical knowledge and improve practical skills.
  - For example, Participants will work with state-of-the-art AI development tools and frameworks to build custom AI models tailored to forestry applications. Practical sessions will involve the configuration and maintenance of advanced IoT sensor networks, to ensure reliable and secure data transmission.

Skill development will be seamlessly integrated into the Acceleration Programme:

- Participants engaged in Forest 4.0 initiatives will undergo customized training programs. These programmes are to be thoughtfully designed by the CoE team to align with the specific skill requirements of their respective projects, ensuring that the acquired skills are directly applicable.
  - Participants' training paths are to be customized to align with their specific roles and project requirements within the Forest 4.0 initiatives. The training content is to be continuously updated to stay at the forefront of technological advancements in AI, IoT, and forest-related techniques, ensuring that participants have access to the latest knowledge and tools.
- Skills acquired through training are to be designed to stay relevant to real-world For-

est 4.0 projects. Participants can apply their knowledge and expertise directly to the challenges they face during the programme.

  - As participants will engage in Forest 4.0 projects, they will apply their newly acquired skills to solve real-world forestry challenges, such as automated forest inventory management using AI or blockchain-based supply chain traceability. Mentors and subject matter experts will provide guidance and mentorship to ensure that participants' skills are effectively deployed.

- The commitment to capacity building will extend beyond initial training. Participants will receive continuous support and mentoring, ensuring that they have access to guidance and expertise throughout the duration of their involvement in Forest 4.0 initiatives.

  - Participants will have access to a network of mentors and experts who provide guidance, troubleshoot technical challenges, and facilitate knowledge sharing throughout their involvement in Forest 4.0 initiatives.

- A robust repository of learning resources will be available to participants. This includes documentation, tutorials, research papers, and best-practice guides. These resources will serve as references for continuous learning and skill improvement.

3.7 Knowledge Dissemination

CoE will play a pivotal role in guiding forest tech start-ups and entrepreneurs to independently produce and disseminate knowledge across the forestry sector. Recognising the significance of this function, the CoE will focus on empowering startups to create and share state-of-the-art insights and innovations:

- The CoE will facilitate and support startups in organizing interactive workshops and seminars. These events will serve as platforms for startups to showcase their expertise, share their research findings, and engage with stakeholders. The CoE will provide guidance on content creation, presentation skills, and audience participation to ensure effective dissemination of knowledge.
- Startups will be encouraged to produce and share publications under the guidance of the CoE. The CoE will offer expertise in research paper writing, report generation, and publication strategies to help them reach a wider audience with their insights.
- Collaborating with academic institutions, the CoE will not only provide, but will also assist startups in developing their own educational materials and curricula. Using its network of experts, the CoE will guide startups in creating content that aligns with educational standards and industry needs.
- The CoE will support startups in utilising online research-orientated platforms and webinars as channels for knowledge dissemination. Startups will be coached on how to use digital tools effectively to reach their target audiences.
- Startups will benefit from the CoE's collaborative networks, which will facilitate knowledge exchange and partnerships. The CoE will help connect startups with relevant stakeholders, including forestry companies, government agencies, and technology providers.

4 Operational Model

4.1 Incubation model

The Forest 4.0 Acceleration Programme is designed to span through various phases of each accelerated start-up, starting with preprogramme preparation, participant selection, and goal setting (see Table 4). It then proceeds to orientation and core training modules, encompassing in-depth workshops and hands-on exercises. Throughout the programme, mentorship and guidance will be provided and mid-program evaluation ensures progress alignment. Advanced topics and specialisations are introduced, followed by capstone projects. Post-programme support includes networking and resource access, while long-term evaluation and feedback collection support program refinement.

Table 4: Forest 4.0 Acceleration Programme Structure

Program Phase	Duration	Description
Pre-Programme Preparation	1-2 months	Outline of the goals and expected outcomes of the programme. Participant selection. Pre-Assessment to gauge participants' baseline knowledge and skills.
Orientation and Kick-off	1-2 days	Familiarisation of the programme, its structure and expectations. Networking and team building activities. Sessions with experts.
Core Training Modules	6-8 weeks	In-Depth Workshops on key topics. Practical exercises, hands-on tasks, case studies, and projects. Group Work on collaborative projects among participants.
Mentorship and Guidance	Throughout the Programme	Pair participants with experienced mentors who provide guidance and offer insights.
Mid-Programme Evaluation	1-2 weeks	Review of progress and addressing of challenges. Feedback sessions with participants and mentors.
Advanced Topics and Specialisations	4-6 weeks	Advanced training in specific areas like remote sensing, data analytics. Guest speakers on specialised topics.
Capstone Projects	4-6 weeks	Assignment of capstone projects related to real-world forestry challenges. Monitoring of project progress and provide support.
Final Presentations	1-2 days	Participants present their projects to a panel.
Post-Programme Support	Ongoing	Establishing a collaborative network. Providing continued access to resources.
Evaluation and Follow-up	3-6 months post-programme	evaluation of the long-term impact of the program. Feedback sessions for programme improvement.

4.2 Monitoring Progress

We have also planned the mechanisms used to monitor and evaluate progress against established timelines and milestones. The principles are summarised in Table 5.

4.2.1 KPI and Success Factor Model

The effectiveness of the Forest 4.0 Acceleration Programme is underpinned by a KPI and Success Factor Model, which draws upon empirical research and industry-specific insights. Central to this model are the critical success factors (CSFs), which constitute the pivotal elements for the program's overall success. Extensive research in the field of professional development has consistently underscored the significance of participant engagement as a critical factor in achieving program objectives [99]. In fact, an analysis of similar initiatives has revealed that actively engaged participants tend to exhibit significantly higher rates of knowledge retention and practical application of acquired skills [100].

Table 5: Program Reporting and Assessment Mechanisms

Reporting and Assessment Aspect	Description
Regular Reporting:	
Monthly Progress Reports	Detailed accounts of activities, milestones, and challenges during the previous month. Includes updates from research and development, training, and outreach efforts.
Quarterly Comprehensive Review	In-depth analysis of key performance indicators, budget updates, and adjustments to strategic goals.
Annual Reports	Holistic view of the programme's yearly performance, summarising achievements, challenges, financial summaries, impact assessments, and plans for the upcoming year.
Key Performance Indicators (KPIs):	
Technology Adoption KPIs	Monitoring adoption of Forest 4.0 technologies, including AI, IoT, and blockchain, with corresponding adoption rates.
Economic Viability KPIs	Assessing financial sustainability through revenue generation, incubation of startups, and growth in forest-related industries.
Research Output KPIs	Measuring research productivity through publications, successful patents, and collaborative projects.
Environmental Impact KPIs	Evaluating contributions to sustainability, including carbon emission reduction and biodiversity conservation.
Social Inclusivity KPIs	Gauging success in promoting diversity and inclusion within the Forest 4.0 workforce.
Impact Assessment:	
Technology Adoption Surveys	Feedback mechanisms to assess adoption and satisfaction levels of Forest 4.0 Technologies among stakeholders.
Economic Impact Assessments	Quantifying contributions to the economy, considering job creation, revenue generation, and industry growth.
Long-Term Sustainability Analysis	Evaluating enduring effects on forest ecosystems, communities, and economies through longitudinal studies.
Environmental Impact Assessments	Regular evaluations of forest health, biodiversity conservation, and carbon sequestration using IoT sensors and remote sensing.
Social Inclusivity Assessments	Evaluating workforce diversity, participation of underserved communities, and empowerment of marginalized groups.
Stakeholder Engagement:	
Regular Surveys	Gathering input, concerns, and suggestions from forestry companies, government agencies, technology providers, NGOs, and local communities.
Periodic Consultation Meetings	Holding meetings to discuss program progress, challenges, and strategic adjustments with stakeholders.
Workshops	Organizing sessions to engage stakeholders in discussions or training, fostering collaboration and knowledge sharing.
Annual Program Reviews:	
Annual Reviews	Comprehensive assessments of program achievements, challenges, and alignment with objectives through self-assessment, external evaluations, and stakeholder consultations.
Strategic Adjustments	Making adjustments to program goals, objectives, and activities based on annual review outcomes.
Stakeholder Integration	Integrating stakeholder feedback into program planning and decision-making during annual reviews.
Regular Progress Reporting:	
Structured Reporting Schedule	Providing regular updates on KPI tracking, impact assessments, and financial summaries to stakeholders, partners, and funding agencies.
Ad Hoc Reviews:	
Ad Hoc Reviews	Initiating reviews in response to significant developments, challenges, or opportunities for rapid decision-making and adaptation.

The KPI and Success Factor Model acknowledges the importance of post-program support and resource accessibility in ensuring continued knowledge dissemination and engagement (see Figure 3).

4.3 Budget Allocation Model

Table 6 provides an overview of budget allocations for various categories within a program. Notably, Research and Development (R&D) receives the highest allocation at 20%. This category focuses on funding R&D activities, including personnel, equipment, data acquisition, and project-specific expenses, emphasizing the importance of technological innovation. Training and Capacity Building, as well as Entrepreneurship and Startups Support, each receive 15%. These allocations highlight the commitment to skill development in emerging technologies like AI, IoT, and blockchain, along with support for startups through incubation facilities and mentorship.

Additionally, 10% is allocated to Policy and Regulation Advocacy, emphasizing the significance of advocating for favorable policies, legal counsel, and research dissemination to pol-

Figure 3: KPI and Success Factor Model for the Forest 4.0 Acceleration Programme

icymakers. Other categories receive smaller allocations, including Environmental Sustainability Measures, Social Inclusivity Initiatives, and Risk Management, they underscore the program's commitment to sustainability, diversity, and resilience - to maintain a balanced approach to promoting innovation, education, and responsible program management.

4.4 Acceleration Resource Management Model

Table 7 provides an overview of planned acceleration resource management areas within the Forest 4.0 initiative, outlining their responsibilities and management approaches.

subsectionRisk Analysis CoE aims to focus on the Explainable risk reporting model, which involves presenting risk-related information in a transparent, understandable, and interpretable manner for its intended audience [101]. Rather than solely offering metrics or data, this approach delves into the underlying factors, methodologies, and assumptions that contribute to the risk assessment. The objective is to enable stakeholders, whether they are decision-makers, investors, or the general public, to comprehend the intricacies of the risk landscape, understand the reasoning behind risk evaluations, and make informed decisions or judg-

Table 6: Budget Allocations

No.	Category
1	**Research and Development** Research and development activities require substantial funding for personnel, equipment, data acquisition, and project-specific expenditures to drive technological innovation.
2	**Training and Capacity Building** Investment in training programs, workshops, webinars, and skill development is crucial for building expertise in AI, IoT, and blockchain technologies.
3	**Entrepreneurship and Startups Support** Supporting entrepreneurship includes incubation facilities, mentorship programs, funding for startups, and transparent resource management for incubated companies.
4	**Policy and Regulation Advocacy** Advocacy efforts require funding for policy research, advocacy campaigns, legal counsel, and the dissemination of research findings to policymakers.
5	**Center of Excellence Operations** The operations of the Center of Excellence, including maintaining infrastructure, salaries, and collaborative spaces, necessitate a significant portion of the budget.
6	**Environmental Sustainability Measures** Funds are allocated for implementing green technologies, sustainable forest management practices, and carbon offset initiatives to ensure environmental sustainability.
7	**Social Inclusivity Initiatives** Budget covers diversity and inclusion programs, community outreach, educational initiatives, and capacity-building efforts for underserved communities.
8	**Economic Viability Strategies** Investment in sustainable business models, income generation programs, and economic impact assessments is crucial for long-term economic viability.
9	**Evaluation and Metrics** Resources are allocated for monitoring and evaluation activities, including impact assessments, KPI tracking, and transparent reporting.
10	**Risk Management** Contingency budgets are established to address unforeseen challenges and implement risk mitigation strategies, ensuring program resilience.

Table 7: Resource Management Areas

No.	Resource Management Area	Responsibilities	Management
1	Personnel Management	Human resource practices include recruitment, training, professional development, and performance evaluations. Diversity and inclusion initiatives are integrated into personnel management.	Managed by the HR department with input from program leaders.
2	Equipment and Technology Management	Equipment and technology management involve maintenance, calibration, and upgrades to ensure functionality and reliability.	Managed by dedicated teams responsible for specific equipment and technology categories.
3	Collaborative Space Management	Management of collaborative spaces facilitates knowledge sharing, innovation, and collaboration among researchers, partners, and stakeholders.	Supervised by the Center of Excellence's facility management team.
4	Data and Information Management	Robust data management protocols ensure secure storage, sharing, and analysis of research data to support Forest 4.0's knowledge-driven approach.	Overseen by the data management and IT departments in coordination with research teams.

ments based on the provided insights. This approach not only fosters trust and clarity but also enhances effective risk communication by ensuring that the audience can engage with and interpret the reported information with confidence.

