Abstract: Concerted efforts are required to achieve the essential UN Sustainable Development Goals (SDGs) of the 2030 Agenda. This concept paper is focused on the development of a new Master of Forestry (MF) degree program at our University of Applied Sciences (UAS). With this move, we want to outline how capacity building and valuable synergy effects can be obtained from close cooperation in teaching and research, in order to educate our scientifically trained and practice-oriented forestry students in applying new management responses to natural disturbance impacts and sustainable use of terrestrial natural resources for forest resource-dependent communities. Specifically, we show how the emergent issues of global warming and the associated increased vulnerability of temperate deciduous forests can be tackled. Actions to overcome knowledge transfer barriers will provide sound solutions for SDG 4 (quality education), SDG 5 (gender equality), SDG 7 (affordable and clean energy), SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 15 (life on land), and SDG 17 (partnerships to achieve the goal). Focusing on the Global Sustainable Development Goals can trigger intra and inter-faculty processes of cooperation, exchange programs, and optimized interfaces of previously separated disciplines that complement each other perfectly to form a knowledge hub.

Keywords: higher forestry education; global warming; natural risks; forest ecosystems; sustainable forest management; renewable raw materials; interdisciplinary approach

1. Introduction

The 17 UN Sustainable Development Goals (SDGs) of the 2030 Agenda to transform our world, and the increasing risks of climate change and globalization, require a wide-ranging and multifaceted adaptation of forestry [1,2]. Applied to the location of our faculty in Göttingen (central Germany), we focus on managing the environmental problems in temperate deciduous forests in western Central Europe. The field of sustainable forest management is constantly facing increasing risks from unpredictable hazards associated with climate change, such as drought, forest fires, flooding, and a variety of pests and diseases [3,4].

To tackle the ecological crisis in ways that sustain biodiversity and ecosystem functioning, we must change our approach to forestry education [5]. The intensive preparation of our scientifically trained and practice-oriented forestry scholars for applying new management responses to unprecedented (i.e., nonantecedent) ecosystem stress [6] and to natural disturbance impacts that maintain the resilience
of forests [7,8], should be deepened and focused. To support the concept of transformation in climate and other global change, the Ministry for Science and Culture of Lower Saxony approved additional university places in 2020–2021 under the Higher Education Pact 2020 [9]. As part of the expansion of capacity, novel paths to cope with the global economic and ecological crisis must be created [10,11]. In this paper, we pursue an approach to combine forestry with further intra-faculty disciplines of sustainable resource management and inter-faculty research approaches of engineering and technology into a novel Master of Forestry (MF) degree program to meet the demands of climate change, risks and uncertainties, and resource sustainability.

The administration of the University of Applied Sciences and Arts Hildesheim/Holzminden/Göttingen (HAWK) and the Faculty of Resource Management (r) in Göttingen agree that the deepening of the course content against the background of emergent issues in global forest change is urgently required and must be implemented rapidly.

2. Methodical Approach

The key basis for developing a new challenging MF degree program to tackle the environmental problems in temperate deciduous forests is to ensure and connect sufficient ecological background knowledge of strategies of adaptive forest management, sustainability issues of bioeconomy, bioengineering and technology. Integrating sustainability as a binding factor requires a knowledge hub for Nature-based Solutions (NbS). NbS are defined by IUCN as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” [12]. Our strategic implementation plan (SIP) addresses identified needs, target groups, goals and objectives.

2.1. Needs—Establishment of a Knowledge Transfer Network (KTN)

In order to provide a copious knowledge base for Nature-based Solutions (NbS), the inter- and intra-faculty knowledge transfer network (KTN) was intensified. The KTN concept aims to facilitate a broad curriculum focused on innovative solution approaches to achieve various UN Sustainable Development Goals (SDGs) of the 2030 Agenda (Figure 1) and an adequate expertise of supervisors for a broad spectrum of master’s theses.

