Framework for a Proposed New Research Focused Graduate Education Program at Madan Bhandari University of Science and Technology (MBUST) in Nepal:

Master's and PhD Program in Forest Biomaterials Science and Engineering

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List of Abbreviations

AFM	Atomic Force Microscope
AFU	Agriculture Forestry University
AI	Artificial Intelligence
DSC	Differential Scanning Calorimeter
FSS	Forest Sector Strategy
FTIR	Fourier Transfer Infrared Microscope
GC-MS	Gas Chromatography-Mass Spectrometer
GDP	Gross Domestic Product
GPC	Gel Permeation Chromatography
HPLC	High Pressure Liquid Chromatography
IOF	Institute of Forestry, Tribhuban University
MAPs	Medicinal & Aromatic Plants
MBUST	Madan Bhandari University of Science and Technology
MBUSTDB	Madan Bhandari University of Science and Technology Development Board
MFSC	Ministry of Forests and Soil Conservation of Nepal
NFF	National Forestry Forum
NGO	Non-Governmental Organization
NMR	Nuclear Magnetic Resonance
NTFPs	Non-Timber Forest Products
SEM	Scanning Electron Microscope
SFM	Sustainable Forest Management
STEM	Science, Technology, Engineering and Mathematics
TEM	Transmission Electron Microscope
TGA	Thermogravimetric Analyzer
TU	Tribhuban University
UV-Vis	UV-Visible Spectrometer

Executive Summary

Madan Bhandari University of Science and Technology (MBUST) is envisioned to become a world-class university in developing innovative technologies and training of high caliper technical experts for accelerating economic growth of the country. This report outlines the framework for establishing a new flagship research focused graduate education program in ***Forest Biomaterials Science and Engineering*** at MBUST in support of its mission. The objective of the new graduate education program is to educate future leaders in sustainable development of forest resources for generating significant economic, environmental, and social and cultural benefits to the Nepalese people.

The new graduate education program will provide fully funded multidisciplinary training to master's students for 2 years and PhD students for 3 years at MBUST. Students are required to take technical credit courses related to fundamentals and applications of forest biomaterials, together with non-credit courses covering broad transformable skills in research methods and data analytics, and professional hard and soft skills in entrepreneurship, communications and leadership. Students enrolled in this flagship program will conduct leading-edge research to develop innovative commercializable green forest bioproducts, both timber-based and non-timber forest products, that are fit for the Nepal's context. The new flagship education program will offer experiential learning opportunities to students via participating in field trips to forest communities, internships at partner forest enterprises, and working in the state-of-the-art wood processing, materials characterization, and chemical analysis laboratories at the university. Students will gain international exposures by interacting with leading scientists from research and educational institutions around the world.

As an important natural resource in Nepal, forests are vital for supporting environmental stability, biodiversity, and livelihoods of rural communities. Despite the fact that 45% of Nepal's territory is covered by forests, contribution by the forest sector to national economy has been stagnantly below expectation. Outdated technology and lack of technical capacity are some of main reasons responsible for underperformance. The new flagship graduate education program at MBUST fits well with the strategic directions set by the Forest Sector Strategy 10 year-plan for 2016-2025 developed by the Ministry of Forestry and Soil Conservation of Nepal. By forging strong partnerships with all stakeholders, the new program will serve as a nucleus to create vibrant innovation ecosystems for developing groundbreaking research and engineering solutions to increase competitiveness of Nepal's forest products sector. Success of this new flagship graduate education program at MBUST will greatly help Nepal's forest sector to harness its potential as an economic engine of the country.

1. Introduction

The Government of Nepal has decided to establish Madan Bhandari University of Science and Technology (MBUST), envisioned as a world-class university, to support the country's aspirations for rapid economic growth. The expectation is that MBUST would be able to speed up the pace of economic growth by developing new technology and producing human resources with research capacity to enable Nepal to gain a competitive edge in the global market. The preparation for the establishment of MBUST is entrusted to Madan Bhandari University of Science and Technology Development Board (MBUSTDB). The university bill has been presented to the Parliament.

AI and IOT, water resources and energy, tourism and hill economy have been initially chosen as core economic sectors, which the university will engage in. MBUSTDB is in the process of identifying research areas related to these sectors of the economy, which can contribute to significant outcomes in terms of economic growth. The intention is to align academic research and teaching with the identified research areas. Development of products based on natural resources has emerged as one of the potential areas for research and teaching. One of such natural resources is forest resources.

At present, forest covers around 45% of territory of Nepal. Nepal experienced severe deforestation in the recent past. In the seventies, the risk of desertification was a matter of grave concern. Nepal was able to regenerate forest by adopting the policy of community management of forest. The current policy framework for forest management overall aims at conservation of forest and discourages the commercial use of forest resources, including timber products, fearing deforestation. While a large quantity of timber and other forest products rots away in Nepal, it relies heavily on import of timber and timber products.

The discourse on scientific forest management to exploit forest resources sustainably has begun. But due to the lack of adequate expertise in this area not much progress has been made. The existing higher education institutions have not been able to effectively contribute to the development of forest products as they are predominantly teaching institutions and focused primarily on conservation and management aspects. MBUST as a research-oriented university plans to address this gap. MBUST intends to start academic programs at the postgraduate level – PhD and Masters in support of utilization of forest resources. The goal of this consulting project is to establish a world-class graduate education program at MBUST that focusses on the sustainable development of forest products in accordance with the specific needs of Nepal.

2. Objective

The overall objective of this consulting effort is to develop a flamework for *establishing a flagship STEM-based research focused master and PhD graduate education program at MBUST to champion sustainable value-added utilization of forest resources in Nepal*. The new graduate program will train students in leading edge research and technologies related to forest products and allow students to gain professional skills so they can become future leaders in sustainable development of forest resources for creating significant economic, environmental, and social benefits to the Nepalese people.

Specifically, this consulting project plans to identify research areas pertinent for the development of forest products sector in Nepal, including both timber and non-timber forest products; suggest themes for master and PhD research; propose curricula for the graduate program; and formulate faculty, equipment, and resource requirements. Suggestions on ways to partner with government, industry, NGOs,

communities, and academic institutions to further enrich the program will be made. Leading international research and educational excellence centres will be listed as potential candidates for building global linkages to keep students in tune with the latest scientific development in the field. Students graduating from this flagship program will not only receive transformative education and world-class research and technical training, but also be instilled with a strong sense of connection to Nepal's forest community and global engagements.

3. Project Team and Approach

MBUST has engaged Dr. Ning Yan, a University Distinguished Professor and Director of the Low Carbon Renewable Materials Centre from the University of Toronto, Canada, as the lead consultant for the project. She was assisted by two local consultants, Dr. Sanjay Nath Khanal and Dr. Sudip Pandey. Prof. Rajendra Dhoj Joshi, Chairperson of the MBUSTDB, acted as the key liaison and provided guidance and advices throughout the project. This project was funded by the Asian Development Bank.

For completion of this consulting project, both literature survey and stakeholder consultation and feedback meetings involving a wide range of representatives from Nepal's business, policy, forest, and academic communities were conducted. Moreover, existing forest related academic programs in peer institutions in Nepal, including degree offerings at Agriculture Forestry University (AFU) and Tribhuban University (TU), were reviewed. Due to the COVID-19 global pandemic situation, all consultation meetings were conducted virtually via internet and all other communications were through emails.