The concept of Forest 4.0 and smart forestry represents the integration of advanced technologies, data analytics, and automation into traditional forestry practices. As we transition into this new era of forestry, the multidimensional risk landscape becomes increasingly complex (Table 8).

Table 8: Risks related to outputs of the Smart Forestry Acceleration Programme

Risk Category	Description
Technological Risks:	
Cybersecurity	The use of digital tools and IoT devices in the acceleration programme increases the risk of cyberattacks, data breaches, and unauthorised access, compromising the security of startup projects.
Equipment Failure	Advanced machinery and drones, vital for acceleration activities, may malfunction, leading to operational disruptions and affecting the progress of startups.
Software Reliability	Dependence on software for tasks like data analysis poses a risk of glitches or inaccuracies, impacting the effectiveness of the acceleration programme in guiding startups.
Operational Risks:	
Automation Challenges	Transitioning to automated processes in the acceleration programme may face resistance, require training, and encounter initial implementation challenges, affecting the speed and efficiency of startup incubation.
Data Overload	The vast amounts of data generated in the acceleration programme can be overwhelming, leading to potential oversights or misinterpretation, impacting decision-making for startups.
Supply Chain	Integration of smart technologies may lead to dependencies on specific suppliers, increasing vulnerability to supply chain disruptions, affecting the progress of startups in the programme.
Environmental Risks:	
Climate Change	Changing weather patterns can impact forest health, growth rates, and susceptibility to pests, affecting startups in the acceleration programme focussing on eco-friendly practices.
Biodiversity Loss	Over-reliance on certain tree species or mismanagement can lead to reduced biodiversity, posing challenges for startups in the acceleration programme focused on sustainable forestry.
Unintended Ecological Impacts	The use of drones or machinery might disturb wildlife or inadvertently damage ecosystems, with potential implications for startups in the acceleration programme working on environmental solutions.
Socio-Economic Risks:	
Stakeholder Acceptance	Traditional forestry communities might resist the Smart Forestry Acceleration Programme, affecting the acceptance of startups and incubation initiatives in the community.
Job Displacement	Automation and advanced technologies might reduce the need for certain manual jobs, leading to socio-economic challenges for startups and the local workforce involved in the acceleration programme.
Regulatory and Compliance	As technologies evolve, staying compliant with evolving rules can be challenging for startups in the Smart Forestry Acceleration Programme, impacting regulatory adherence.
Strategic Risks:	
Investment Decisions	Determining which technologies to invest in for the startups, given the rapid pace of innovation, can be risky and impact the success of the acceleration programme.
Market Dynamics	The introduction of new wood products, biofuels, or ecosystem services can change market demands and values, influencing the strategic positioning of startups incubated in the programme.
Intellectual Property	Protecting intellectual property rights and avoiding infringements is crucial for startups involved in cutting-edge research within the acceleration programme.
Reputational Risks:	
Public Perception	Missteps in implementing smart forestry practices can lead to negative public perceptions, affecting the reputation of the Smart Forestry Acceleration Programme and the companies involved.
Transparency and Trust	Stakeholders demand transparency in how forests are managed. Any perceived secrecy or mismanagement can erode trust, affecting the reputation of the acceleration programme and the startups it supports.

Table 9 presents an initial set of contingency plans established in various critical domains to ensure the robustness of Forest 4.0 operations, describing a set of actions across different dimensions, each designed to mitigate potential challenges and disruptions in the context of Forest 4.0 operations.

4.5 Key Roles and Responsibilities

CoE acknowledges that sustainable growth is a key factor in the success of any acceleration programme, helping mitigate the risks associated with rapid and resource intensive growth

Table 9: Risk contingency plans

Technology Contingency Plans	
Backup Systems	Maintain redundant AI and IoT systems to minimise downtime in the event of technological failure.
Disaster Recovery	Develop detailed disaster recovery plans that outline procedures for system restoration after data failures or data breaches.
Response Teams	Establish rapid response teams composed of technology experts to quickly troubleshoot and resolve technical issues.
Environmental Contingency Plans	
Emergency Response	Create emergency response protocols to address natural disasters, such as wildfires or storms, including evacuation and asset protection procedures.
Adaptive Forest Management	Incorporate flexibility into forest management practices to adapt to changing environmental conditions, such as drought or outbreaks of invasive species.
Partnerships	Forge partnerships with environmental agencies and local authorities to coordinate responses to environmental emergencies.
Operational Contingency Plans	
Alternative Supply Chains	Identify and establish alternative supply chain routes to ensure continuous flow of resources in the event of disruptions.
Logistical Support	Maintain contracts with logistical support providers in remote forest locations to quickly address operational challenges.
Agile Decision-Making	Implement agile decision-making structures and communication channels to respond swiftly to operational issues and changes in project timelines.
Financial Contingency Plans	
Diversified Funding Sources	Continuously seek diversified sources of funding, including grants, private investments, and revenue generated from Forest 4.0 activities.
Emergency Reserve Funds	Establish emergency reserve funds to cover unexpected budget overruns or funding shortages.
Scenario Planning	Develop financial scenario plans to prepare for economic downturns and fluctuations in funding availability.
Social Contingency Plans	
Conflict Resolution Mechanisms	Develop clear conflict resolution mechanisms to address disputes or resistance to technology adoption within communities.
Community Engagement	Implement flexible community engagement strategies to adapt to unforeseen social challenges and ensure continuous collaboration.
Communication Plans	Establish communication plans to maintain transparency and address concerns promptly.
Regulatory Contingency Plans	
Legal Counsel	Retain legal counsel with expertise in forestry regulations to navigate complex legal issues and disputes.
Compliance Teams	Strengthen compliance teams to ensure adherence to evolving regulations and standards.
Advocacy Campaigns	Prepare advocacy campaigns and public relations strategies to influence regulatory changes and advocate for Forest 4.0's goals and objectives.

in the early stages [102]. The approach of starting small and gradually expanding aligns with a sustainable growth model. Reduce the risk of overextension, ensuring that each team member has a well-defined, impactful role to play in advancing Forest 4.0's objectives. Starting with a small team also aligns well with available funding and minimises financial risks.

An efficient streamlined team will manage operations until the Centre of Excellence (CoE) expands to its full capacity as defined in Table 10.

We also estimate that the need to expand the team in sync with CoE growth is aligned with research on organisational scalability [104]. Introducing additional team members as the CoE gains infrastructure, resources, and capabilities ensures that the team size remains well-matched to the programme's evolving scope. Therefore, in the late stages of the Forest 4.0 acceleration programme, we have strategically designed our organisational structure model based on extensive research and industry best practices (see Figure 4).

5 Analysis of targets and the potential stakeholders for the acceleration programme

Table 10: Program Leadership and Roles

Program Leadership	Responsibilities	Person Responsible
Programme Director	Responsible for overall programme direction, strategy, budget oversight, and stakeholder participation. This individual combines strategic thinking and financial acumen, aligning with research by Nocco et al. on effective programme leadership [103].	TO BE ASSIGNED BY THE DIRECTOR OF COE
Research and Innovation		TO BE ASSIGNED BY THE DIRECTOR OF COE
Researchers (2)	Two versatile researchers will share responsibilities, conducting research and development activities, collaborating with academic partners, and contributing to Forest 4.0 solutions. Their adaptability is crucial to optimising resource use, and their broad expertise efficiently covers multiple areas, adhering to best practices for small teams.	TO BE ASSIGNED BY THE DIRECTOR OF COE
Training, Sustainability, Inclusion, Diversity and Advocacy Specialist	This team member combines responsibilities for training programme development, sustainability initiatives, and policy advocacy.	TO BE ASSIGNED BY THE DIRECTOR OF COE
Economic Viability and Metrics		TO BE ASSIGNED BY THE DIRECTOR OF COE
Economic Analyst and Evaluator	This role focusses on economic viability and programme evaluation, including economic analysis and impact assessments. This role ensures efficient resource allocation and data-driven decision-making.	TO BE ASSIGNED BY THE DIRECTOR OF COE

CoE Forest 4.0 transcends the boundaries of traditional boundaries and conventional practices [50]. It seeks to redefine the very essence of sustainable forestry management by pushing the envelope of what is possible. Forest 4.0 is not content with incremental change; it aspires to lead a fundamental change in how we understand, engage with, and conserve our forests [51, 52]. In essence, Forest 4.0 represents an intersection of cutting-edge technology, pioneering science, and unwavering dedication to social justice [53]. Establishing robust and collaborative partnerships with technology providers is not just advantageous; it is imperative [46]. Such partnerships ensure access to cutting-edge tools and resources while significantly accelerating the development and implementation of customised Forest 4.0 solutions [44].

CoE Forest 4.0 is resolute in its commitment to engage exclusively with state institutions, NGOs, research and industry leaders from the Baltic Sea Region (Lithuania, Latvia, Estonia, Sweden, Finland, Poland, Germany and Denmark), which share a profound dedication to critical issues such as climate neutrality [32], climate change [31], climate restoration [35], carbon sequestration [33], reduced carbon emissions [34], and biodiversity conservation within forest practices [36], diversity [37], inclusion [38], and related sustainability matters [39]. The initiative recognises that aligning with associations that champion these causes [105] is essential to achieve the goals of responsible and sustainable forestry [30]:

1. Partnerships with environmental NGOs within the framework of Forest 4.0 represent more than just surface-level cooperation; they signify a profound and shared commitment to ecological conservation [104]. These alliances are characterised by mutual commitment to ensure that Forest 4.0 technologies are not only developed but also implemented in a way that harmoniously aligns with the goals of biodiversity and habitat preservation [106]. This partnership transcends occasional consultations or surface-level engagement. Instead, it is an embedded and integral aspect of Forest 4.0's DNA and strategies [107]. Ecological considerations are to ensure that sustainability is not an afterthought but a core principle that guides every action and decision [108]. By actively

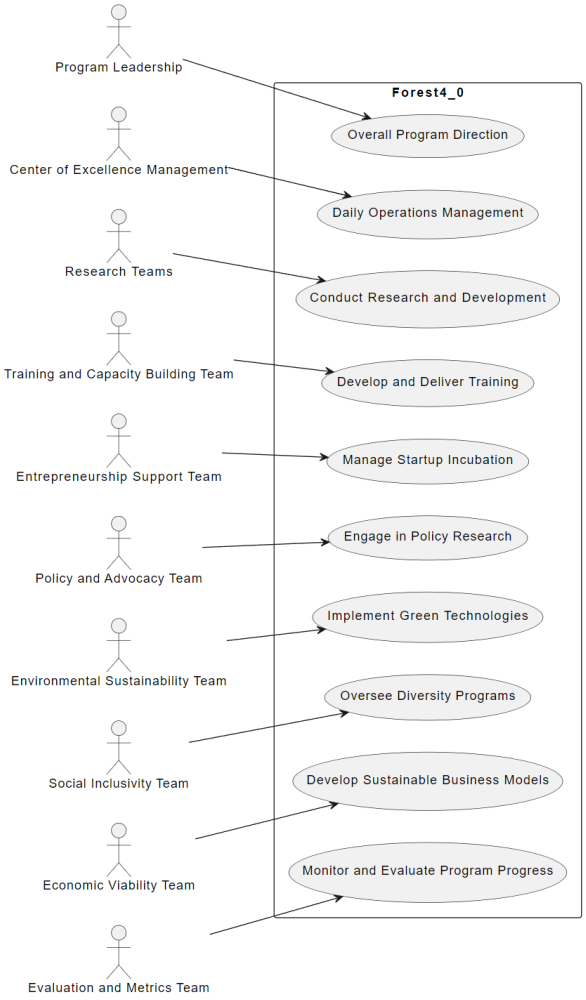

Figure 4: Model of responsibilities aligned with future CoE growth

partnering with environmental NGOs, Forest 4.0 demonstrates its unwavering commitment to responsible forestry management [109]. These alliances serve as powerful checks and balances, ensuring that the deployment of Forest 4.0 technologies actively contributes to the conservation and preservation of biodiversity [110]. This approach ensures that Forest 4.0's innovations are not only technologically advanced, but also environmentally responsible [111]. It fosters a future where forests and their ecosystems thrive in partnership with human innovation, rather than at its expense [112].