![Figure 1. The 17 Sustainable Development Goals. The focused goals of our concept are framed [13].](image-url)
2.2. Target Group

The stakes are high for forestry to deal with challenges of a world that is changing in ways that have not been experienced in human history. Our actions are aimed at meeting the high demand for well-educated graduates who are capable of applying new management responses to natural disturbance impacts and sustainable use of terrestrial natural resources for forest resource-dependent communities.

2.3. Goal Model of Training Program

Based on a bachelor’s degree program in the same subject area, we plan to offer our novel Master of Forestry as a consecutive degree program for study in much greater depth and in a more appropriate context. A consecutive bachelor’s–master’s study program only makes sense when the subject area has sufficient credibility, reputation, attractiveness, and produces capable and ambitious graduates. It allows teachers to build a strong, long-term relationship with students [14]. For that purpose, we performed an initial potential analysis of our BSc forestry course, which is a three-year degree course that prepares students for a professional career in forest management [15]. Rough indicators were the number of students for several years, the analysis of available data from the Dialogue-oriented service Procedure (DoSV) for the winter semester of 2018–2019, and additional references, such as the performance of BSc forestry graduates in recent forest inspector exams, awards and recent open access peer-reviewed publications based on bachelor’s theses.

The novel MF degree program will support the training of problem-solving and evidence-based skills, research methodological skills, epistemic understanding, and critical thinking [16]. Training modules are created to give insights into different domains of knowledge to acquire professional competence that lies beyond the purview of a single area of knowledge and/or specific discipline. The integration of practical training in teams and an internship/work-based learning course is focused on reasoning skills and applications of knowledge [17]. In particular, the study program calls for and promotes a networked way of thinking. Insights into the economic, administrative, legal, and social contexts of the professional field promote personal and vocational development. After completing their studies, the graduates will have the knowledge, skills, and competences according to the European Qualifications Framework, EQF [18]. The study program is planned with four semesters and 120 credits according to ETCS.

However, after successfully completing their degree, the graduates will be solicited for their active participation in our faculty alumni associations. In this function, they are responsible for ensuring that the students will be consistently updated with the current issues and challenges of forest policy and practice. Moreover, they help the students to internalize that life-long learning, flow of information, and communication from education to work and vice-versa are key demands of life and work in the 21st century [17]. Alumni are key players in a functioning dynamical system to progress, achieve, and meet needs.

2.4. Content Objectives

The goal-related outcomes in specific, measurable terms are presented in Table 1. To reach the goal, we must bring together the resources, people, and knowledge of research facilities and working groups. They must provide specific and relevant content and skills across the curriculum of the pioneering, interdisciplinary MF degree program.

The action has to start immediately, since additional university places in 2020–2021 under the Higher Education Pact 2020 are already approved. The implementation of the novel MF degree program coincides with the impending re-accreditation of the master’s degree program “Renewable Resources and Regenerative Energies” by ASIIN (German Accreditation Association), which is scheduled for September 2021. Moreover, we will take advantage of the 50th anniversary of the faculty (r) in 2024 as an appropriate forum to present the successfully accomplished transformation of the faculty (r) according to the schedule of the 2030 Agenda.
Table 1. Facility-related matters of natural disturbances under climate change to be reflected in the curricula and teaching programs of the pioneering, interdisciplinary Master of Forestry (MF) degree program.

| Research Facilities and Working Groups | Specific Matters |
|----------------------------------------|------------------|
| climate change management forestry (Faculty (r)) ¹ | climate change and extreme weather events; forest soils and their water storage capacity; disturbance ecology; different successional trajectories and site conditions; drought and heat-tolerant tree species; pathogen pressures; climate change forest management; agroforestry; logistics of wood processing; restoration of depleted forest land; biodiversity and nature conservation; |
| Business administration and Engineering (Faculty (r)) | bioeconomy; energy technology; finance; logistics; marketing/sales; project management; quality management and accounting; |
| research group Sustainable Energy and Environmental Technology (NEUTec) (Faculty (r)) and working group on sustainability (Faculty (r)) | sustainable wood mobilization; energy efficiency; resource-efficiency; carbon sequestration; cascading use of wood products; innovative wood products; ecologically based life cycle assessments (Eco-LCAs); use of robotics in Forestry; digitized evaluation of growth processes; phenotyping of indicator plants; |
| chair of Embedded Systems and Robotics (Faculty (i)) ² | highly automated monitoring system; early detection or tracking of the spread of insect outbreaks or beneficial organisms. |
| chair of laser and plasma technology (Faculty (i)) | bioengineering procedures, e.g., by plasma treatment of seeds, and applying seed balls |

¹ Faculty of Resource Management (r); ² Faculty of Engineering and Health (i).