4. Background Information on Nepal's Forest Sector

Forest resources are important for Nepal. They play a critical role in supporting livelihoods of rural communities while providing vital ecological services to protect environmental stability, biodiversity, and hydrologic functions. With the success of implementing community forest management practices and a long history of assistance from international development agencies, many regions of Nepal's forests (particularly in the Middle Hills) have recovered from extensive degradation and overuse in the past decades. But duality exists. Forest regions in Terai are still facing a greater risk of degradation due to poorer forest managements. Currently, economic benefits generated from Nepal's forest resources are mainly though forest products (both timber and non-timber products), carbon sequestration, and tourism. However, the contribution level by the forest sector to economic development and poverty reduction of the nation is significantly below expectation. For example, in 2006, officially reported revenue created from timber harvest was only 2.3% of what was conservatively estimated value that could be sustainably generated (US$4.18 million vs. US$180 million) [1]. Thus, forest sector has a tremendous potential for wealth generation for the Nepalese people while maintaining health and sustainability of the forest ecosystems and biodiversity.

The current well-accepted doctrine of sustainable forest management (SFM) is based on the principles of sustainable development that strives for integrated ecological, economic, and social and cultural benefits from the forest resources [2]. Forest sectors in many forest-rich nations known for well-established SFM practices are largely major national economic contributors [3]. Table 1 shows the level of contribution by forest sector for some forest-rich countries around the world compiled from various sources. The importance of the forest sector to a nation's economy can be seen clearly. More importantly, many countries are also major net exporters of forest products which help to bring significant revenues to increase their nations' wealth.

Table 1: Forest Sector Contribution to National Economy for Selected Countries

Country	Forest Coverage	Value Generated by the Forest Sector	% of National GDP	Sources
America				
Canada	40%	CAN$25.8 billion (2018)	1.2%	[4]
USA	33%	US$95.7 billion (2011) US$92.8 billion (wood, paper, furniture only) (2013)	0.6% 0.55% (5.3% of manufacturing GDP)	[5] [6]
Brazil	64%	US$22.5 billion (2011)	1.1%	[5]
Chile	24%	US$7.6 billion (2011)	3.3%	[5]
Europe				
Finland	73%	EUR€8.4 billion (2018)	4%	[7]
Austria	46%	US$7.1 billion (2011)	1.9%	[5]
France	31%	US$15 billion (2011)	0.6%	[5]
Germany	32%	US$26.1 billion (2011)	0.8%	[5]
Sweden	57%	US$13.8 billion (2011)	2.9%	[5]
Asia				
China	22%	US$127 billion (2011) Yuan¥4.46 trillion (2013)	1.6% 7.6%	[5] [8]
Vietnam	40%	US$2.4 billion (2011) US$9.4 billion (value for exported wood and timber products only) (2018)	1.7% 3.8%	[5] [9]
Japan	67%	US$40 billion (2011)	0.7%	[5]
Bangladesh	17.5%	US$1.5 billion (2011)	1.3%	[5]
Malaysia	62%	US$5.7 billion (2011)	2.0%	[5]
India	25%	US$31 billion (2011)	1.7%	[5]
Indonesia	52%	US$15 billion (2011)	1.7%	[5]
Nepal	45%	US$105 million (2011)	0.6%	[5]
Oceania				
Australia	17%	US$7.7 billion (2011)	0.9%	[5]
New Zealand	29%	US$2.9 billion (2011)	2.7%	[5]
Africa				
South Africa	7.6%	US$3.7 billion (2011)	1.0%	[5]

Meanwhile, in Nepal, wood is harvested to provide fuelwood and timber. Fuelwood generates the lowest value, while highly valued wood is utilized as poles for construction and furniture. The main timber species in Nepal are Sal, Asna, and Sissoo with the price of Sissoo being the highest and Asna being the lowest. Sal has the largest market share at 56% [10]. It is evident that the forest sector has not yet capitalized on its full potential. For example, the productivity of timber is below 0.5 million m^3 annually given a total of 982.3 million m^3 of standing volume available in the country. Annually, timber and timber products import (US$38 million) is 65 times higher the export (US$ 0.62 million) [11-15].

Nepal's rich biodiversity provides a wide variety of plant species for non-timber forest products (NTFPs) with 700 plant species and 150 species involved in international trade. Around 80% of rural communities in Nepal relies on NTFPs for supplying of food, medicine, construction, and income. Categories of NTFPs according to their use are: medical and aromatic plants (MAPs); fibre; paper (such as Lokta); dyes; bamboos, rattans, and vines; wild food; resin, soaps/detergents; and others like Sal seed, etc. The volume of trade was more than 33,000 mt in 2012 and the export value for NTFPs was US$59 million in 2012. Despite of a growing market demand and a wide variety of NTFPs available form Nepal's forest, the contribution by NTFPs to national and local economy is still lagging behind. Better harvesting and processing techniques for increasing yield and product quality are needed in order to better explore the potential of NTFPs for income generation [16].

The underperformance of the Nepal's forest sector in providing economic benefits is the result of many complex factors, ranging from unfavorable management policies, lack of access, supply, and investment, to antiquated technologies and poorly trained human capitals. Recently, Ministry of Forests and Soil Conservation of Nepal (MFSC) has released the policy document: Forest Sector Strategy (FSS) (2016) to guide the implementation of the framework set by the Nepal's Forest Policy (2015) over the next 10-year period (2016 to 2025) [11]. A key outcome that FSS aims to accomplish is to raise economic contributions by the forest sector via increased sustainable production and supply of forest products.

Some specific outcomes to be achieved by FSS include:

- Increase the forest area being managed in a sustainable and productive manner;
- Promote wise and efficient use of forest products;
- Ensure transparent, predictable and stable supplies of forest products and services;
- Improve the harvesting technology for forest products and promote 'green' products;
- Enhance partnerships, collaboration and coordination between sectoral agencies, academic institutions, civil society, the private sector and communities;
- Establish *National Forestry Forum (NFF)*;
- Promote biomass-based renewable energy;
- Diversify and optimize the utilization of forest products and services;
- Encourage and promote competitiveness in supply and value-addition of forest products and services;
- Promote community-based and private forest enterprises for livelihoods improvement and wealth creation, especially for the poorest;
- Promote forest-based job creation and incomes in all areas of the sector;
- Increase the role of the private sector to encourage investment in cultivating forestry crops (including trees and Non-Timber Forest Products (NTFP)/ Medicinal & Aromatic Plants (MAPs)), in forestry operations, including service delivery, and forest-based enterprises and eco-tourism.

For each thematic area identified by FSS, clear targets that will be attained by 2025 are specified. Few examples of these milestones are shown below:

- Forestry sector contribution to GDP to be quantified;
- Forestry sector generates at least 1.2 million full-time equivalent jobs annually;
- 1 million m^3 of timber commercially supplied to the domestic market annually and timber imports reduced to zero;

- Annual export value of NTFPs/MAPs increased from about NRs 6 billion to at least NRs 12 billion;
- Establish *three accredited regional laboratories*.

In particular, for the thematic area of "Enhancing Capacities, Institutions, and Partnerships", priority actions proposed related to forestry education include curricula revision, teaching and research enhancement, and more knowledge-sharing and partnership between all stakeholders for forestry-based research. These action plans intend to create conducive environments to attain the goal of sustainable forest management of achieving balanced social, economic, and environmental benefits. To better realize economic potential of the forest sector will be strategically important for Nepal's future growth.

5. Existing Forest Related University Educational Programs in Nepal

Of the 11 existing universities in Nepal, forest related programs are offered only at two of them, namely, TU and AFU. The Institute of Forestry (IOF) at TU provides educations in the field of forestry, biodiversity conservation, and natural resource management. The institute delivers Bachelor, Master and PhD degree programs for training students specializing in forest conservation and management. Bachelor's degree in forestry is a four-year program that students are taught courses covering a broad range of forestry science topics. There are two master's programs at IOF: Master of Science in Forestry and Master of Science in Community Forestry. IOF also offers PhD degrees for students with a master degree in forestry that wish to further advance their trainings.