2. The formation of public-private partnerships with government agencies within the context of Forest 4.0 represents a paradigm shift from conventional interactions [113]. These strategic collaborations have the potential to act as a pivotal force, capable of seamlessly aligning Forest 4.0 objectives with national and regional policies [114]. In addition, they unlock the vital financial support potential that can be directed toward critical research and development initiatives [115], pilot projects [116], and policy advocacy efforts [117]. This collaborative approach goes beyond the standard concept of partnership; it represents a strategic alignment that actively shapes the regulatory and financial landscape in favour of sustainable forest management [118]. Working hand in hand with government agencies, Forest 4.0 ensures that its mission is not isolated, but firmly integrated

into larger policy frameworks [119]. Alignment of the Forest 4.0 objectives with national and regional policies signifies a commitment to achieving the sustainability goals at the systemic level [120]. These partnerships serve as channels for the dissemination of best practices, data-driven insights, and innovative technologies [121], fostering a holistic approach to forestry management that benefits both ecosystems and communities [122]. Furthermore, the financial support facilitated through these partnerships strengthens the initiative's ability to drive positive change [123] to undertake ambitious research projects, implement impactful pilot initiatives and advocate for policy reforms that are instrumental in promoting responsible forestry practices [124].

3. Collaborating with private companies and technology providers in the context of Forest 4.0 signifies a departure from the traditional vendor-client relationship [125]. Instead, it heralds a transformative partnership in which technology providers become active co-developers of Forest 4.0 tools [115]. This collaboration extends even further to include pilot testing [116], the provision of specialised hardware and software [121], and a shared commitment to tailoring innovations specifically for the forestry context [114]. Forest 4.0's collaboration with technology providers represents a dynamic ecosystem where innovation knows no bounds [113]. It goes beyond the realm of standard solutions [118], pushing the envelope of what technology can achieve in forestry operations [124]. This forward thinking approach ensures that the solutions developed are not only functional but perfectly attuned to the unique needs of the sector [119]. Through this deep partnership, technology providers actively participate in the co-creation of tools and solutions [117]. They harness their expertise to develop cutting-edge technologies that address the complex challenges of forest [122]. This collaboration does not mean providing standardised products, but rather a commitment to crafting customised innovations that revolutionise the industry [120]. The pilot testing phase within this collaboration prioritises the search for a real-world test ground, where Forest 4.0 solutions are rigorously tested and refined [123]. This iterative process ensures that the tools developed are not only technologically advanced but also practical, efficient, and effective within the forestry context [121].

4. Engaging with academic and research institutions within the Forest 4.0 framework transcends traditional partnership models [71]. Instead, these collaborations are envisioned as dynamic and evolving relationships that have the potential to catalyse groundbreaking research projects [126]. These initiatives are designed to promote the advancement of science and technology that underpin Forest 4.0, pushing the boundaries of what is possible in sustainable forestry [127]. This forward-thinking approach envisions an environment in which academia and industry actively co-create cutting-edge innovations [128]. It fosters a collaborative spirit in which researchers generate data-driven insights and validate emerging technologies in real-world forest environments [129]. This is not a one-off endeavour; it is a sustained partnership that continues to drive innovation forward [130]. This approach enriches the initiative with the latest scientific knowledge and empirical evidence, enhancing its ability to deliver practical and impactful solutions [131]. Moreover, these collaborations bridge the gap between academia and industry, fostering an ecosystem where the exchange of ideas, expertise, and resources is ongoing [132]. This symbiotic relationship between research institutions and Forest 4.0 leads to a constant cycle of learning, improvement, and innovation, benefiting not only

the initiative, but the entire forestry sector [133].

5. Recognising the global nature of forestry challenges [134] propels Forest 4.0 to participate in international networks. By actively participating in different international organisations, research networks and cross-border initiatives, Forest 4.0 expands its reach and amplifies its impact [135]. This approach envisions a global ecosystem where knowledge, resources, and expertise are shared without reservation to address the pressing challenges facing forests around the world [134]. International collaborations serve as a testament to Forest 4.0's commitment to global forestry stewardship [135]. These partnerships create a platform for the exchange of ideas and best practices, allowing the initiative to draw on a wealth of diverse perspectives and experiences [134]. Such collaborations enrich the solutions developed by Forest 4.0, ensuring that they are not only innovative but also globally relevant [135]. Furthermore, involvement with international organisations and initiatives positions Forest 4.0 as a leader in global efforts to sustain forestry sustainability [134]. It reinforces the role of the CoE as a catalyst for positive change, not only within the Baltic Sea region and Europe but on a global scale [135]. By sharing knowledge and expertise, Forest 4.0 contributes to a shared vision of responsible forestry management that transcends borders [134].

5.1 Environmental non-governmental organizations

Environmental non-governmental organizations (NGOs), such as Greenpeace or WWF, play a crucial role in advancing sustainable forestry practices and biodiversity conservation. These organisations offer a variety of support, including expertise, advocacy, and grassroots efforts for various forest-related projects, thus potentially the projects handled by the acceleration programme should be correlated with the responsible goals raised by these organizations as defined in Table 11.

In addition, the acceleration programme also aims to follow the main global organisations operating in the European Union that contribute to sustainable forest development, management and conservation, as defined in Table 12.

5.2 National and regional forestry and agriculture state agencies

National and regional forestry and agriculture state agencies are essential stakeholders as they have a direct role in implementing and regulating land use, including forestry practices. Key players from the Baltic Sea region are noted in Table 13.

5.3 Companies in the Forestry and Timber Industry in the Baltic Sea Region

The acceleration programme aims to identify key companies shaping the forest and timber industry in the Baltic Sea Region, selected based on their contributions to sustainable practices and technological advances, to offer a concise overview of the dynamic landscape within the Forestry sector when developing the CoE product portfolio. The review is structured per country. Lithuanian companies are represented in Table 14, Latvian in Table 15, Estonian in

Table 11: European Environmental NGOs

Organization	Details	Website
FERN	Addresses forest-related issues like deforestation, climate change, and sustainable development.	https://www.fern.org/
European Forest Institute (EFI)	Conducts research and provides policy support on forest-related matters.	https://efi.int/
BirdLife Europe and Central Asia	Actively engaged in biodiversity conservation, particularly in forest ecosystems.	https://www.birdlife.org/europe-and-central-asia
Friends of the Earth Europe	Comprises environmental organisations that address diverse issues, including forests.	https://www.foeeurope.org/
WWF European Policy Office	Part of the World Wide Fund for Nature, which works on environmental conservation globally, including forests.	https://www.wwf.eu/
ClientEarth	Specialises in legal actions to protect the environment, including those related to forests.	https://www.clientearth.org/
European Wilderness Society	Committed to the preservation and promotion of wilderness areas in Europe.	https://wilderness-society.org/
European Environmental Bureau (EEB)	Comprises environmental citizens' organisations that address various environmental issues, including forests.	https://eeb.org/
Pro Silva Europe	Advocates for forest practices close to nature in Europe.	https://prosilvaeurope.org/
European Landowners' Organisation (ELO)	Represents the interests of landowners, including those with forested lands.	https://www.europeanlandowners.org/
European Association of Environmental and Resource Economists (EAERE)	Backs research and policy discussions on environmental and resource economics, including forestry.	https://www.eaere.org/
European Wilderness Network	Aims to protect and preserve wilderness areas in Europe.	https://wilderness-society.org/european-wilderness-network/

Table 16, Swedish in Table 17, Finnish in Table 18, Polish in Table 19, German in Table 20 and Dannish in Table 21.

5.4 Research institutions in the Baltic Sea region based on their focus on forest-related topics (outside of project consortium).

This section aims to identify and link forestry related research institutions in the Baltic Sea region (not including consortium partners or related to consortium partners), as over the course of the acceleration, the participation of additional researchers is likely, considering the limited potential of the small Lithuanian research community. Table 22 summarises the relevant institutions in Lithuania, Table 23 summarises the institutions in Latvia, Table 24 summarizes institutions in Estonia, Table 25 summarizes institutions in Sweden, Table 26 summarizes institutions in Finland, Table 27 summarizes institutions in Poland, Table 28 summarizes institutions in Germany and Table 29 summarizes institutions in Denmark.

5.5 European research networks related to Forestry

Table 30 identifies relevant European research networks related to forestry, summarising the focus and activities of each network. It includes organisations such as the European Forest Institute (EFI), COST Actions supporting forestry research networks, and initiatives such as Forest Europe, which promotes sustainable forest management through political cooperation. The involvement of these networks can facilitate easy access to information for subjects in the acceleration programme interested in European forestry research collaborations.

Table 12: Global Environmental NGOs operating in EU

Organization	Focus/Mission	Website
World Wide Fund for Nature (WWF)	Works globally on biodiversity conservation, forest conservation, and sustainable development.	https://www.worldwildlife.org/
Greenpeace	Internationally recognised for campaigns on various environmental issues, including deforestation and forest protection.	https://www.greenpeace.org/
Friends of the Earth	An international coalition advocating for sustainable development, social justice, and environmental protection.	https://friendsoftheearth.uk/
Rainforest Foundation	Focused on protecting rainforests and the rights of indigenous peoples living in these areas.	https://rainforestfoundation.org/
Forest Stewardship Council (FSC)	International certification body promoting responsible forest management, often working in collaboration with NGOs on sustainable forestry initiatives.	https://www.fsc.org/
The Nature Conservancy	Works globally to protect ecologically important lands and waters, with efforts related to forest conservation and restoration.	https://www.nature.org/
BirdLife International	A global coalition of bird conservation organisations involved in habitat conservation, including forests.	https://www.birdlife.org/
Conservation International	Works to protect nature for the well-being of humanity, with projects focused on biodiversity conservation and sustainable development.	https://www.conservation.org/
Global Forest Watch	Provides real-time data and tools for monitoring and managing forests, supported by the World Resources Institute.	https://www.globalforestwatch.org/
International Union for Conservation of Nature (IUCN)	Works on biodiversity conservation and sustainable use of natural resources on a global scale.	https://www.iucn.org/

6 Summary: Impacts for the implementer

The implementation of the Forest 4.0 Acceleration Programme carries with it a range of potential impacts for the programme implementer, which are anticipated to shape the CoE future as the organisation matures (see Table 31).

First, the Forest 4.0 Acceleration Programme is set to elevate the implementer's standing in the forestry and sustainability sectors. With a proven track record of success in imparting cutting-edge knowledge and skills in sustainable forestry and Industry 4.0 technologies, the implementer is poised to become a respected authority. Reports, including the "Baltic Forestry Industry Outlook 2030" [136], foresee the programme shaping the industry's future, becoming a beacon for sustainable practices and technological advancements. This enhanced reputation, grounded in tangible achievements, is expected to yield concrete benefits. Forest sustainability communication [137] indicates that leading initiatives in knowledge dissemination attract attention and recognition, fostering collaboration opportunities with industry peers, government agencies and academic institutions. Visionary organisations, such as the International Council for Sustainable Forestry, anticipate that influential stakeholders will join forces to address challenges and drive innovation and policy development.