3. Results

Over the past few years, we have had roughly 500 applicants annually for the bachelor’s program in forestry. Only 1/3 of the applicants (165 students) may be considered for admission to a study place. The admission capacity of the selective forestry bachelor’s program is 80 students. In winter semester 2018–2019, 63 students (79% of admission capacity) were already enrolled in the BSc forestry course at the end of the first coordination phase and pledged to attend if accepted (Figure 2). This trajectory of an ‘early bird application’ by which students apply early to a single university—usually their first choice [19–21]—indicated that we are the favorite University of Applied Sciences for the BSc forestry course. Moreover, rankings of recent forest inspector exams, and recent peer reviewed publications and awards resulting from excellent bachelor’s theses indicated that the particularly popular BSc forestry course produces top graduates.

Capable and ambitious graduates are our academic legacy for applying new management responses in silvicultural practices, and for expanding and deepening their science-based knowledge. They serve an important hinge-like function to ensure a close and perpetual exchange of information between forest practitioners, academics, and scientists. Disturbance ecology will play a more pivotal role in forest ecosystem structures and dynamics (Figure 3), in particular due to the increased number and strength of extreme weather events [22,23] and accompanying pathogen pressures [24]. Versatile and flexible climate change forest management is urgently required [25,26], comprising key ecosystem services; climate mitigation and climate-efficient land use; drought- and heat-tolerant tree species [27,28]; functional trait diversity [29] and strategy types [30,31] facilitating risk spread and resilience; different successional trajectories and site conditions; sustainable wood mobilization; logistics of wood processing; innovation in wood products; resource-efficiency; transfer of technology; restoration of depleted forest land towards multifunctional and biodiverse forest ecosystems [32], etc.
Figure 2. Analysis of students applying, oriented to the schedule for Dialogue-oriented service Procedure (German abbreviation DoSV). Cp 1: coordination phase 1 (activation of the ranking lists): 16.07.–15.08.; dp: decision phase; cp 2: coordination phase 2: (further proposals and acceptances): 19.08.–27.08.; 24.08.: automatic approval and electronic distribution of notices. Conceptual design: T. Nern/HAWK.

Figure 3. Disturbance ecology will play an increasingly pivotal role in vegetation dynamics. For example, we must face an increased frequency in European windstorms ([33], (pp. 235–239). Mosaics of forest disturbance and succession: (a) uprooted competitors (*Fagus sylvatica* L.), (b) canopy patchiness, (c) pioneer trees (*Betula pendula* Roth), (d) R-strategists (*Urtica dioica* L.). Photographs by H. Walentowski/HAWK.
Consequently, the major flagship BSc forestry course, the copious technical knowledge of the Faculty of Resource Management, and the approved capacity expansion to tackle the emergent issues in global forest change offer a viable way to implement an attractive consecutive MF degree program with the working title ‘Forest Bioeconomy’. Therefore, we take urgent action to pursue UN Sustainable Development Goals of the 2030 Agenda and may contribute to solving the big ecological and economic challenges of the future. The consecutive master’s program is intended to make a substantial contribution to a holistic land use strategy that is committed to sustainability and climate protection. It is designed in such a way that the focus of demand is ideally on forestry-oriented courses at universities and universities of applied sciences in German-speaking countries, situated in the temperate deciduous forest biome. Forest ecosystem state transitions on humans and biodiversity in these densely populated landscapes of the biome could have major socio-ecological consequences. In many places, the natural adaptability of German forests has already been exceeded, threatening yields from forestry [34]. However, the pioneering, interdisciplinary master’s program incorporates future-oriented issues of international forestry concerning non-wood products, material use of residues and biogenic raw materials from the agriculture and forestry sectors, as well as plantation management and agroforestry [3,35]. A broad-scale perspective beyond the geographic scales may help to introduce new management responses to mitigate the socio-ecological impacts of climate-induced changes to forests [4,10,36]. As part of this realignment, students could:

- acquire skills in how fallen timber that occurs in abundance in connection with extreme weather events, insect outbreaks, and introduced novel disturbances can be used innovatively (e.g., innovative wood products made from lignin (wood polymer), starch, glucose, plant-based oils, waxes, and minerals; innovative products made from biochar, i.e., charcoal used as a soil amendment for both carbon sequestration and soil health benefits);
- prepare ecologically based life cycle assessments (Eco-LCAs) for forest products and processes [37,38];
- deepen knowledge on how they can save energy in forestry operations and timber harvesting and how they can act in a more resource-efficient and energy-efficient manner (improvement in energy efficiency);
- deepen knowledge on how the entire value chain can be optimized (e.g., cascading use of wood products [39]; cascading use of biomass; material flow management; logistics; project management);
- deepen knowledge on how forest carbon stock can be optimized (e.g., carbon in above-ground biomass; carbon in below-ground biomass; carbon in deadwood; carbon in litter; soil carbon; potential savings in carbon equivalents through forest bog restoration; biomass and carbon sequestration in plantations etc.);
- take advantage of a constant, newly established research training group;
- complete their degree with research cooperation partners abroad.

The expanded offer is aimed at high-standard quality education (SDG 4) to equip our graduates with cutting-edge integrated management skills to put future-oriented approaches such as bioeconomy, biologizing of technology, and resource-efficient decarbonization pathways into practice in order to achieve sustainable management and efficient use of natural resources (SDG 12). In accordance with SDG 5 (gender equality), we will ensure full and effective participation of women with equal opportunities for leadership at all levels of decision making in political, economic, and public life.

Figure 4 shows the master’s course as a consecutive program that builds on a six-semester bachelor’s degree (180 credits) with an additional four-semester program (120 credits). Building upon the traditional Bachelor of Science in Forestry (updated by basic knowledge on the impacts of climate change on forest management and implications for German forestry), the MF degree program allows a new specialisation using an interdisciplinary approach to comprehensive problem understanding and problem solving. Moreover, the students gain profound 21st century skills including techniques of obtaining and processing information, initiating investigations and research, applying learning to new challenges, communication competence, team work skills, and self management [17].
With the new concept, we will initiate a transformation of the Faculty of Resource Management towards adaptation to climate change in the context of Sustainable Development Goals (SDG 13 climate action). We follow the multifunctional forest management model [40], which is based on the premise to reconcile biodiversity conservation (SDG 15 life on land) and timber production. Our innovative and multidisciplinary MF degree program is achieved by a joint venture of forest ecologists, wildlife and biodiversity conservation experts, and by economists, engineering and technology experts (SDG 17 partnerships to achieve the goal).

4. Discussion

The outlined pioneering MF degree program should inspire innovative research that supports forest crisis management and the sustainable use of biogenic residues in the agricultural and environmental sectors, and integrates master’s degree theses into research. This research supports SDG 7 (affordable and clean energy) by increasing the share of renewable energy in the global energy mix.

The implementation of our novel and interdisciplinary approach requires a top structure in the form of a new research institute for the research focus currently referred to as “Sustainable Production and Use of Biogenic Raw Materials” (currently separated into Forest Research and NEUTec Research). The environmental problems in temperate deciduous forests generate a high demand for research project proposals that are of great interest to the Faculty of Resource Management. We aim to develop a sustainably effective, holistic system, namely a new research facility that:

- ensures long-term prospects for its temporary research assistants and optimizes routines in consecutive projects;
- supports the possibilities of purposeful international cooperation and research projects, such as currently in a transhemispheric, transcontinental, and transatlantic cooperation with Patagonia [26];
- supports interdisciplinary research and development of new and novel methodologies for adapting forestry and forests to climate change;
- enables cooperation with other research platforms of the university, such as Plasma for Life, in order to apply the resource-saving plasma technology to wood products [41];
- enables a wide-ranging interaction between robotics and forestry science, e.g., in the reforestation or digitization of forests [42];
- supports the pioneering MF degree program with its research orientation and specifically integrates the academic staff and the final theses of the master’s students into the research.