AFU, established in 2010, is a state-owned university focusing on higher education, research and extension in agriculture, veterinary, animal science, fisheries, and forestry. The university is fully supported by the Government of Nepal with an aim to produce well-trained human resources to modernize agriculture and forestry for the improvement of social and economic status of the rural people. The forestry related education programs at AFU are offered through the Faculty of Forestry that include B.Sc. Forestry, M.Sc. Forestry, and PhD degree programs. The Faculty of Forestry at AFU is organized into eight departments, including the Department of Forest Products Utilization, that offer both undergraduate and graduate degrees across the bachelor, master and PhD levels.

Feedbacks from multi-stakeholder consultation meetings suggest that forest programs at both universities are doing well with a steady growth in enrolment and successful graduate job placements. Both forest programs expose students to the whole spectrum of forest sciences and share a similar emphasis on forest conservation and management. However, there is a gap in advanced research-based training program in forest products in Nepal, especially at the graduate level. For example, trainings related to production of value-added timber products in line with commercial needs and market demand, and efficient harvesting for timber and non-timber products are missing. Highly-trained technical personnel with expertise in developing valued-added products from Nepal's forest resources are needed to lead the transformation of the sector into significant drivers for prosperity and economic growth.

6. Challenges and Opportunities

In today's knowledge-driven economy, technology and innovation are the key for wealth generation. The importance of innovation capacity to national prosperity has been well-established by Dr. Joshi's report [17]. In order to jump start the forest sector in Nepal as an economic engine for sustainable development of rural communities, world-class research capacity in science, technology, and engineering is critically needed by the sector.

MBUST is established with the ambition of being a research-oriented world-class institution. The primary mission of MBUST is to deliver leading-edge research and training programs and to develop innovative technologies for helping Nepalese enterprises upgrade production technology and increase competitiveness. MBUST aims to become a catalyst in stimulating economic growth and job creation of the country by forging strong partnerships with all stakeholders in government, industry, academia, and communities for the creation of vibrant innovation ecosystems. Specifically, MBUST will strategically aligns its academic programs and research with high potential economic sectors for country's economic growth. Forest sector in Nepal with its significant untapped potentials for rural development presents an excellent opportunity for MBUST to launch research training programs.

However, there are a number of key challenges need to be addressed in order for the research educational program at MBUST to play an effectively role in the transformation of the forest sector. Some of these challenges are summarized below:

1. Currently, forest products industry is poorly established. Significant problems exist across the entire value chain from timber supply, processing, downstream converting, to trading and market access [18]. *It will be difficult for any university research and training program to generate strong impacts without the full support of a well-established product supply value chain.*
2. The technical receiving capacity of the forest sector for capitalizing technology innovations developed by universities is very low due to the lack of highly trained technical work force in the sector. *Substantial challenges present in how to move research findings from university labs to practical applications in industry*.
3. Forest enterprises in Nepal still rely primarily on antiquated processing equipment and technologies due to the lack of financial investment and skilled labour force. *This creates additional barriers for improving product quality and producing more valued-added products for higher economic return* [19].
4. Most state-of-the-art technologies in forest products are based on large forest supply scenarios in developed nations where strong focusses are placed on *capital intensive, high volume, and high productivity products. While in Nepal, these are not viable product options*.
5. Historically, forest sector is seen as a low-tech sector with poor financial compensations to the public. *This biased negative perception prevents talented young people as well as potential investors getting into the field*.
6. Multidisciplinary approaches are needed for developing novel forest products while the current university educational programs in Nepal are still following rather *rigid disciplinary classifications/boundaries that are not conducive for collaborative efforts*.

Therefore, designing of the new graduate research training program needs to consider these challenges and identify pathways that not only allow the delivery of world-class education and research trainings to the students, but also facilitate practical adaptation of research findings from the university to generate tangible benefits to the forest communities. The program should take advantage of a number of trends and governmental policies to devise effective measures for addressing these challenges. They include:

1. MFSC has listed improving forest management for better timber yield and supply, revising timber access and tender policies, and strengthening forest products value chain as some of the major actions in FSS for making the forest sector a bigger player in the economic growth of the country. *Innovative technology and value-added products from the new research program at MBUST* would

help to better inform MFSC and policy makers to develop strategies for constructing a functional value chain for manufacturing of value-added forest products. Meanwhile, students trained by the program with a wholistic understanding of the interplay among policy, management, conservation, and utilization of the forest sector in Nepal would be able to identify appropriate entry points of their innovations to ensure their technology pursuits meet Nepal's local needs.

2. The graduates from the new research and educational program will enhance innovation capacity of the forest sector. *To overcome the current lack of technical experts in the industry, graduates from the new research and education program should possess not only technology expertise, but also entrepreneurship skills so they can champion commercialization efforts by forming start-ups and SMEs to bring new products to market. Therefore, curriculum design of the new program needs to include trainings also in skills in business, leadership, and communications so these students can act as future leaders for changing the sector. Having extension capacity built into the university research program will also greatly help with tech transfer activities.*
3. University can play a highly supportive role in helping forest industry to attract investments for upgrading machinery and implementing latest technologies. *University can use their expertise, infrastructure, and lab facilities to help business community carry out proof-of-concept studies to reduce investment risk and build compelling business case for justifying upgrading expenditures*.
4. Nepal's forest stock is heterogenous with significant differences in species, availability and management practices among different geographical regions (i.e. Hill vs. Terai) [20]. The newly designed research program should place a strong emphasis on topics suited for the type of forest resources in Nepal according to local needs. For example, popular harvesting practice in community managed forests is largely based on selective low intensity logging of 3D (dead, diseased, and degraded) wood and a significant amount of wasted biomass exists both in the forest and at the saw mill, research geared towards products that can use these under-utilized/waste resources would be highly beneficial. Also, timber processing in Nepal is primarily based on Sal timber and few other selected hardwood species only, softwoods and other local species are not explored. Meanwhile, there are also tremendous opportunities in producing more NTFPs/MAPs, upgrading product quality, and increasing market competitiveness. *By focussing on local needs of the sector, research from the new university program will be able to effectively apply knowledges gained from other countries based on different forest management regimes to suit Nepalese context.*
5. The new program at MBUST involves research and innovation at the forefront of technological development related to green products. *Better branding and more effective outreach will help to rectify the biased public view of the sector and to better reflect the dynamic and technology intensive nature of the new program.* They will also help to educate the public about the strategic importance of the forest sector to the country.
6. *Recruiting faculty members and students with diverse technical backgrounds and forming partnerships across different academic disciplines will help to eliminate silos and allow for cross fertilization of ideas and approaches.* They will help to develop solutions for some complex problems existing in the forestry sector. Multidisciplinary based curricula would also impart students with a system's view and teach students collaborative approaches that are required for the real world.

Incorporating these strategies will help the new training program at MBUST overcome these major challenges to be successfully in meeting the needs of the forest sector in Nepal.

7. Proposed New Graduate Program in Forest Products at MBUST

The proposed research and education program at MBUST will be *a STEM focused master and PhD program focused on developing sustainable technologies for value-added utilization of forest resources*. The program will train students in how to apply leading-edge research and technologies for sustainably developing Nepal's forest resources to generate economic, environmental, and social benefits to the Nepalese people. Some key features of the program include:

- The new research-based master and PhD program will have a distinctive focus that differentiates from, but complements the existing forestry related graduate programs in Nepal.
- The program will include both timber and NTFPs as research topics.
- Students will build a solid foundation in fundamental science and technology in materials science, chemistry, physics, and engineering related to forest biomaterials. While at the same time, they will develop an understanding of Nepal's forest conservation and management practices and the importance of the forest sector to climate change, biodiversity, sustainable development, economic income, and social equity.
- Students enrolled in the program will be exposed to frontier science and technology developments through interactions with leading scientists from around the world and be provided with opportunities to participate in international training programs.
- The program will deliver experiential learnings to the students. They will gain first-hand knowledge with the forest sector through field trips, internships, and collaborative projects on real problems. They will also work in the state-of-the art laboratory facilities at the university.
- Students will be taught latest research analysis and computer programming tools, such as AI and data analytics and modeling,
- The program will also incorporate entrepreneurship, communications, and leadership trainings in the curriculum to further develop students' professional skills.
- The program will strive to be a magnet for attracting bright young people to the forest products sector and will act as a nucleus for building partnerships among industry, community, academia, and government for an enriched educational experience.