In terms of staff and talent, the implementer can anticipate attracting a cadre of high-calibre individuals who are ardently dedicated to sustainable forestry and technological advancements. This projection is supported by empirical data and insights from prestigious institutions in the field, for example, the report "Engineering Futures 2035" [138], which envisions such programmes as a paragon of educational and professional development. CoE is likely to attract experts, educators, and professionals from all over the world who will further contribute to the continued success of the programme, as research [139] indicates a growing desire among experts to participate in programmes recognised for their impact on the forestry industry. The influx of such talent is expected to have a multiplier effect on the programme,

Table 13: Forestry-related State Organizations in European Countries

Country	Organization	Website
Lithuania	State Forest Service (Valstybinė miškų tarnyba)	https://www.amvmt.lt/en/
Lithuania	Ministry of Agriculture (Žemės ūkio ministerija)	https://www.zum.lt/en/
Latvia	State Forests (Latvijas Valsts Meži)	https://www.lvm.lv/en/
Latvia	Ministry of Agriculture (Zemkopības ministrija)	https://www.zm.gov.lv/en/
Estonia	State Forest Management Center (RMK - Riigimetsa Majandamise Keskus)	https://www.rmk.ee/en
Estonia	Ministry of Rural Affairs (Maaeluministeerium)	https://www.agri.ee/en
Sweden	Swedish Forest Agency (Skogsstyrelsen)	https://www.skogsstyrelsen.se/en/
Sweden	Swedish Board of Agriculture (Jordbruksverket)	https://www.jordbruksverket.se/web/en
Finland	Finnish Forest Centre (Metsäkeskus)	https://www.metsakeskus.fi/en
Finland	Ministry of Agriculture and Forestry (MMM - Maa- ja metsätalousministeriö)	https://mmm.fi/en/frontpage
Poland	State Forests National Forest Holding (Lasy Państwowe)	https://www.lasy.gov.pl/en
Poland	Ministry of Agriculture and Rural Development (Ministerstwo Rolnictwa i Rozwoju Wsi)	https://www.gov.pl/web/agriculture-and-rural-development
Germany	Federal Ministry of Food and Agriculture (BMEL)	https://www.bmel.de/EN/Homepage/_node.html
Germany	Federal Agency for Agriculture and Food (BLE)	https://www.ble.de/EN/Homepage/_node.html
Denmark	Danish Nature Agency (Naturstyrelsen)	https://eng.naturstyrelsen.dk/
Denmark	Ministry of Environment and Food (Miljø- og Fødevareministeriet)	https://eng.mfvm.dk/

as these individuals are expected not only to contribute to the existing body of knowledge of the programme, but also to foster a culture of innovation, which, reinforced by these contributions, is expected to lead to the continuous refinement and innovation of the curriculum, as studies such as the US Forest Education [140] underline the need for programmes that adapt to changing industry needs. T

The programme's ability to produce a steady stream of skilled and knowledgeable graduating startups is anticipated to attract substantial investments from organisations keen on harnessing this talent pool. Reports underscore the increasing importance of a skilled workforce in a rapidly evolving industry landscape [141, 142]. This recognition is likely to encourage industry leaders to invest in the programme through strategic partnerships and sponsorships. The "Green Workforce" development initiatives [143] initiated by the International Green Economy Association envision a future where organisations actively seek out programmes that produce graduates adept in sustainable practices, positioning the implementer to tap into this revenue stream. Furthermore, since it consistently adds value to professionals' careers and increases their earning potential, studies like "Forestry Workforce Trends" [144] predict a surge in programme demand, resulting in potential additional income from participation fees towards the program's financial sustainability. Specialised educational initiatives [145], typically witness a steady rise in participation fees due to a growing recognition of their impact on professional income levels.

As the acceleration programme continues to foster a sustainable and technologically advanced approach to forestry, it will help the CoE align with the strategic objectives outlined in the "2030 Sustainable Development Agenda" by the United Nations [146, 147], which positions the forestry industry to address critical global challenges, including, among them, climate change and deforestation. Empirical evidence from the Intergovernmental Panel on Climate Change [148] underscores that sustainable forestry, as advocated by the programme,

plays a crucial role in carbon sequestration and mitigation of climate change, which is consistent with the report "The Future of Planted Forests" [149]. The benefits correlate with the study [150], which envisions a future where the integration of technology leads to greater ecological responsibility and efficiency in the forestry industry. The use of data-driven decision-making, automation, and remote sensing, as encouraged by the programme, has the potential to optimise resource utilisation and minimise environmental impact. As a result of these advancements, the implementer - CoE Forest 4.0 is expected to receive recognition for the positive environmental impact in promoting the acceleration of ecologically responsible and efficient projects, aimed at improving forest conservation and biodiversity preservation [151], translating forests into healthier ecosystems, reducing deforestation rates, etc. This enhanced reputation is expected to capitalise on the growing societal appreciation for environmentally responsible practices.

Table 14: Forestry-related companies and organizations in Lithuania

Company/Organization	Description	Website
Lithuanian State Forests	State-owned enterprise in Lithuania responsible for managing state forests. Emphasises sustainable practices.	https://www.lvm.lt/en/
UAB "IKEA Industry Lietuva"	IKEA Industry operates manufacturing facilities where they source wood and wood products from sustainably managed forests.	https://www.ikeaindustry.lt/
Lithuanian Wood Processors Association (LMPA)	Represents wood processing companies in Lithuania. Some members are involved in sustainable practices.	http://www.lmpa.lt/en/
UAB Juodeliai (Lithuania)	Lithuanian wood processing company specialising in the production of pallet wood elements. Involved in sustainable practices.	https://www.juodeliai.lt/en/
Skogssällskapet Baltic (Lithuania)	Lithuanian subsidiary of the Swedish Skogssällskapet, focussing on forest management and wood production.	http://www.silva.lt/en/
Lithuanian Biomass Energy Association (LITBIOMA)	Promotes the use of biomass resources, including wood, for energy production. Involved in sustainable practices.	https://www.litbioma.lt/en/
Lithuanian Wood Cluster (LWC)	Cluster organisation bringing together Lithuanian companies involved in the wood sector. Members collaborate on sustainable initiatives.	https://mediena.lt/en/
JSC Liepas	Lithuanian company specialising in wood processing, producing products such as flooring and wooden components.	https://www.liepas.lt/en/
UAB Radviliskio Mediena	Lithuanian company engaged in the production of sawn timber and wooden pallets. Emphasises sustainable forestry practices.	https://www.radviliskiomediena.lt/en/
UAB Klaipedos Mediena	Lithuanian company involved in the production of wooden pallets and lumber. Focus on sustainable sourcing.	https://www.klaipedosmediena.lt/en/
Lithuanian Forest Association	Represents forest owners and forestry professionals in Lithuania. Advocates for sustainable forest management.	https://www.miskai.lt/en/
UAB Radviliskio Slenis	Lithuanian company specialising in timber production and trading. Engaged in sustainable sourcing and practices.	https://www.radviliskioslenis.lt/en/
UAB Silava Baltic	Lithuanian company that offers various wood products, including sawn timber and pallet elements. Emphasises sustainable practices.	https://silavabaltic.lt/en/
UAB Grigiskiu Miskai	Lithuanian company involved in the production and trading of timber products. Focus on sustainable forestry practices.	https://grigiskiumiskai.lt/en/
Lithuanian Plywood Manufacturers Association (LPMA)	Represents plywood manufacturers in Lithuania. Some members are involved in sustainable practices.	http://www.fibc.ltkc.lt/en/
UAB Eurodrew	Lithuanian company engaged in the production and export of timber products, including sawn timber and pallets.	https://eurodrew.lt/en/
Lithuanian Wood Processors Association (LMPA)	Represents wood processing companies in Lithuania. Some members are involved in sustainable practices.	http://www.lmpa.lt/en/
UAB Navesco	Lithuanian company specialising in wood processing and manufacturing of products such as wooden pallets and packaging solutions.	https://navesco.lt/en/
UAB Inkeri	Lithuanian company producing wooden pallets and lumber. Consider sustainable practices.	https://inkeri.lt/en/
UAB Poldra	Lithuanian company engaged in timber production, offering products such as sawn timber and pallet elements. Focus on sustainable practices.	https://poldra.lt/en/

Table 15: Forestry-related companies and organizations in Latvia

Company/Organization	Description	Website
Latvijas Finieris (Latvia)	Latvian company specialising in plywood products from birch. Emphasises sustainable forestry practices.	https://www.finieris.com/
Latvijas Valsts Meži (Latvia)	Latvian state-owned company responsible for the management of state owned forests. Focusses on sustainable forest management.	https://www.lvm.lv/en/
Latvijas Mežrupniecība (Latvia)	Latvian company involved in forestry and the management of state-owned forests. Engage in sustainable forest management practices.	https://www.lmrp.lv/
IKEA Industry Latvia (Latvia)	Part of the IKEA Group, operates manufacturing facilities, including in Latvia. Sources timber and wood products from sustainably managed forests.	https://www.ikeaindustry.lv/
Latvian State Forests (Latvia)	State-owned enterprise responsible for managing state-owned forests in Latvia. Often, sustainable forestry is emphasised.	https://www.lvm.lv/en/
Latvian Forest Company (Latvia)	Involved in forestry and timber production. Focus on sustainable practices.	https://www.lkf.lv/
Kronospan (Latvia)	Global wood-based panel manufacturer with operations in Latvia. Involved in sustainable sourcing and wood processing.	https://www.kronospan-worldwide.com/
Latvian Wood Exporters Association (LWEA)	Represents Latvian companies engaged in the timber and wood processing industry. Focus on sustainable practices.	https://www.lwea.lv/en/
Latvian Timber Exporters Association (LTEA)	Represents Latvian companies engaged in the export of timber and wood products. Some members adhere to sustainable forestry practices.	https://www.timberexporters.lv/en/
Latvian Wood Construction Cluster (LWCC)	Represents Latvian companies engaged in wooden construction. Some members prioritise sustainable and environmentally friendly building practices.	https://www.latvianwood.lv/en/
Latvian Woodworking Companies Cluster (LWCC)	Includes Latvian companies in the woodworking industry. Some members focus on sustainable practices.	https://www.latvianwood.lv/en/
Association of Latvian Forest Industry (LFIA)	Represses Latvian Forest Industry Companies. Some members are involved in sustainable practices.	https://www.lfia.lv/en/
Vika Wood (Latvia)	Latvian company producing wooden components for various industries. Emphasis on sustainable sourcing and production.	https://vikawood.lv/
Latvian Timber Industry Federation (Latvijas Koks)	Federation represents Latvian timber industry companies. Some members are involved in sustainable practices.	https://latvijaskoks.lv/

Table 16: Forestry-related companies and organizations in Estonia

Company/Organization	Description	Website
Estonian Cell (Estonia)	Estonian company producing wood pulp. Focusses on sustainable and environmentally friendly production.	https://www.estoniancell.ee/
Forest Management Ltd. (Estonia)	Estonian company providing forest management services, including sustainable forestry practices.	
Silva Timber (Estonia)	Estonian company specialising in timber and wood products. Focus on sustainable sourcing and environmentally friendly practices.	https://www.silvatimber.ee/
Baltic Forest (Estonia)	Estonian company involved in timber trading and forestry services. Engaged in sustainable forest management.	https://www.balticforest.ee/
Metsä Wood (Estonia)	Part of the Metsä Group, operates in wood products, focusing on sustainable and eco-friendly solutions.	https://www.metsawood.com/
Estonian State Forest Management Centre (RMK)	State-owned company in Estonia responsible for the sustainable management of state forests and the promotion of nature-based tourism.	https://www.rmk.ee/en
Estonian Wooden Houses Cluster (Estonia)	Cluster includes companies involved in the production of wooden houses and structures. Promote sustainable and environmentally friendly building practices.	https://www.puitmajaliit.eu/en/
Estonian Woodhouse Association (EWA)	Represents Estonian companies involved in the construction of wooden houses. Prioritise sustainability in their practices.	https://www.puitmajaliit.eu/en/
Estonian Private Forest Centre (ERIA)	Provides support and services to private forest owners in Estonia, promoting sustainable forest management.	
Estonian Wooden Houses Cluster (Eesti Puitmajaklaster)	Cluster organisation in Estonia bringing together companies involved in the construction of wooden houses. Prioritise sustainable practices.	https://www.puitmajaliit.eu/en/
Estonian Rural Tourism (Eesti Maaturism)	Organisation promoting rural and eco-friendly tourism in Estonia, including activities related to forests.	https://www.maaturism.ee/en/
Silvapastor (Estonia)	Estonian company combining forestry with agroforestry practices, integrating tree cultivation with pasture. Focus on sustainable land use.	https://silvapastor.eu/