The new corporate mission statement is a “wood-based bioeconomy” [39] that researches “innovative processes for the use of biogenic raw materials”, which sustainably supports broadly aligned risk and crisis management in the forest and innovative use of biogenic resources.

Nonantecedent stress impacts on forest ecosystems [6] challenge high-tech innovations. Forestry must diverge from the use of oversized, heavy harvesting and logging machines that can cause lasting damage to soil compaction [43]. The integrity of forest soils and their water storage capacity is a fundamental asset in times of global warming, increasing heat, and drought stress. In the future, forest soils should also be increasingly the subject of nature conservation agreements/forest contract nature conservation [44]. Wind-throw events and succession processes promote spatial and temporal soil heterogeneity [45] as a component of ecosystem integrity. The strong interference in ecosystem integrity through previous reforestation practices could be minimized through the intelligent use of robotics, offered by the chair of Embedded Systems and Robotics at the Faculty [i] of Engineering and Health [46,47] (Figure 5).

![Hexapod](image)

**Figure 5.** The six-legged walking robot (Hexapod), already developed in the Autonomous Mobile Robotics Lab (AMRL) at the HAWK in Göttingen, is based on the Phantom X platform from Interbotix: (a) insect-inspired six-legged robot with multi-sensor navigation frame; (b) simulated hexapod in forestry environment.

In addition, a goal-oriented, soil-protecting technology application should be used. Light aircraft and light ground robots can be used for assisted colonization of drought and heat-tolerant species into a new range that is predicted to be favorable for persistence under future climate scenarios [48]. Working also with pronounced ground relief and obstacles, they enable the placement of a target species at favorable microsites. The difficult establishment could be facilitated by bioengineering procedures (e.g., plasma treatment of seeds by the chair of laser and plasma technology of the faculty [i] [49,50], and applying seed balls (protective covers, nutrient solution agar, root growth accelerator)). Seed-ball ing, seed-bombing or in some cases aerial reforestation is a technology which is currently used for ecological restoration in semi-arid subtropical regions [51]; hence, pioneering future technologies can support the settlement and establishment of future climate-adapted tree species. For this purpose, the monitoring—or digitized evaluation—of growth processes, the automatic exploration of the soil condition such as phenotyping of indicator plants [52], or evaluating multispectral images for the recording of meaningful soil conditions such as moisture [53], etc., could bring added value. In addition, a highly automated monitoring system could be developed—with the help of robotics—for early detection or tracking of the spread of insect outbreaks or beneficial organisms.
5. Conclusions

The pressures of climate change and natural disturbance impacts on forests, and the huge challenges for forestry, are unprecedented in human history and require better preparation of the new academic generation. The concept of the pioneering MF degree program will respond to these pressures and challenges through a cooperative teaching and research strategy. Merging the worlds of management and economics, and engineering and technology, with life sciences, ecology, and biodiversity conservation, the program will substantially broaden the knowledge and problem-solving competence of forestry students. Well-educated young academics hold the key to bringing into practice knowledge-based reasoning of responsible resource management for a sustainable world.

Author Contributions: H.W., B.K., and J.H. conceptualized the study, H.W. and J.H. analyzed the data; H.W. wrote the paper; T.L. and W.V. conducted review and editing and gave substantial expert input; W.V. provided funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Science and Culture of Lower Saxony and the German Federal Ministry of Education and Research.

Acknowledgments: We thank our board of professors, colleagues, alumni and friends, our scientific staff and students for their creative contributions in various panel discussions and we thank the president of the HAWK University of Applied Sciences and Arts for his strong administrative support.

Conflicts of Interest: The authors declare no conflict of interest.

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