8. Proposed Program Name

Based on the feedbacks from stakeholder consultation meetings, "***Forest Biomaterials Science and Engineering***" has been selected as the proposed name for the new graduate education program at MBUST. By including both "science" and "engineering", this name captures well the fact that the new program will cover both fundamental sciences and applied engineering aspects related to forest biomaterials. Particularly, the incorporation of "engineering" makes clear the applied focus of the research program and helps to attract top engineering students to be interested in the program.

Moreover, globally there is a growing trend of shifting away from more traditional program names, such as wood science and forest products, to names that can better convey the idea that the discipline is working with a natural biomaterial using leading edge science and technologies from a broad field of materials science and engineering. Thus, there is an increasing trend of using terms, such as biomaterials, and renewable materials, for names (see Table 2 below). Table 2 shows that many traditionally strong wood science/forest products educational institutions have changed the names for either their department or their program.

Table 2: Program Name and Degree Offered by Some Major Forest Products Educational Institutions

Department, Institution	Degree and Program Name
Wood Science Dept., University of British Columbia, Canada	B.Sc. in Forest Bioeconomy Sciences and Technology M.A.Sc. in Forestry, PhD.
Dept. of Wood Science and Engineering, Oregon State University, USA	Bachelor in Renewable Materials: Advanced wood manufacturing, Science and Engineering options M.Sc., PhD.
Dept. of Sustainable Biomaterials, Virginia Tech., USA	Bachelor in Sustainable Biomaterials Science M.Sc., PhD.
Institute of Wood Technology and Renewable Materials, BOKU University, Austria	Bachelor, Master, and PhD. in Wood and Natural Fibre Technology
Dept. of Bioproducts and Biosystems, Aalto University, Finland	Master's in Chemical, Biochemical, and Materials Engineering, Doctoral program in Chemical Engineering

Keeping the word "forest" in the name of the proposed program at MBUST provides a stronger identification/connection to the forest sector. The new program at MBUST will offer fully funded training to students at both master's and PhD levels. Master students will be funded for 2 years and PhD students for 3 years to pursue their degree studies.

9. Curricula Design

Students enrolled in the new graduate program will gain technical knowledge and professional skills by taking courses and conducting research. However, there is a strong emphasis on generating publishable scholarly work and patentable inventions by self-directed thesis research under the guidance of a faculty supervisor. Details about course offerings and other program requirements are covered in following sections.

9.1 Course Offerings and Requirements

Students will be offered required technical core courses and technical electives to help them learn fundamental knowledges and gain technical specialties. All students are also required to take mandatory non-credit courses covering non-technical professional skills. To complete the program, students need to write a thesis summarizing the results of their research and pass the thesis defense.

For the 2-year master program, program structure and the required degree components and number of credits are given in Table 3 below. The number of courses and the distribution of credit and non-credit courses across different semesters are done by considering the following considerations:

- Students with diverse backgrounds can gain enough fundamental knowledge and develop sufficient basic understandings and first-hand experiences in processing of wood and NTFPs within the first semester so they can effectively work on their research project quickly. Thus,

students are required to take two core courses (one in biomaterials science, and one in biomass conversion) within the first semester after they enter the program.

- Students will also be taught research methods and numerical and computer analysis tools. They will gain an overall knowledge of the forest sector in management, policy, conservation, and sustainable development areas. As a result, they will take two non-credit courses: one in forest management and conservation and one in research methods and data analytics.
- For the second semester, with the knowledge gained from the first semester, students will be taking a core course delivered as an invited lecture series. The course will be taught by leading experts from a broad range of fields relevant to forest products around the world. This course will students connected with the latest technological developments globally to ensure their research projects are built on most up-to-date scientific findings. They will also receive training through a non-credit required course in entrepreneurship, communication, and leadership skills that will help them to better disseminate and communicate their research findings to broad audiences and assist them to commercialize new technologies developed at the end of their program.
- Students will be able to dedicate a significant amount of their program time to focus on their thesis project so they can produce high caliper thesis work that is publishable in leading scientific journals and suitable for practical implementations. Thus, students will spend a significant amount of time (21hrs per week) to work on their thesis from 2nd semester with a lighter course load.
- Students will work full time on their thesis research for the second year of the program.
- Master students are not required to take technical electives. However, if they wish to gain more depth in a particular field to help with their thesis research, they will be permitted to do so with the approval of their thesis supervisors.
- Workload for students per semester will be in-line with the workloads for other Nepalese institutions.

Table 3: Program Component and Workload per Semester for the 2-year Master's Program

Semester	Core Course	Open Elective^	Thesis++	Total Credit course**	Non-credit course***	Workload (Credit Course) (h)	Workload (Non-Credit Course)+ (h)	Workload Per Semester+++ (h)
I	2	-		2	2	384	384	768
II	1*	-	7	1	1	528	192	720
III-IV	-	-	16	-	-	768	-	768

* Advanced Topics in Sustainable Bio-based Products Course (invited lecture series)

** Credit courses (4 credit-hour each)

*** Non-credit courses (4 credit-hour each)

+1 Cr. hour = 1 hour in class room and 2 hours outside class room per week

++1 Cr. hour thesis is equivalent to 3 hours student work per week.

+++One semester is 16 weeks. Workload per week is 45-48 hours

^Elective course is not required, but students may take them if they wish with the approval of their supervisors

Meanwhile, the total required minimum course credits for the master's program are shown in Table 4 below:

Table 4: Minimum Required Components and Credits for the Master's Program

Category	Required Component	Number of Courses	Credit	%
1	Core Courses (including Advanced Topics in Sustainable Bio-based Products course)	3	12	26
2	Mandatory Non-credit Courses	3	0	0
3	Thesis (independent research work under supervision initiated in the first year and to be complete in 2 years)*	-	38	76
Total		**6**	**50**	**100**

The required degree components and course credits for the PhD program are given in Table 5 as shown below. Similar considerations to those for the master's degree are made with the following differences:

- PhD student will be required to take at least one technical elective to acquire more depth in a specialized field.
- Students will start to work on their thesis project from 2nd semester to formulate a PhD thesis proposal in preparation for the qualifying exam which they have to pass within the first year.

Table 5: Program Component and Workload per Semester for the 3-year PhD Program

Semester	Core Course	Open Elective	Thesis++	Total Credit course***	Non-credit course****	Workload (Credit Course) (h)	Workload (Non-Credit Course)+ (h)	Workload Per Semester+++ (h)
I	2	-		2	2	384	384	768
II*	1**	1	4	2	1	576	192	768
III to VI	-	-	16	-	-	768	-	768

* Passing of a qualify exam on doctoral thesis proposal within the 1st year of the program is required

**Advanced topics in sustainable bio-based products course (invited lecture series)

*** Credit courses (4 credit-hour each)

**** Non-credit courses (4 credit-hour each)

+1 Cr. hour = 1 hour in class room and 2 hours outside classroom per week.

++1 Cr. hour thesis is equivalent to 3 hours student work per week.