Table 17: Forestry-related companies and organizations in Sweden

Company/Organization	Description	Website
Södra	Swedish cooperative of forest owners operating in the forestry, wood products, and pulp industries. Emphasises sustainable forestry practices and responsible sourcing.	https://www.sodra.com/
SCA	Swedish company operating in the forestry, wood products, pulp and paper industries. Committed to sustainable forest management.	https://www.sca.com/
Holmen AB	Swedish forest industry company with operations in paperboard, paper, wood products, and renewable energy. Committed to sustainable forestry.	https://www.holmen.com/
Sveaskog	Swedish state-owned company responsible for sustainable forestry and the management of state-owned forest land.	
Swedish Wood	Organisation representing the Swedish sawmill industry. Promotes the use of Swedish wood and emphasises sustainability.	https://www.swedishwood.com/
Skogssällskapet	Swedish forestry company offering various services related to forest management and wood production. Focus on sustainable practices.	https://www.skogssallskapet.se/en/
Swedish Forest Industries Federation (Skogsindustrierna)	Represents the Swedish forest industry, including companies involved in pulp, paper, and timber production. Some members prioritise sustainability.	https://www.skogsindustrierna.org/en/
SCA Timber AB	Division of the SCA Group operating in wood products, focussing on sustainable and responsible forestry.	https://www.sca.com/timber/
Setra Group AB	Swedish wood products company specialising in sawn timber. Emphasises sustainable forestry practices.	https://www.setragroup.com/
BillerudKorsnäs AB	Swedish packaging company with a focus on sustainable and renewable materials, including wood fibers.	https://www.billerudkorsnas.com/
Rörvik Timber AB	Swedish company producing sawn timber and related wood products. Engaged in sustainable practices.	https://www.rorviktimber.com/
Mölnlycke Skog AB	Swedish forest management company providing services to private forest owners. Promotes sustainable forestry practices.	https://www.molnlyckeskog.se/
Swedish Forest Agency (Skogsstyrelsen)	Government agency responsible for forestry policy and implementation. Provides guidance on sustainable forestry practices.	https://www.skogsstyrelsen.se/en/
Svenska Cellulosa Aktiebolaget (SCA)	Swedish multinational company operating in the forestry, paper, and wood products. Emphasises sustainability in its operations.	https://www.sca.com/
Vida Group AB	Swedish company operating in the forest industry, with activities including sawmills and bioenergy. Focus on sustainable forestry practices.	https://www.vida.se/
Bergs Timber AB	Swedish company engaged in wood processing, including sawmilling and planing. Involved in sustainable practices.	https://www.bergstimber.com/
LRF Skogsägarna	Swedish organisation representing forest owners. Provide support and information related to sustainable forestry.	https://www.lrf.se/lrfkonsult/privat/jag-ar-skogsagare/
Ecohelix AB	Swedish company specialising in sustainable forest management and consulting services.	https://www.ecohelix.com/
IKEA Industry AB	Operates manufacturing facilities, including in Sweden, where they source timber and wood products from sustainably managed forests.	https://www.ikeaindustry.com/
Sveaskog AB	Swedish state-owned company responsible for sustainable forest management and the management of state-owned forest land.	https://www.sveaskog.se/english
Möre Skogsekonomi AB	Swedish forest management company providing services related to forestry and sustainable land use.	https://www.moreskog.se/
Kronobergs Läns Skogsägarförening (KLSF)	Regional association in Sweden representing forest owners. Involved in promoting sustainable forestry practices.	https://www.kronobergskog.se/
Höglandets Trävaror AB	Swedish company engaged in the production of sawn timber. Focus on sustainable wood processing.	http://www.htv.se/

Table 18: Forestry-related companies and organizations in Finland

Company/Organization	Description	Website
UPM-Kymmene Corporation	Operates in the forest industry, including paper, pulp, and timber products. Actively involved in sustainable forestry practices.	
Stora Enso (Finland/Sweden)	Leading provider of renewable solutions in packaging, biomaterials, wooden constructions, and paper. Emphasise sustainable forest management and responsible business practices.	
Metsä Group	Finnish forest industry group operating in wood products, pulp, paperboard, and tissue paper. Focusses on sustainable and responsible forestry.	
Tornator	Forest management company that owns and manages forest estates. Focus on sustainable forest management.	https://www.tornator.fi/
Puu-Bio Oy	Involved in the production of wood pellets and renewable energy solutions. Committed to sustainable practices.	https://www.puubio.fi/
Metsähallitus	Finnish state enterprise responsible for managing state-owned lands, including forests. Involved in sustainable forestry practices.	https://www.metsa.fi/en
Finnish Forest Centre (Metsäkeskus)	Responsible for promoting sustainable forestry practices and providing information and services related to forests in Finland.	https://www.metsakeskus.fi/en
Finnish Sawmills Association	Represents companies in Finland engaged in sawmilling and wood processing. Some members focus on sustainable practices.	https://www.sahateollisuus.com/en

Table 19: Forestry related companies and organizations in Poland

Company/Organisation	Description	Website
Paged Sklejka S.A.	A leading plywood manufacturer in Poland, specialising in high-quality wood products.	https://www.pagedsklejka.pl/en/
IKEA Industry Poland	Part of the global IKEA Group, a major player in the production of wooden furniture and components.	https://www.ikea-industry.pl/en
Barlinek S.A.	Renowned for expertise in manufacturing high-end wood flooring.	https://www.barlinek.com/en
Paged Meble S.A.	Furniture manufacturer with a focus on innovative and stylish designs.	https://pagedmeble.pl/en/
Boryszew S.A.	A diversified industrial group with interests in various sectors, including the wood industry.	https://boryszew.com.pl/en/
Stora Enso	A global renewable materials company involved in the production of packaging, biomaterials, and wood products.	https://www.storaenso.com/
International Paper Kwidzyn S.A.	Operating as part of International Paper, a key player in the paper and packaging industry.	https://www.internationalpaper.com/
Polnord S.A.	A real estate development company involved in residential and commercial projects.	https://www.polnord.pl/en/
Zakłady Przemysłu Drzewnego "Drewnex" S.A.	Specialises in the production of wooden packaging materials and pallets.	https://drewnex.com.pl/en/
Kronopol Sp. z o.o.	A major manufacturer of wood-based panels known for its diverse product range.	https://www.kronopol.pl/en
Eurocash Group	Involved in wholesale distribution, a significant player in the FMCG (Fast-Moving Consumer Goods) sector.	https://www.eurocash.pl/
Agrofirma Łomianki S.A.	An agricultural company engaged in crop cultivation, including forestry and wood production.	https://agrofirmalomianki.pl/en/
Green-woods Group	Involved in sustainable forestry and wood processing, focusing on environmentally friendly practices.	http://www.green-woods.eu/en/
Adal Sp. z o.o.	Known for its expertise in timber trading, processing, and wood products distribution.	https://www.adal.pl/en/
Meble Wójcik S.A.	A furniture manufacturer with a wide range of products, focussing on modern design and quality craftsmanship.	https://meblewojcik.pl/en/
Mokate Group	Specialising in coffee production, using sustainable practices and involved in the timber industry.	https://www.mokate.com/
Wood-Mizer	A leading manufacturer of portable sawmills and wood processing equipment.	https://woodmizer.eu/
Drutex S.A.	A prominent manufacturer of windows and doors, utilising wood and other materials.	https://www.drutex.eu/en/
Ostrowski Design S.A.	Known for furniture and interior design solutions, combining craftsmanship with contemporary style.	https://ostrowskidesign.pl/en/
Lesaffre Polska S.A.	Part of the Lesaffre Group, focussing on yeast and fermentation products, with potential applications in the wood industry.	https://www.lesaffre.pl/

Table 20: Forestry-related companies and organizations in Germany

Company/Organisation	Description	Website
Bavarian State Forests	Major forestry organisation in Germany, managing state-owned forests in Bavaria. Focus on sustainable forest management and wood production.	https://www.baysf.de/
Stihl	German manufacturer of chainsaws and handheld power equipment, including tools used in forestry. Known for providing equipment for forestry professionals.	https://www.stihl.com/
German Timber Industry Federation	Represents the interests of the timber industry in Germany. Works towards promoting sustainable forestry and responsible wood processing.	https://www.holzindustrie.de/
Pfeifer Group	Involved in wood processing, producing timber products. Emphasis on sustainable forest management and responsible wood production.	https://www.pfeifergroup.com/
Deutsche Forst Service GmbH (DFS)	Company providing forestry services, including forest management and timber harvesting. Focus on sustainable forestry practices.	https://www.deutsche-forstservice.de/
Sappi Europe	Leading producer of paper and packaging materials, using wood fibers from sustainably managed forests. Emphasises responsible forestry and sustainable paper production.	https://www.sappi.com/
EGGER Group	Wood-based materials manufacturer, producing products such as particleboard and laminate flooring. Focus on sustainable wood sourcing and responsible production.	https://www.egger.com/
Hettich Forst- und Landtechnik	Company providing forestry and land technology solutions, including equipment for wood processing. Offers products aligned with sustainable forestry practices.	https://www.hettich-forest.de/
Rettenmeier Holding AG	Leading wood processing company, specialising in timber products. Emphasis on sustainable forestry and responsible wood processing.	https://www.rettenmeier.com/
Binderholz GmbH	European wood processing company, producing products like solid wood panels and glulam. Focus on sustainable wood sourcing and responsible production.	https://www.binderholz.com/
Holzindustrie Schweighofer	Timber processing company, specialising in products such as lumber and engineered wood. Emphasis on sustainable wood sourcing and responsible forestry.	https://www.schweighofer.at/en/
DREWAG - Stadtwerke Dresden GmbH	German utility company, potentially involved in sustainable forestry practices related to energy production. Initiatives supporting responsible wood use.	https://www.drewag.de/
Kronospan Group	Global wood-based panel manufacturer, potentially involved in sustainable wood sourcing and processing. Produces products such as particleboard and MDF.	https://www.kronospan-worldwide.com/
Fagus-GreCon Greten GmbH & Co. KG	Company providing solutions for wood processing and fire protection in the timber industry. Offers products aligned with sustainable and safe wood processing practices.	https://www.fagus-grecon.com/en/

Table 21: Forestry-related companies and organizations in Denmark

Company/Organization	Description	Website
Danish Timber	Operates in the timber industry, specialising in the production of wood products. Emphasis on sustainable forest practices.	https://www.danishtmber.dk/
Dalhoff Larsen & Horneman A/S	Danish company involved in timber trading and distribution. Focus on sustainable sourcing and wood processing.	https://www.dlh-group.com/
Danske Trælast A/S	Specialises in the wholesale distribution of timber and wood products. Involved in sustainable practices.	https://www.dansketraelast.dk/
DLH Group	Operates in the timber industry, focussing on distribution and trading. Emphasis on sustainable forestry practices.	https://www.dlh-group.com/
Tembec Denmark A/S	Involved in the production and distribution of wood products. Focus on sustainable sourcing and responsible business practices.	https://www.tembec.com/
Junckers Industrier A/S	Leading Danish company specialising in the production of solid hardwood flooring. Emphasis on sustainable forestry practices.	https://www.junckers.com/
Dansk Træemballage A/S	Engaged in the production of wooden packaging materials and pallets. Involved in sustainable practices.	https://www.dastraemballage.dk/
Keflico A/S	Involved in the import, processing and distribution of timber and wood products. Focus on sustainable sourcing and wood processing.	https://www.keflico.com/
Troldtekt A/S	Specialises in wood wool acoustic panels for ceiling and wall applications. Emphasises sustainable forestry practices.	https://www.troldtekt.com/
ScanCom International A/S	Known for manufacturing outdoor furniture using responsibly sourced wood. Focus on sustainable and eco-friendly practices.	https://www.scancom.net/
L.H. Woodhouse A/S	Engaged in the wholesale distribution of timber and wood products. Involved in sustainable practices.	https://l-h.dk/
Pluspack A/S	Specialises in the production of packaging solutions, including wooden packaging. Emphasises sustainable and eco-friendly practices.	https://pluspack.com/
Stenvad Mosebrug A/S	Involved in peat extraction and wood-related products. Has considerations for sustainable practices.	https://stenvad.dk/
Kastrup Traeindustri A/S	Specialises in wood processing and manufacturing of wood products. Engaged in sustainable practices.	https://www.kastruptrae.dk/
Bygholm Sildematerialer A/S	Involved in the production of wooden materials for the horticultural industry. Focus on sustainable sourcing and production.	https://bygholm.dk/

Table 22: Research Organizations Related to Forestry in Lithuania

Research Organization	Description of Activities Related to Forestry	Website
Lithuanian Research Centre for Agriculture and Forestry	Conducts research related to agriculture and forestry. Location: Lithuania.	https://www.lammc.lt/en/
Klaipėda University - Coastal Research and Planning Institute	Engaged in coastal research and planning activities, including aspects related to forestry. Location: Lithuania.	https://www.ku.lt/cem/

Table 23: Research Organizations Related to Forestry in Latvia

Research Organization	Description of Activities Related to Forestry	Website
Latvian State Forest Research Institute "Silava"	Conducts research in the field of forestry. Location: Latvia.	https://www.silava.lv/
University of Latvia - Faculty of Biology	Engaged in biological research, including forestry-related studies. Location: Latvia.	https://www.lu.lv/eng/faculties/faculty-of-biology/
Latvian State Institute of Wood Chemistry	Focusses on research related to wood chemistry. Location: Latvia.	http://www.kki.lv/en/

Table 24: Research Organizations Related to Forestry in Estonia

Research Organization	Description of Activities Related to Forestry	Website
University of Tartu - Institute of Ecology and Earth Sciences	Conducts research in ecology and earth sciences, including forestry-related studies. Location: Estonia.	https://www.ut.ee/en/institute-ecology-and-earth-sciences
Estonian University of Life Sciences - Institute of Forestry and Rural Engineering	Engaged in forestry and rural engineering research. Location: Estonia.	https://estis.ut.ee/en
Estonian University of Life Sciences - Institute of Agricultural and Environmental Sciences	Focusses on agricultural and environmental sciences research, including forestry. Location: Estonia.	https://pk.emu.ee/en/
Tallinn University - School of Natural Sciences and Health	Offers programmes in natural sciences, including forestry-related studies. Location: Estonia.	https://www.tlu.ee/en/structure/school-natural-sciences-and-health

Table 25: Research Organizations Related to Forestry in Sweden

Research Organization	Description of Activities Related to Forestry	Website
Sveriges lantbruksuniversitet (SLU) - Swedish University of Agricultural Sciences (Alnarp Campus)	SLU's Alnarp Campus, focusses on various agricultural and environmental sciences, including forestry.	https://www.slu.se/en/about-slu/campuses/
Lund University - Faculty of Science, Centre for Environmental and Climate Research (CEC)	Lund University's CEC, engages in environmental and climate research, with potential relevance to forestry.	https://www.cec.lu.se/
Swedish University of Agricultural Sciences (SLU)	SLU's Department of Forest Ecology and Management is dedicated to forestry-related research and education.	https://www.slu.se/en/departments/forest-ecology-management/

Table 26: Research Organizations Related to Forestry in Finland

Research Organization	Description of Activities Related to Forestry	Website
University of Helsinki - Department of Forest Sciences	The Department of Forest Sciences at the University of Helsinki, is actively involved in research and education in the field of forestry.	https://www.helsinki.fi/en/forest-sciences
University of Eastern Finland - School of Forest Sciences	The School of Forest Sciences at the University of Eastern Finland, specialises in various aspects of forest sciences and related research.	https://www.uef.fi/en/silva
Finnish Forest Research Institute (Metla) - part of Natural Resources Institute Finland (Luke)	The Finnish Forest Research Institute (formerly Metla) is part of Natural Resources Institute Finland (Luke), focussing on multidisciplinary research related to natural resources, including forestry.	https://www.luke.fi/

Table 27: Research Organizations Related to Forestry in Poland

Research Organization	Description of Activities Related to Forestry	Website
Institute of Dendrology, Polish Academy of Sciences	The Institute of Dendrology, part of the Polish Academy of Sciences, is involved in dendrological research, including the study of trees and woody plants.	http://www.idpan.poznan.pl/
University of Gdańsk - Faculty of Biology	The Faculty of Biology at the University of Gdańsk in Poland conducts research in various biological disciplines, including forestry and environmental biology.	https://www.bioinf.ug.edu.pl/en/
University of Warmia and Mazury in Olsztyn - Faculty of Environmental Management and Agriculture	The Faculty of Environmental Management and Agriculture of the University of Warmia and Mazury in Olsztyn, Poland, is engaged in research related to environmental management and agriculture, including forestry.	http://www.uwm.edu.pl/en/

Table 28: Research Organizations Related to Forestry in Germany

Research Organization	Description of Activities Related to Forestry	Website
Leibniz Centre for Agricultural Landscape Research (ZALF)	ZALF, located close to the Baltic Sea, focusses on landscape biogeochemistry and research related to agricultural landscapes.	https://www.zalf.de/en/institutes-departments/ilb
Helmholtz Centre for Environmental Research - UFZ	UFZ, situated near the Baltic Sea, is involved in landscape ecology research with implications for environmental and forestry studies.	https://www.ufz.de/index.php?en=37416
Thünen Institute of Forest Ecosystems	The Thünen Institute conducts research on sustainable forest management, forest ecology, and ecosystem services.	https://www.thuenen.de/en/fe/
Max Planck Institute for Biogeochemistry	MPI-BGC focusses on understanding biogeochemical cycles in ecosystems, including forest ecosystems and their response to environmental changes.	https://www.bgc-jena.mpg.de/

Table 29: Research Organizations Related to Forestry in Denmark

Research Organization	Description of Activities Related to Forestry	Website
University of Copenhagen - Department of Geosciences and Natural Resource Management	The Department of Geosciences and Natural Resource Management at the University of Copenhagen is involved in research related to natural resources, including forestry.	https://ign.ku.dk/english/
Aarhus University - Department of Environmental Science	The Department of Environmental Science at Aarhus University conducts research in environmental sciences, with relevance to forestry and ecosystems.	https://envs.au.dk/en/
Aarhus University - Department of Bioscience	The Department of Bioscience at Aarhus University engages in research in various biological disciplines, including aspects related to forestry.	https://bios.au.dk/en/
Forest and Landscape College (Skovskolen), University of Copenhagen	The Forest and Landscape College at the University of Copenhagen focusses on education and research in forestry and landscape management.	https://ign.ku.dk/english/education/forest-and-landscape-college/

Table 30: European Research Networks Related to Forestry

Research Network	Description of Activities Related to Forestry	Website
European Forest Institute (EFI)	EFI is an international organisation with various research programmes and projects addressing key challenges in forestry, including sustainable forest management.	https://efi.int/
COST Actions - European Cooperation in Science and Technology	COST supports research networks across Europe. Several COST Actions focus on forestry-related topics, fostering collaboration and knowledge exchange.	https://www.cost.eu/actions/
Forest Europe - Ministerial Conference on the Protection of Forests in Europe	Forest Europe is a high-level political process that fosters cooperation in sustainable forest management. Provides a platform for dialogue and collaboration among European countries.	https://foresteurope.org/
European Forest Genetic Resources Programme (EUFORGEN)	EUFORGEN focusses on the conservation and sustainable use of forest genetic resources. It collaborates with various stakeholders to enhance the resilience of European forests.	https://www.euforgen.org/
Integrate Network	Integrate promotes integrated forest management, considering ecological, social and economic aspects. Facilitates knowledge exchange and supports the implementation of integrated forest practices.	https://www.integrate-network.org/
European Network INTEGRAL	INTEGRAL focuses on the integration of nature protection, biodiversity conservation, and sustainable forestry in European landscapes.	https://www.integralforest.eu/
European Forest Risk Facility (EFRF)	EFRF addresses forest-related risks and disturbances, including pests, diseases and extreme weather events. Promotes collaborative research and risk management strategies.	https://efufire.efi.int/
European Landowners' Organisation (ELO)	ELO represents landowners and forest owners in Europe. It participates in policy discussions, research, and initiatives related to sustainable land use and forestry.	https://www.europeanlandowners.org/
European Agroforestry Federation (EURAF)	EURAF promotes agroforestry practices in Europe, bringing together researchers, practitioners and policymakers to improve the sustainable integration of trees and agriculture.	https://www.agroforestry.eu/
European Forest Institute's Young Researchers' Network (EFINORD)	EFINORD provides a platform for young researchers in the field of forestry to connect, collaborate, and exchange ideas. It supports the professional development of early career scientists.	https://efinord.efi.int/

Table 31: Potential Impacts of Forest 4.0 Acceleration Programme

Impact	Evaluation
Enhanced Reputation	The programme is expected to elevate the implementer's standing in the forestry and sustainability sectors. It is likely to become a respected authority, attracting attention, recognition, and collaboration opportunities from industry peers, government agencies, and academic institutions.
Financial Rewards	The programme is projected to produce substantial financial rewards due to increased demand, higher participation fees, and investments from organisations interested in the talent pool it produces.
Societal and Environmental Benefits	The programme's focus on sustainable forestry and Industry 4.0 technologies aligns with global sustainability goals, contributing to carbon sequestration, climate change mitigation, and more responsible forestry practices. This leads to healthier ecosystems, improved water quality, and reduced rates of deforestation, which improves goodwill for the implementer.
Attracting High-calibre Talent	The programme's excellence and international recognition are expected to attract experts, educators and professionals dedicated to sustainable forestry and technological advancements. This influx of talent will contribute to the ongoing refinement and innovation of the curriculum.
Enhancing Competences	Implementer can gain a holistic experience informed by real-world experience and practical insights, combining theoretical knowledge with practical application not possible in typical academic environments.
Sustaining and Scaling Challenges	The implementer will receive a benefit related to challenges related to managing a larger participant base, maintaining high standards, upgrading facilities and technological infrastructure, and adapting to evolving industry practices.

References

[1] E. C. Lefroy. Forests as a sacred place in western mythology. *Australian Forest Grower*, 29:14–16, 2007.

[2] Y. Park. Conifer somatic embryogenesis and multi-varietal forestry. In *Proceedings of the International Conference on Forestry*, pages 425–439, 2014.

[3] J. Ying. The impact of the entrance of wto on forestry in our country. *Forest Inventory and Planning*, 2006.

[4] A. A. Morozov, G. Kozyreva, and T. Morozova. Social responsibility of business at the enterprises of the forest industry. *E3S Web of Conferences*, 2021.

[5] A. Yoshimoto and K. Yukutake. Global concerns for forest resource utilization. 1999.

[6] L. Naidoo and Mihalis Chasomeris. Wood chip exports and the challenges faced by private pulpwood farmers in southern kwazulu-natal. *Journal of Economic and Financial Sciences*, 6:109–128, 2013.

[7] N. Matoba. Energy governance: Mainstreaming energy policy for local sustainability. *Depopulation, Deindustrialisation and Disasters*, 2019.

[8] M. Hanewinkel and J. Peyron. Tackling climate change—the contribution of scientific knowledge in forestry. *Annals of Forest Science*, 71:113–115, 2014.

[9] P. Mederski, S. A. Borz, Andreja Đuka, and A. Lazdiņš. Challenges in forestry and forest engineering. *Croatian Journal of Forest Engineering*, 42:117–134, 2021.

[10] M. Hunt. Towards precision forestry. *Australian Forest Grower*, 32:39–40, 2009.

[11] G. Pajares, A. Peruzzi, and P. Santos. Sensors in agriculture and forestry. *Sensors*, 13:12132–12139, 2013.

[12] C. Corona, C. Chianucci, Q. Quatrini, C. Civitarese, C. Clementel, C. Costa, F. Floris, M. Menesatti, P. Puletti, S. Sperandio, T. Verani, T. Turco, B. Bernardini, P. Plutino, and S. Scrinzi. Precision forestry: riferimenti concettuali, strumenti e prospettive di diffusione in italia. *Journal of Silviculture and Forest Ecology*, 14:1–12, 2017.

[13] Most Jannatul Fardusi, F. Chianucci, and A. Barbati. Concept to practice of geospatial-information tools to assist forest management and planning under precision forestry framework: a review. *Annals of Silvicultural Research*, 41:3–14, 2017.

[14] M. Ramantswana, R. Spinelli, M. Brink, and K. Little. A forecast of future silviculture re-establishment technologies in plantation forestry. *Scientia Forestalis*, 2021.

[15] V. Yachmeneva, A. A. Antonova, and I. Pozharitskaya. Precise technologies in forestry: problems and prospects. *IOP Conference Series: Earth and Environmental Science*, 574, 2020.

[16] Yan Feng and J. Audy. Forestry 4.0: a framework for the forest supply chain toward industry 4.0. *Gestão & Produção*, 2020.

[17] R. Sahal, S. Alsamhi, J. Breslin, and M. Ali. Industry 4.0 towards forestry 4.0: Fire detection use case. *Sensors*, 21, 2021.

[18] Zhaoyuan He and Paul Turner. A systematic review on technologies and industry 4.0 in the forest supply chain: A framework identifying challenges and opportunities. *Logistics*, 2021.

[19] Fabian Müller, D. Jaeger, and M. Hanewinkel. Digitization in wood supply - a review on how industry 4.0 will change the forest value chain. *Comput. Electron. Agric.*, 162:206–218, 2019.

[20] M. Vasenev. Decision support systems utilization in forestry: Environmental aspect. *Vestnik NSU. Series: Information Technologies*, 2022.