+++One semester is 16 weeks. Workload per week is 48 hours

In summary, the required course credits and other program components for the PhD program are given in Table 6 below:

Table 6: Required Degree Components and Credit for the PhD Program

Category	Required Component	Number of Courses	Credit	%
1	Core Courses (including Advanced Topics in Sustainable Bio-based Products course)	3	12	16
2	Technical Elective	1	4	5.3
3	Mandatory Non-credit Course	3	0	0
4	Passing Qualifying Exam	-	-	-
5	Thesis (independent research work with supervision initiated in first year and to be completed in 3 years)*	-	59	78.7
Total		**7**	**75**	**100**

9.2 Overall Course Curricula Design

Proper design of course offerings is an important aspect to ensure students will be successful in the program. The goal of the program is to provide wholistic training to the students so they can develop into future leaders. The proposed structure for the course component of the curriculum covers a wide range of areas, including core fundamentals, technical specialties, research analytical tools, social and political context of the field, experiential learning opportunities, and professional skills and entrepreneurship development. However, there are some challenges we have to overcome in order to be able to cover such a broad area of topics.

- Students entering the program may have large variations in their background preparation and skill levels given their bachelor degrees may be from a wide range of disciplines, departments, and institutions.
- At the start of the program, the course offerings will be limited given the small number of faculty members.
- Demand for the number of courses will not be large for the first couple of years due to a small student enrollment number.
- Number of the required courses has to be balanced against workload to allow sufficient time for students to conduct a significant amount of research work.

Additionally, since MBUST is a new university, there is no existing courses to be taken advantage of by the program within the university. However, there are possibilities to explore other universities to collaboratively deliver course contents and/or expand course options, especially with TU and AFU.

By looking at courses offered at other leading forest products education institutions, we designed a smaller set of credit and non-credit courses to focus on key concepts while still be able to cover the broad knowledge base we like students to acquire from the program. The list of courses, especially technical electives, will expand as the student enrolment and faculty complement grow.

The overall course offerings will cover three categories: credit core courses, credit technical electives, and non-credit required courses. More detailed discussions of these courses are given in the sections below.

9.2.1 Mandatory Non-credit Courses

There will be three non-credit courses (pass/fail) that all students regardless of their program (master or PhD) are required to take. They are listed in Table 7 below:

Table 7: List of Mandatory Non-Credit Courses for All Graduate Students

Course Name	Course Modules to be included in the Course
1. Research Methods and Data Mining	• Research methodology (critical literature review, formulation of research proposal, and develop research hypothesis, etc.) • Statistical analysis (Design of experiments, analysis of variance, data regression, correlation analysis, etc.) • AI and data analytics (Computer coding and deep learning basics, clustering analysis, etc.)
2. Forest Conservation and Management	• Forest conservation and management systems and practices • Forest and climate change • Forest timber extraction and tenure systems • Environmental management, circular economy, and carbon policy • Sustainable development issues and UN goals • Field trip to community forests and forest products production facilities
3. Entrepreneurship, Communications, and leadership	• Entrepreneurship (business case and startup) • Leadership skills • Communications (technical writings and presentation skills)

The course on research methods and data mining will teach students skills necessary for conduct research, ranging from critical literature review to data analysis. The course will also teach students some basic skills in experimental design and statistical analysis and provide basic trainings to students in AI and machine learning techniques. This course is recommended to be offered together with the new organic agriculture and AI graduate programs at MBUST.

Students will take the forest management and conservation course to gain a broad knowledge base about the interplay between environmental protection, social equity, and sustainability development. They will

develop an overall understanding of Nepal's unique forest management system and the importance of the forest sector as well as the challenges. They will be able to related Nepal's local scenarios to global sustainable development initiatives. Moreover, they will also build connections to Nepal's forest communities through field trips and internships.

The Entrepreneurship, Communications, and Leadership course will allow students to further improve their professional skills and learn how to start a business. They will be trained on how to effectively communicate their research findings and pursue commercialization of their research findings. These skills are vital for students to be successful in their future professional career and to become change agents for the forest sector.

Due to the diverse topics need to be covered, it is recommended that these courses are offered in partnership with other graduate programs at MBUST with course modules team taught by internal and external professors and experts. The non-credit courses will be run in a seminar format in modules and students are required to attend the seminar talks, complete course projects, make presentations, and participate in course activities.

9.2.2 Core Courses

All technical core courses and elective courses will be conducted as lectures and guided studies that are combined with project-based learnings. Specifically, there are three proposed core courses as listed in Table 8 below. The core course in fundamentals of forest biomaterials will also include a lab component to allow students work in the state-of-the-art laboratories to gain hands on experiences in working with forest biomaterials. This course will also teach students about wood-based products in terms of sawn lumber, wood panels, and various types of composites. New technologies like 3D fabrication will also be introduced.

Table 8: List of Core Courses for All Graduate Students

#	Course Title	Description
1	Fundamentals of Forest Biomaterials Science (incl. Labs on design and fabrication)	Wood anatomy, wood interaction with the environment, wood grading and mechanics, wood chemistry, wood treatment, wood processing, wood-based products (lumber, plywood, wood panel and composites, wood parquets, mass timbers), 3D fabrication, and materials testing
2	Biomass Conversion Technologies	Chemical conversion, thermal-chemical conversion, biological conversion, nanomaterials and nanotechnology, bioenergy, biofuel, bio-based chemicals, and advanced bio-based materials
3	Advanced Topics in Sustainable Bioproducts (invited seminars)	Guest lectures on the latest developments related to sustainable bioproducts from around the world

Biomass conversion course will allow students to gain an overall understanding on various mechanical, chemical, and biological pathways for utilizing biomass for producing energy, materials, and chemicals. Moreover, advanced functional materials, including nano-bio-materials produced from biomass, will also be covered.

The goal of the seminar course on advanced topics in sustainable bioproducts is to expose students to the latest breakthroughs in the field and spark their interests and ideas in how to apply latest scientific discoveries to their research projects. The course will also help them to build global connections.

9.2.3 Technical Elective Courses

Proposed technical elective courses that PhD students can take to expand their breadth in knowledge or gain a specialization in a particular topical area. A list of suggested courses is included in Table 9. Master students are not required to take technical electives, but they can still take the electives if they wish to gain more depth with the approval of their thesis supervisors as extra courses.

Table 9: List of Suggested Technical Elective Courses

#	Course Title
1	Mechanics of Biomaterials and Biocomposites
2	Bonding and Adhesion sciences and Technology
3	Wood Drying, Grading, Finishing, Treatment, and Protection
4	Non-timber Forest Products Processing and Value Addition
5	Natural Products Chemistry
6	Bioenergy, Bio-carbon, and Biorefinery
7	Biological Treatment and Conversion of Biomass
8	Utilization of Bamboo and Other Non-wood Natural Materials
9	Furniture Design and Construction (in partnership with a design and architecture school)

Technical elective course offerings should align with the expertise of the faculty complement. At the beginning of the program, due to a small number of enrolled PhD students, there will be only a limited demand on the elective course options. Nevertheless, course #1-4 are suggested to be made available initially since they would help students gain a deeper understanding in areas that are currently in need by the forest products sector. As the student demand for electives and the number of the faculty members grow, course #5-9 may be gradually added. Course #9 needs to be taught in collaboration with a furniture design/art school.

9.3 Course Grading System

All courses will be marked using letter grades. Descriptions of the grading system and the corresponding grade point average (GPA) is given in Table 10 below:

Table 10: Suggested Grading System

Letter Grade	Explanation	Grade Point Average (GPA)
A	Excellent	4.0
B	Good	3.0
C	Satisfactory	2.0
D	Poor	1.0
F	Failure	0.0

Thesis for master and PhD degrees will be graded as either pass or fail in the final transcript.

9.4 Degree Requirements

Degrees will be conferred to students after they have successfully completed all required courses and other degree components, including thesis defense. An overview of the minimum requirements for awarding the master and PhD degrees are shown in Table 11:

Table 11: An Overview of the Degree Requirements

Degree Requirement	Master Degree	PhD Degree
Course Requirements	3 Core Courses+ 3 Non-Credit Courses (Overall GPA>2.0)	3 Core Courses + 1 Elective Course+3 Non-Credit Courses (overall GPA>2.0)
Qualifying Exam	_	Pass
Conference Presentation (at least)	1	2
Paper Submitted to Peer Reviewed Scientific Journal [SCI (index) journals or equivalent] (at least)	1	2
Paper Accepted/Published by Peer Reviewed Scientific Journal: [SCI (index) journals or equivalent] (at least)	-	1
Thesis Defense*	Pass	Pass

* must secure an overall GPA>2.0 (cumulative grade point average) in credit courses and pass all non-credit courses to qualify for thesis defense.

It is also recommended to award honors and scholarships to students recognizing top performing students who have excelled in the program.

10. Research Themes/Topics

The new graduate research program at MBUST should be strategically focused on few key research areas of strong relevance to the forest sector in Nepal initially to allow for a quick establishment of core competency and visibility. Based on the current needs of the Nepal's forest sector and feedbacks from stakeholders' meetings, initial research efforts are recommended to concentrate on two broad thematic areas, i.e. conversion of forest wastes/residue streams and low-quality wood into value-added products and improvement of processing and quality of NTFPs. Some example research topics for master and PhD projects are given below:

- Applying tree branches, mill wastes, and under-utilized low-quality wood as wood composites and solid fuels
- Pyrolysis of woody biomass for biofuel, biochemical, biochar, and biocarbon products
- Using low quality wood as laminated wood beams and poles for higher value return
- Utilizing softwood species in Nepal for making plywood and other wood-based products
- Improving processing technologies for Sal and other species wood indigenous to Nepal (drying, veneering, etc.)
- Developing functional wood treatments and bonding and coating technologies for value-added wood products
- Studying the effects of climate change and ecological practices on wood anatomical features and wood quality
- Explore value-added utilization of bamboo and rattan resources in Nepal
- Extracting medicinal and nutraceutical compounds and specialty chemicals from Nepal's forest resources
- Improving extraction and purification of essential oils, aromatics and turpentine etc.

There are some other areas of research are very important. For example, *improving productivity and yield of timber and NTFPs from Nepal's forests and Developing better harvest techniques are important areas for the production of forest products. But these topics are best pursued in partnership with forest ecologists and forest management experts from other institutions to achieve the best outcome*.

As faculty complement grows, the research topics can be broadened to include other topics, *such as biological treatment of biomass, biomass catalysis, advanced smart and functional materials from biomass, natural fibre production, and etc*. Research synergies should be explored to develop joint research projects with organic agriculture and AI and IOT programs at MTBU. *Some example projects include application of forest extractives and biochar as organic pesticides and soil fertilizer; utilization of organic agriculture waste stream for bioproducts; deployment of machine learning tools to predict wood quality and improve product quality and consistency.* These joint projects will help foster more collaborations and exchanges among different programs to create a dynamic innovative environment on campus, which is a key feature of a world-class university.

11. State-of-the-Art Laboratories

State-of-the-art laboratory facilities are critical for the success of the new graduate program at MBUST. Lab facilities will be able to support research and innovation that are at the cutting-edge. The facilities will help to build academic and industry partnerships and provide hands on experiences to the students. Based on the selected initial thematic focus of the research program, the suggestion is to first establish ***three main laboratories*** specializing in wood processing, structural characterization, and wet chemistry and chemical analysis areas. Suggested equipment for each laboratory is listed below:

1. **Wood Processing Laboratory**

    - Kiln, grinder, screening, veneering machine, wood particle rotary blender, **hot press (both lab bench top and lab pilot scales)**, **twin Screw extruder (bench top and floor standing models)**, **weighing scale, fume hood, rheometer, oven, tube furnace, bomb calorimeter, universal mechanical tester** (Instron-type), impact tester, x-ray densitometer, access to machining and 3D fabrication labs at MBUST

2. **Structural Characterization Laboratory**

    - **Optical microscope, Leica Rotary Microtomes and LINTAB, TSAP Win software (For wood anatomical studies**), **Scanning Electron Microscope (SEM),** (Transmission Electron Microscope (TEM) and Atomic Force Microscope (AFM) in future)

3. **Wet Chemistry and Chemical Analysis Laboratory**

    - **Standard wet chemistry lab set up, fume hoods, Soxhlet extractor, evaporator, reactor, centrifuge, solvent cabinets, stirrer, hot plate, freeze drier, viscometer, gas cylinder, Gel Permeation Chromatography (GPC), High Pressure Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometer (GC-MS), Differential Scanning Calorimeter (DSC), Thermogravimetric Analyzer (TGA),** access to Nuclear Magnetic Resonance (NMR), Fourier Transfer Infrared Microscope (FTIR), and UV-Visible Spectrometer (UV-Vis) facilities at MBUST

The suggestion is to acquire the equipment shown in bold at the start. The rest of equipment can be added according to the need and expansion of the program and faculty expertise. A proposed rough layout for the laboratories is given in **Appendix I** according to the available room space of 43x50 ft^2 at the low carbon bamboo building. **Appendix II** gives an example of manufacturer and model for few main processing equipment (bench top and floor standing hot press, bench top and floor standing twin screw extruder, and universal testing machine). It is recommended that these examples are used only as a guide. There may be more cost-effective options that are made by India or China available. It will be more economic to explore those options instead. Suppliers for other equipment could be either easily identified or may be sourced locally.

The Wood Processing Laboratory will be necessary for supporting research projects dealing with manufacturing of both traditional wood products and new wood-based products and composites. Instruments in Structural Characterization Laboratory help to provide a better understanding of structure-property relationship of materials. The Wet Chemistry and Chemical Analysis Laboratory enables research in the area of wood adhesives, extractives, and synthesis of bio-based chemicals.

Moreover, all labs will be used as teaching labs in support of the core course: Fundamentals of Forest Biomaterial Sciences. Students will learn how to operate machinery in the Wood Processing lab to make novel wood products as part of their course projects. They will also learn how to interrogate microstructures of wood materials using microscopes in the Structural Characterization lab. Moreover, students will be trained on how to perform chemical compositional analysis for wood and extractives. These hands-on trainings are critically important for students to link university research with the practical needs of the real world.

As the program grows, MBUST may consider to add another biotechnology laboratory focusing on biological treatment and conversion of biomass together with hiring a faculty member with expertise in areas such as microbiology or bioprocessing. Some of the equipment to be included for the biotechnology laboratory includes:

- Biotechnology Laboratory (future expansion): lab and pilot scale fermenter and bioreactor, incubator, autoclave, Gel Electrophoresis equipment and transilluminator apparatus, laminar flow hoods, PCR thermocyclers, live cell microscope, biological safety cabinets.

Another important function for these state-of-the-art labs is to attract industry partners to work with the university for collaborative research and development activities. These facilities can help companies to perform product testing, trouble shooting, and processing evaluation.

According to FSS set by the ministry, *MFSC plans to fund three certified regional labs for the forest sector, MBUST is recommended to discuss with the ministry for opportunities to host a certified regional lab (such as machine grading of lumber, plywood and other panel performance grading, etc.) on campus*. A certified lab will help industry launch new products into the market and generate revenues by performing product certification services for forest enterprises to pay for regular operation and maintenance of the facilities. At the same time, the facilities in the certified lab can also be used for teaching and research purposes.