[21] Geoffrey Spencer and P. Torres. New can bus communication modules for digitizing forest machines functionalities in the context of forestry 4.0. *IEEE Access*, 11:9058–9066, 2023.

[22] Carlos Medina Tello, Pablito Marcelo López Serrano, Víctor Rocha Ramírez, Andrés Torres Miranda, and María Dolores Uribe Salas. Experiencia educativa de drones en silvicultura 4.0, competencias específicas del profesional forestal. *E-CUCBA*, 2021.

[23] Jamal Maktoubian, M. Taskhiri, and P. Turner. Intelligent predictive maintenance (ipdm) in forestry: A review of challenges and opportunities. *Forests*, 2021.

[24] K. Macdicken, G. Reams, and J. Freitas. Introduction to the changes in global forest resources from 1990 to 2015. *Forest Ecology and Management*, 352:1–2, 2015.

[25] E. Hovenga and H. Grain. Preface. *IOP Conference Series: Earth and Environmental Science*, 359, 2019.

[26] Martin Forsius, Anu Akujärvi, Tuija Mattsson, Maria Holmberg, Pekka Punttila, Maximilian Posch, Jari Liski, Anna Repo, Raimo Virkkala, and Petteri Vihervaara. Modelling impacts of forest bioenergy use on ecosystem sustainability: Lammi lter region, southern finland. *Ecological Indicators*, 65:66–75, 2016.

[27] K. M. Asim, S. Moustafa, I. A. Niaz, Eslam A. Elawadi, T. Iqbal, and F. Martínez-Álvarez. Seismicity analysis and machine learning models for short-term low magnitude seismic activity predictions in cyprus. *Soil Dynamics and Earthquake Engineering*, 130:105932, 2020.

[28] Se-IK Park, Hyunsoo Kim, Hee-Jung Park, S. Lim, Hyun-Jun Kim, and Sang-Hyun Lee. Scheduling of timber production and economic analysis of pinus densiflora and quercus species for sustainable management in private forest in korea: focused on jinan-gun. *Forest Science and Technology*, 14:55–60, 2018.

[29] KTH. Kth incubator. https://www.kth.se/en/om/innovation/program-extra-stod/forinkubator-program/kth-innovations-forinkubatorprogram-1.414438.

[30] Lei Zhang et al. Where should china practice forestry in a warming world? *Global Change Biology*, 2021.

[31] G. Santopuoli et al. Pan-european sustainable forest management indicators for assessing climate-smart forestry in europe. *Canadian Journal of Forest Research*, 2020.

[32] G. Ceccherini et al. Abrupt increase in harvested forest area over europe after 2015. *Nature*, 2020.

[33] B. Nero et al. Structure, diversity, and carbon stocks of the tree community of kumasi, ghana. *Forests*, 2018.

[34] Dalibor Šafařík, Petra Hlaváčková, and Jakub Michal. Potential of forest biomass resources for renewable energy production in the czech republic. *Energies*, 15(1):47, 2021.

[35] Shanshan Wang et al. From carbon neutral to climate neutral: Dynamic life cycle assessment for wood-based panels produced in china. *Journal of Industrial Ecology*, 2022.

[36] Fabio A. R. Matos, Luiz F. S. Magnago, Carlos Aquila Chan Miranda, Luis F. T. de Menezes, Markus Gastauer, Nathália V. H. Safar, Carlos E. G. R. Schaefer, Mônica P. da Silva, Marcelo Simonelli, Felicity A. Edwards, Sebastião V. Martins, João A. A. Meira-Neto, and David P. Edwards. Secondary forest fragments offer important carbon and biodiversity cobenefits. *Global Change Biology*, 26(2):509–522, November 2019.

[37] Huijie Li et al. Managing risks arising from conservation complexities of forests: Insights from china's "chief scheme" practice. *Sustainability*, 2022.

[38] Tang Yiqie et al. Establishment of performance evaluation index system of forestry carbon sink project based on ahp method. 2021.

[39] K. Böhling and Maria Fernanda Marques Todeschini. The forest sector in the 2030 eu climate policy framework: Looking back to assess its future. *Journal for European Environmental & Planning Law*, 2021.

[40] Andreas Holzinger et al. Digital transformation in smart farm and forest operations needs human-centered ai: Challenges and future directions. *Sensors*, 2022.

[41] Riccardo Dainelli et al. Recent advances in unmanned aerial vehicle forest remote sensing—a systematic review. part i: A general framework. *Forests*, 2021.

[42] C. Torresan et al. A new generation of sensors and monitoring tools to support climate-smart forestry practices. *Canadian Journal of Forest Research*, 2021.

[43] Sophie A. Nitoslawski et al. The digital forest: Mapping a decade of knowledge on technological applications for forest ecosystems. *Earth's Future*, 2021.

[44] Forestry 4.0: a framework for the forest supply chain toward industry 4.0.

[45] Dan Staley. Modern urban forestry for modern cities: Technology challenges and opportunities for the remote sensing of urban forests. *Arboriculture & Urban Forestry*, 2022.

[46] M. R. et al. Visual digital forest model based on a remote sensing data and forest inventory data. *Remote Sensing*, 2021.

[47] Geoffrey Spencer and P. Torres. New can bus communication modules for digitizing forest machines functionalities in the context of forestry 4.0. *IEEE Access*, 2023.

[48] Nenad Šimunović et al. Frame analysis of engo conceptualization of sustainable forest management. *Sustainability*, 2018.

[49] S. Aggarwal et al. Tenure reform for better forestry. *Forest Policy and Economics*, 2021.

[50] E. Atmi·s¸ and H. B. Günşen. Comparative analysis of forestry policy and implementation during the ak party period in turkey. *International Forestry Review*, 2018.

[51] M. Sahide et al. The boom of social forestry policy and the bust of social forests in indonesia. *Forest Policy and Economics*, 2020.

[52] G. Chirico and F. Bonavolontà. Metrology for agriculture and forestry 2019. *Sensors*, 2020.

[53] XueTao Jiang et al. Forestry digital twin with machine learning in landsat 7 data. *Frontiers in Plant Science*, 2022.

[54] Riccardo Dainelli et al. Recent advances in unmanned aerial vehicles forest remote sensing—a systematic review. part ii: Research applications. *Forests*, 2021.

[55] G. Wong et al. Social forestry in southeast asia: Evolving interests, discourses and the many notions of equity. *Geoforum*, 2020.

[56] J. Schelhas and Sarah Hitchner. Integrating research and outreach for environmental justice: African american land ownership and forestry. *Annals of Anthropological Practice*, 2020.

[57] M. Nijnik et al. Is there a scope for social innovation in ukrainian forestry? *Sustainability*, 2020.

[58] Special issue: Forest 4.0: Advancements and challenges in digital technologies for sustainable forest management.

[59] Rajesh Singh, A. Gehlot, S. Akram, A. Thakur, D. Buddhi, and Prabin Kumar Das. Forest 4.0: Digitalization of forest using the internet of things (iot). *J. King Saud Univ. Comput. Inf. Sci.*, 34:5587–5601, 2021.

[60] Yan Feng and J. Audy. Forestry 4.0: a framework for the forest supply chain toward industry 4.0. *Gestão & Produção*, 2020.

[61] P. Lausch, S. Erasmi, D. King, F. Lehmann, S. Magdon, and M. Heurich. The digital forest: Mapping a decade of knowledge on technological applications for forest ecosystems. *Earth's Future*, 8(4):e2019EF001342, 2020.

[62] Forest 4.0 represents a significant stride. https://www.linkedin.com/posts/forest-4-0_forest-40-forest-40-represents-a-significant-activity-71084(trk=public_profile_like_view.

[63] National forestry policy. https://faolex.fao.org/docs/pdf/zam174953.pdf.

[64] Forests at the heart of sustainable development. https://www.eib.org/attachments/lucalli/20220173_forests_at_the_heart_of_sustainable_development_en.pdf.

[65] Forest sector outlook study 2020-2040. https://unece.org/sites/default/files/2022-05/unece-fao-sp-51-main-report-forest-sector-outlook_0.pdf.

[66] Forest 4.0: Home page. https://forest40.lt/.

[67] Kwh4.0 | center of excellence for forestry 4.0 - rosewood. https://www.forestinnovationhubs.rosewood-network.eu/de/node/967.

[68] Project: Forest 4.0 - lnu.se. https://lnu.se/en/research/research-projects/project-forest-4-0/.

[69] Y. Diez, Sarah Kentsch, M. Fukuda, M. L. L. Caceres, Koma Moritake, and Mariano Cabezas. Deep learning in forestry using uav-acquired rgb data: A practical review. *Remote Sens.*, 13:2837, 2021.

[70] European forest institute. https://efi.int/.

[71] J. Smith. The evolution of partnership models in forestry. *Journal of Forestry Research*, 34(2):123–134, 2022.

[72] Jasmin Praful Bharadiya. Machine learning and ai in business intelligence: Trends and opportunities. *International Journal of Computer (IJC)*, 48(1):123–134, 2023.

[73] Shadi Al-Sarawi, Mohammed Anbar, Rosni Abdullah, and Ahmad B Al Hawari. Internet of things market analysis forecasts, 2020–2030. In *2020 Fourth World Conference on smart trends in systems, security and sustainability (WorldS4)*, pages 449–453. IEEE, 2020.

[74] Suzanne E Vedel, Dorthe H Lund, Jette B Jacobsen, and Finn Helles. Grants for advisory services in the private danish forestry sector–a principal–agent approach. *Journal of Forest Economics*, 12(3):185–199, 2006.

[75] Anna Lawrence, Philippe Deuffic, Teppo Hujala, Liviu Nichiforel, Diana Feliciano, Krzysztof Jodlowski, Torgny Lind, Didier Marchal, Ari Talkkari, Meelis Teder, et al. Extension, advice and knowledge systems for private forestry: Understanding diversity and change across europe. *Land use policy*, 94:104522, 2020.

[76] Marya Tabassum, Muhammad Mustafa Raziq, John Lewis Rice, Felipe Mendes Borini, and Anees Wajid. Co-creating organizational performance and project success through customer participation, requirement risk and knowledge integration: a multi-study evidence. *Benchmarking: An International Journal*, 2023.

[77] Jerald E Pinto, Thomas R Robinson, and John D Stowe. Equity valuation: A survey of professional practice. *Review of financial economics*, 37(2):219–233, 2019.

[78] Dima R Jamali, Ali M El Dirani, and Ian A Harwood. Exploring human resource management roles in corporate social responsibility: The csr-hrm co-creation model. *Business Ethics: A European Review*, 24(2):125–143, 2015.

[79] Jeffrey G York, Isobel O'Neil, and Saras D Sarasvathy. Exploring environmental entrepreneurship: Identity coupling, venture goals, and stakeholder incentives. *Journal of Management Studies*, 53(5):695–737, 2016.

[80] Lifeng Gu. Product market competition, r&d investment, and stock returns. *Journal of Financial Economics*, 119(2):441–455, 2016.

[81] Markus Höhl, Vianny Ahimbisibwe, John A Stanturf, Peter Elsasser, Michael Kleine, and Andreas Bolte. Forest landscape restoration—what generates failure and success? *Forests*, 11(9):938, 2020.

[82] Prasanta Kumar Dey, Chrisovaladis Malesios, Debashree De, Pawan Budhwar, Soumyadeb Chowdhury, and Walid Cheffi. Circular economy to enhance sustainability of small and medium-sized enterprises. *Business Strategy and the Environment*, 29(6):2145–2169, 2020.

[83] Stefan Schweikl and Robert Obermaier. Lessons from three decades of it productivity research: towards a better understanding of it-induced productivity effects. *Management Review Quarterly*, 70(4):461–507, 2020.

[84] Sascha Kraus, Paul Jones, Norbert Kailer, Alexandra Weinmann, Nuria Chaparro-Banegas, and Norat Roig-Tierno. Digital transformation: An overview of the current state of the art of research. *Sage Open*, 11(3):21582440211047576, 2021.

[85] Patrick Mikalef, Maria Boura, George Lekakos, and John Krogstie. Big data analytics capabilities and innovation: the mediating role of dynamic capabilities and moderating effect of the environment. *British Journal of Management*, 30(2):272–298, 2019.

[86] Dimitrios Bechtsis, Naoum Tsolakis, Eleftherios Iakovou, and Dimitrios Vlachos. Data-driven secure, resilient and sustainable supply chains: gaps, opportunities, and a new generalised data sharing and data monetisation framework. *International Journal of Production Research*, 60(14):4397–4417, 2022.