Besides the three laboratories, MBUST also owns 600 hectares of forest land managed by the local community forest users. Visits to these forests can be arranged in support of classroom teaching of fundamental wood sciences and student research projects. *Forests owned by MBUST can be a good choice to act as a test/pilot site for implementing new technologies developed by the new research program.*

The suggested equipment related to lumber and veneer processing listed under the wood processing laboratory requires a much larger lab space. *One recommendation is to explore the possibility of building a small sawmill in the forest owned by MBUST in collaboration with the communities that are managing the forest.* The sawmill could then serve both as a teaching site and as a research location for the program. Moreover, products produced by the mill could also generate incomes to the university and the communities involved. Additionally, the sawmill could also be developed into a service training site for the sector with MBUST offering short-term training courses to the forest industry. This will create further revenue streams to support the new program.

12. Student Recruitment

Both master and PhD programs will admit students with academic backgrounds from a wide range of disciplines. Master program requires applicants to have obtained a bachelor degree, while PhD program requires applicants to have obtained a master degree previously. A degree from the following majors are considered acceptable.

- Wood Science/Forest Products/Forestry
- Materials Science
- Engineering (Mechanical, Chemical, Materials)
- Chemistry
- Physics
- Computer Science (for modeling and AI and data analytics type of projects)
- Biology/Biotechnology/Bioengineering

Recruitment efforts should aim for attracting top performing students via extensive marketing and promotion of the new program to targeted pool of applicants. *The program should recruit not only fresh graduates but also students with some prior working experiences in the sector.* Particularly, *admitting students who can be funded by their own employers to upgrade their knowledges would be highly desirable.* It is beneficial to have students with different academic backgrounds and experiences in the program since it will stimulate diverse ideas and views that are crucial for innovation.

The enrolment targets for the first cohort intake are 5-10 master's and 3 PhD students. If the admission is to be held steady at annually 5 (or 10) master's students and 3 PhD students, we would reach a steady state of 19 (or 29) students per year at year 3 of the program, as shown in Table 12.

Table 12: Number of Students in the Program with a Steady Intake of 5-10 master and 3 PhD Per Year

Students	Year 1	Year 2	Year 3	Year 4	Year 5
New	5 master + 3 PhD (or 10 master)	5 master + 3 PhD (or 10 master)	5 master + 3 PhD (or 10 master)	5 master + 3 PhD (or 10 master)	5 master + 3 PhD (or 10 master)
Continuing	-	5 master + 3 PhD (or 10 master)	5 master + 6 PhD (or 10 master)	5 master + 6 PhD (or 10 master)	5 master = 6 PhD (or 10 master)
Total Count	**8 (13)**	**16 (26)**	**19 (29)**	**19 (29)**	**19 (29)**

The admission decisions will be made via reviewing application package, entrance test result, and interview performance. *Specific attentions should be paid to form an inclusive cohort with students representing different gender and socioeconomic backgrounds.*

13. Faculty Complement and Supporting Staff

Success of the new program depends largely on hiring of top faculty members with a strong track record in scholarship, student training, external funding, and partnership. Given the selected thematic focus of the research program and required course offerings, hiring a minimum of *three* full time-equivalent faculty members at the start of the program is recommended. The faculty members will be responsible for carrying out course teaching and student research supervision duties for the program. Specifically, MBUST is suggested to hire *one faculty member with expertise in wood bioproducts, one focus on biomass conversion, and one specializes in NTFPs*.

One way to cost-effectively expand faculty complement is to build a faculty team by pairing young professors with more established senior professors (retired or high-profile professors) in a blend of full time, part-time, and guest/visiting appointments. MBUST can also explore combined hiring between different academic units of the university to further grow faculty complements.

For supporting staff, a minimum of *2 senior technicians (one with prior experiences in wood processing and materials testing, one with chemistry background who is familiar with operation of analytical instruments*) for maintaining the lab facilities and running lab components of the fundamental core course. Besides running the lab facilities, *both technicians are also expected to be assisting faculty members in extensional and tech transfer activities through collaborative projects with the industry*.

If budget permits, it is preferable to engage a highly experienced person who has worked for the forest sector previously with a strong connection to forest enterprises as a full-time staff to be primarily in charge of extensional/tech transfer activities. He/she can bring partners from the forest communities to the university to develop collaborative projects and service contracts and help with the uptake of the research developments from the university by the forest sector.

Additionally, *administrative support from the university is needed for the management of the program and help from the university on fund raising, marketing, and promotion activities is required*.

14. Internal and External Partnerships

To attain the goal of creating a flagship graduate program at MBUST, broad internal and external partnerships are needed for delivering a high-quality program and attracting public interests as well as securing financial resources for support. Within the university, the new program should explore synergies with other academic units (such as programs in organic agriculture, and AI) for joint course offerings and projects and sharing of laboratory resources and faculty complements.

Since the new graduate program in forest biomaterials at MBUST complements forest conservation and management focused educational programs at TU and AFU, it will be mutually beneficial for the three institutions to form strong working ties to encourage program exchanges and explore opportunities for shared course teachings and collaborative initiatives that will help the forest sector as a whole.

Besides academic institutions and industry, partnering with MFSC in ways that the new graduate program can contribute to the implementation of Forest Sector Strategy's 10-year plan is highly recommended. Particularly, MFSC plans to enhance educational training capacity, retrain staffs for knowledge update, support technology upgrades, and establish regional certified laboratories to facilitate business growth of the sector. *There is also plans to create forestry council and national forestry forum (NFF) to coordinate national implementation efforts in the sector. These action plans present excellent opportunities for the new graduate education program at MBUST to join these initiatives and align its research and training priorities to work together with all stakeholders for accelerating the transformation of the sector*.

Specifically, partnership opportunities with government agencies, peer institutions, industry, NGOs, and communities in the following areas should be pursued:

- Guest lectures and hosting of field trips and internships
- Collaborative research projects and research funding grants
- Student scholarships and industrial research chairs/professorships

- Funding and usage of lab equipment and facilities
- Naming and endowment opportunities
- Service contracts and testing services and tech transfer contracts
- Continuing education and retraining of current employees
- Employment opportunities for program graduates

With strong supports from internal and external partners, the new graduate education program will flourish and growth and long-term sustainability of the program will be ensured.

15. Global Linkages

In order to stay connected with the latest developments in forest products research, the new graduate program is recommended to seek linkages with global leading academic institutions and research centres in the forest products area. Some examples of leading forest products education and research institutions are listed below:

North America:

- Department of Wood Science, Faculty of Forestry, University of British Columbia, Canada, https://wood.ubc.ca/
- FPInnovations, Canada, https://web.fpinnovations.ca/
- Department of Wood Science and Engineering, Faculty of Forestry, Oregon State University, USA, https://wse.forestry.oregonstate.edu/
- Department of Sustainable Biomaterials, College of Natural Resources and Environment, Virginia Tech., USA, https://sbio.vt.edu/
- USDA Forest Products Laboratory, Madison, USA, https://www.fpl.fs.fed.us/

European Union:

- Institute of Wood Technology and Renewable Materials, Department of Material Sciences and Process Engineering, Boko University, Austria, https://boku.ac.at/en/map/holztechnologie
- Wood K Plus, Austria, https://www.wood-kplus.at/en/company/vision-mission
- Institute of Wood Science, University of Hamburg, Germany, https://www.biologie.uni-hamburg.de/en/einrichtungen/ihw.html
- Department of Bioproducts and Biosystems, Aalto University, Finland, https://www.aalto.fi/en/department-of-bioproducts-and-biosystems/wood-material-science-and-technology
- VTT, Finland, https://www.vttresearch.com/en/research-expertise/biomass-processing-and-products
- Department of Fibre and Polymer Technology, KTH, Sweden, https://www.kth.se/fpt
- Rise Inventia, Sweden, https://www.ri.se/en

Asia:

- Chinese Academy of Forestry, China, http://www.caf.ac.cn/
- Beijing Forestry University, China, http://international.bjfu.edu.cn/eng_index/index.html
- Nanjing Forestry University, China, https://eng.njfu.edu.cn/

- Northeast Forestry University, China, https://www.nefu.edu.cn/
- International Bamboo and Rattan Organisation (INBAR), https://www.inbar.int/
- Department of Biomaterial Science, University of Tokyo, Japan, https://www.a.u-tokyo.ac.jp/english/departments_e/d-bs.html
- Institute of Wood Science and Technology, Bangalore, India, https://iwst.icfre.gov.in

Oceania:

- SCION, New Zealand, https://www.scionresearch.com/science/research-programmes

Through established global linkages, student and faculty exchanges and joint research projects and collaborative grants can be developed at the international level. These interactions will greatly strengthen quality, visibility, sustainability, and competitiveness of the new program at MBUST.