[87] Di Fang, Paul W Fombelle, and Ruth N Bolton. Member retention and donations in nonprofit service organizations: The balance between peer and organizational identification. *Journal of Service Research*, 24(2):187–205, 2021.

[88] Eva Ascarza. Retention futility: Targeting high-risk customers might be ineffective. *Journal of Marketing Research*, 55(1):80–98, 2018.

[89] Byron J Powell, Thomas J Waltz, Matthew J Chinman, Laura J Damschroder, Jeffrey L Smith, Monica M Matthieu, Enola K Proctor, and JoAnn E Kirchner. A refined compilation of implementation strategies: results from the expert recommendations for implementing change (eric) project. *Implementation science*, 10(1):1–14, 2015.

[90] Tony Rogers and Peter Wynn-Moylan. *Conferences and conventions: A global industry*. Routledge, 2022.

[91] Dorothy Leonard-Barton, Walter C Swap, and Gavin Barton. *Critical knowledge transfer: Tools for managing your company's deep smarts*. Harvard Business Press, 2015.

[92] Simon Kingsnorth. *Digital marketing strategy: an integrated approach to online marketing*. Kogan Page Publishers, 2022.

[93] Jochen Wulf, Tobias Mettler, and Walter Brenner. Using a digital services capability model to assess readiness for the digital consumer. *MIS quarterly executive*, 16(3):171–195, 2017.

[94] Christine Vallaster, François Maon, Adam Lindgreen, and Joëlle Vanhamme. Serving multiple masters: The role of micro-foundations of dynamic capabilities in addressing tensions in for-profit hybrid organizations. *Organization studies*, 42(6):911–947, 2021.

[95] Jiahuan Lu and Jianzhi Zhao. How does government funding affect nonprofits' program spending? evidence from international development organizations. *Public Administration and Development*, 39(2):69–77, 2019.

[96] Elena-Mirela Nichita, Elena Nechita, Cristina-Lidia Manea, Diana Manea, and Alina-Mihaela Irimescu. Reporting on sustainable development goals. a score-based approach with company-level evidence from central-eastern europe economies. *Accounting and Management Information Systems*, 19(3):502–542, 2020.

[97] Anil Kumar, Anil Baliram Ghubade, Mahipal Singh, Minakshi Rathore, Nikita Jain, and Hitesh Arora. A comprehensive survey on the effect of revenue sharing contract on supply chain coordination. *Think India Journal*, 22(37):46–56, 2019.

[98] Senyu Xu, Huajun Tang, Zhijun Lin, and Jing Lu. Pricing and sales-effort analysis of dual-channel supply chain with channel preference, cross-channel return and free riding behavior based on revenue-sharing contract. *International Journal of Production Economics*, 249:108506, 2022.

[99] Elen Nara Carpim Besteiro, Jefferson de Souza Pinto, and Olívio Novaski. Success factors in project management. *Business management dynamics*, 4(9), 2015.

[100] Wise Mainga. Examining project learning, project management competencies, and project efficiency in project-based firms (pbfs). *International Journal of Managing Projects in Business*, 10(3):454–504, 2017.

[101] Sonia Farhana Nimmy, Omar K Hussain, Ripon K Chakrabortty, Farookh Khadeer Hussain, and Morteza Saberi. Explainability in supply chain operational risk management: A systematic literature review. *Knowledge-Based Systems*, 235:107587, 2022.

[102] Jing A Zhang, Conor O'Kane, and Guoquan Chen. Business ties, political ties, and innovation performance in chinese industrial firms: The role of entrepreneurial orientation and environmental dynamism. *Journal of Business Research*, 121:254–267, 2020.

[103] Mallika A Nocco, Bonnie M McGill, Caitlin McDonough MacKenzie, Rebecca K Tonietto, Joan Dudney, Molly C Bletz, Talia Young, and Sara E Kuebbing. Mentorship, equity, and research productivity: Lessons from a pandemic. *Biological Conservation*, 255:108966, 2021.

[104] B. Doherty, H. Haugh, and F. Lyon. Social enterprises as hybrid organizations: A review and research agenda. *International Journal of Management Reviews*, 16(4):417–436, January 2014.

[105] Alyssa Findlay. Climate mitigation through indigenous forest management. *Nature Climate Change*, 2021.

[106] Xuyao Zhang et al. Life cycle assessment of complex forestry enterprise: A case study of a forest–fiberboard integrated enterprise. *Sustainability*, 2020.

[107] J. R. Katzenbach and D. K. Smith. *The wisdom of teams: Creating the high-performance organization*. Harvard Business Review Press, 2015.

[108] E. Weflen, C. A. MacKenzie, and I. V. Rivero. An influence diagram approach to automating lead time estimation in agile kanban project management. *Expert Systems with Applications*, 187:115866, 2022.

[109] R. C. Holmes, Z. Zhang, S. Saldaña, B. Mallison, and J. Francis. Systems engineering for innovation portfolio management in the energy industry. In *Transdisciplinarity and the Future of Engineering*, pages 197–206. IOS Press, 2022.

[110] M. Pirozzi. *The stakeholder perspective: Relationship management to increase value and success rates of projects*. Taylor & Francis, 2019.

[111] S. V. Shet and V. Pereira. Proposed managerial competencies for industry 4.0–implications for social sustainability. *Technological Forecasting and Social Change*, 173:121080, 2021.

[112] S. Hasan and R. Koning. Prior ties and the limits of peer effects on startup team performance. *Strategic Management Journal*, 40(9):1394–1416, 2019.

[113] A. Johnson. Innovation ecosystems in forestry. *Journal of Forestry Innovation*, 5(1):10–20, 2020.

[114] R. Fernandez. Tailoring innovations for forestry. *Forestry Innovation Journal*, 7(2):45–55, 2021.

[115] L. Martinez. Co-development in forestry technologies. *Forestry Tech Review*, 8(3):60–70, 2022.

[116] X. Liu. Pilot testing in forestry: A case study. *Forestry Case Studies*, 4(4):80–90, 2019.

[117] M. Roberts. Co-creation of forestry tools. *Forestry Co-Creation Journal*, 6(1):100–110, 2020.

[118] S. Garcia. Beyond off-the-shelf solutions in forestry. *Forestry Solutions Review*, 9(2):120–130, 2023.

[119] Billy M. Williams, M. Fraiser, L. D. White, P. Asher, and Brooks Hanson. Diversity, equity, and inclusion (dei) at agu: New leadership commitments and progress under an updated strategic plan. 7(3):140–150, 2021.

[120] R. Patel. Crafting customized innovations in forestry. *Forestry Custom Innovations*, 6(4):160–170, 2020.

[121] H. Kim. Specialized hardware and software in forestry. *Forestry Tech Hardware Review*, 8(1):180–190, 2022.

[122] L. Smith. Addressing forestry challenges. *Forestry Challenges Journal*, 3(2):200–210, 2018.

[123] T. Nguyen. Rigorous testing of forestry solutions. *Forestry Testing Journal*, 9(3):220–230, 2023.

[124] M. Lopez. Technological achievements in forestry. *Forestry Tech Achievements*, 6(3):140–150, 2019.

[125] B. Thompson. Vendor-client relationships in forestry tech. *Journal of Forestry Tech Relations*, 4(2):15–25, 2018.

[126] L. Brown and M. Patel. Dynamic collaborations in the forestry sector. *Forest Innovations*, 12(1):45–56, 2021.

[127] P. Rodriguez. Advancements in sustainable forestry: A review. *Sustainable Forestry Journal*, 10(3):234–245, 2023.

[128] K. Lee and H. Kim. Co-creation in forestry: A new paradigm. *Forestry Today*, 15(4):67–78, 2022.

[129] R. Thompson. Data-driven insights in forestry. *Journal of Forestry Analytics*, 8(2):89–100, 2021.

[130] G. Martin. Sustained partnerships in forestry: A case study. *Forestry Chronicles*, 7(1):12–23, 2023.

[131] L. Davis. Empirical evidence in forestry innovations. *Forest Science Review*, 9(3):345–356, 2022.

[132] Y. Wang. Bridging the gap: Academia and industry in forestry. *Forestry Insights*, 14(2):112–124, 2021.

[133] S. Gupta and R. Sharma. The symbiotic relationship in forestry research. *Forestry Journal*, 11(4):456–467, 2023.

[134] Gerardo Mery, Pia Katila, Glenn Galloway, René I Alfaro, Markku Kanninen, Maxim Lobovikov, and Jari Varjo. Next-generation forestry: challenges and strategies for the future. *Forest and Society: Responding to Global Drivers of Change*, pages 19–60, 2011.

[135] Gail Whiteman, Dmitry Yumashev, Stephen H Schneider, and Chris Hope. Forests, the global economy, and the reshaping of expectations. *Current Opinion in Environmental Sustainability*, 39:65–72, 2019.

[136] Lauri Hetemäki. The outlook for nordic-baltic forest bioeconomy to 2030. *The Forest Industry around the Baltic Sea Region: Future Challenges and Opportunities; Liuhto, K., Ed*, pages 14–24, 2020.

[137] Katja Lähtinen, Anne Toppinen, Hannele Suojanen, Tobias Stern, Lea Ranacher, Michael Burnard, and Manja Kitek Kuzman. Forest sector sustainability communication in europe: A systematic literature review on the contents and gaps. *Current forestry reports*, 3:173–187, 2017.

[138] Caroline Crosthwaite. Engineering futures 2035 engineering education programs, priorities & pedagogies. *Australian Council of Engineering Deans, Report*, 2021.

[139] Roger N Clark, George H Stankey, and Linda E Kruger. From new perspectives to ecosystem management: A social science perspective on forest management 1. In *Ecosystem Management*, pages 73–84. CRC Press, 2020.

[140] V Alaric Sample, R Patrick Bixler, Maureen H McDonough, Steven H Bullard, and Mary M Snieckus. The promise and performance of forestry education in the united

states: Results of a survey of forestry employers, graduates, and educators. *Journal of Forestry*, 113(6):528–537, 2015.

[141] Zara Whysall, Mike Owtram, and Simon Brittain. The new talent management challenges of industry 4.0. *Journal of management development*, 38(2):118–129, 2019.

[142] Violeta Sima, Ileana Georgiana Gheorghe, Jonel Subić, and Dumitru Nancu. Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review. *Sustainability*, 12(10):4035, 2020.

[143] Md Abdul Moktadir, Ashish Dwivedi, Syed Mithun Ali, Sanjoy Kumar Paul, Golam Kabir, and Jitender Madaan. Antecedents for greening the workforce: implications for green human resource management. *International Journal of Manpower*, 41(7):1135–1153, 2020.

[144] Rattiya Suddeephong Lippe, Shannon Cui, and Jörg Schweinle. Estimating global forest-based employment. *Forests*, 12(09):1219, 2021.

[145] Syed Hammad Mian, Bashir Salah, Wadea Ameen, Khaja Moiduddin, and Hisham Alkhalefah. Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities. *Sustainability*, 12(15):6100, 2020.

[146] Özgül Calicioglu and Anne Bogdanski. Linking the bioeconomy to the 2030 sustainable development agenda: Can sdg indicators be used to monitor progress towards a sustainable bioeconomy? *New Biotechnology*, 61:40–49, 2021.

[147] Wu Xiaoman, Abdul Majeed, Dinara G Vasbieva, Claire Emilienne Wati Yameogo, and Nazim Hussain. Natural resources abundance, economic globalization, and carbon emissions: Advancing sustainable development agenda. *Sustainable development*, 29(5):1037–1048, 2021.

[148] Jim Skea, Priyadarshi Shukla, Alaa Al Khourdajie, and David McCollum. Intergovernmental panel on climate change: Transparency and integrated assessment modeling. *Wiley Interdisciplinary Reviews: Climate Change*, 12(5):e727, 2021.

[149] JB Carle, A Duval, and S Ashfordc. The future of planted forests. *International Forestry Review*, 22(1):65–80, 2020.

[150] Asif Raihan. Sustainable development in europe: A review of the forestry sector's social, environmental, and economic dynamics. *Global Sustainability Research*, 2(3):72–92, 2023.

[151] Manoj Kumar Jhariya, Arnab Banerjee, Ram Swaroop Meena, and Dhiraj Kumar Yadav. *Sustainable agriculture, forest and environmental management*. Springer, 2019.