16. Program Review

Periodic reviews should be carried out to assess the performance of the program and identify areas that need improvements. The first review is recommended to be carried out at 3rd year after the first cohort of master students has graduated from the program. Follow-up reviews at every 2-3-years interval are suggested to further refine the program for quality improvement and student experience enhancement.

17. Conclusions

MBUST plans to establish a STEM-based research-focused graduate education program to train master's and PhD level students in the area of forest products in pursuit of its mission of speeding up growth of key economic sectors in the country. With 45% of land covered by forests, forest sector has an important role in environmental protection and support of livelihoods of rural communities in Nepal. Despite of progresses made in conserving forests by implementing community forestry management policies, contributions by the forest sector to national wealth is much below expectations. There is a tremendous potential for economic development and job creation by utilization of forest resources for value-added products, including both timber-based products and NTFPs/MAPs.

The new **Forest Biomaterials Science and Engineering** graduate education program at MBUST aims to develop innovative technologies and train highly competent students with a specialization in sustainable utilization of forest resources for the forest sector. The new program will engage high caliber faculty and staff members to deliver multidisciplinary curricula. Students will learn latest scientific discoveries with respect to the specific needs of Nepal's forest sector. They will be offered experiential learning opportunities by participating in field visits, industry internships, and collaborative research projects, and working in the state-of-the-art wood processing, structural characterization, and chemical analysis laboratories on campus. Students enrolled in the program will not only build a solid foundation in leading-edge sciences and technologies related to forest biomaterials, but also acquire necessary entrepreneurship, leadership, and communication skills so they can become future leaders for the sector's transformation. They will also gain international exposures via global linkages with leading research and educational institutions around the world.

The new flagship graduate education program at MBUST fits well with the strategic directions outlined by the Forest Sector Strategy 10 year-plan developed by the Ministry of Forestry and Soil Conservation of

Nepal. By forging strong partnerships with all stakeholders, the new program will serve as a catalyst to create innovation clusters for developing value-added green products from forest biomaterials. Research breakthroughs and innovative engineering solutions developed by the program will help increase competitiveness of Nepal's forest products industry. Success of this new graduate education program will have a long-lasting impact on unlocking the forest sector's potential for building a prosperous Nepal.

18. Acknowledgement

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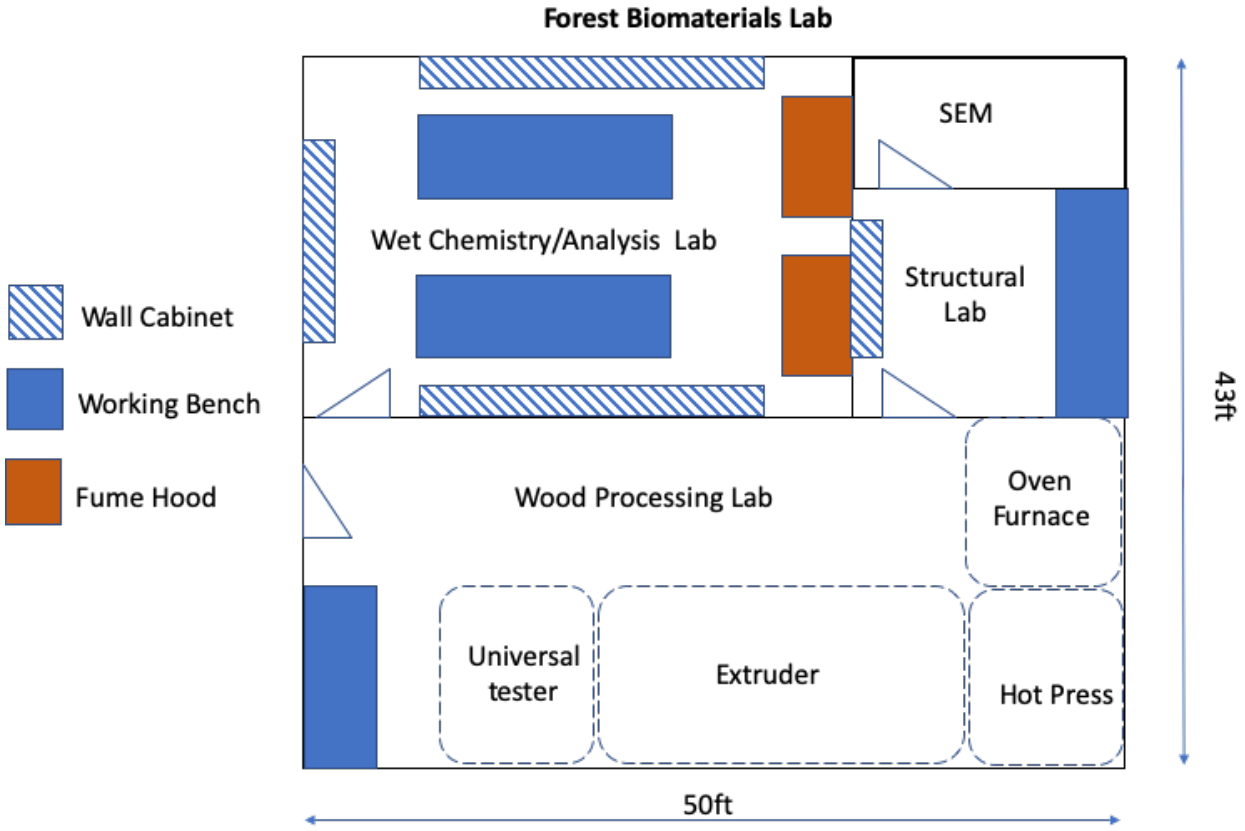
Appendix I: Proposed General Layout for Forest Biomaterials Lab at MBUST



(to be part of the low carbon bamboo building at MBUST)

Appendix II: An Example of Some Key Equipment in the Wood Processing Lab

1 Floor standing hot-press- Carver (https://www.carverpress.com/products/floor-standing/fs-standard)

Floor Standing Laboratory Presses for R&D

Monarch Hydraulic Lab Presses in 30, 50, 75 or 100 Ton Capacity

Carver's Monarch laboratory presses with integral hydraulic system and high technology options are based on standard production press models adapted to precision laboratory requirements.

Recommended for testing or research, compacting, molding rubber or plastic, laminating and assembly where stripping pressure is required.

Standard features include double-acting J.I.C. style cylinder for power open and power close. An integral hydraulic reservoir is easily accessible for cleaning and includes a strainer or cartridge filter, air filter/breather, oil level indicator and oil cooler. A programmable controller with access module is standard.

Optional equipment includes electrically heated platens to 600°, 800° or 1200°F, with digital temperature controllers, low pressure system, pressing speed control and automatic platen cooling. Contact us and we can assist in recommending the proper options for your application.

Request A Quote

Standard Model Ranges

Catalog Number	Max. Capacity (tons)	Nominal Work Area	Adjustable Daylight Opening	Cylinder Stroke (in)	Tie Rod Dia. (in)	Dimensions W x D (in)	Height (lb)	Approx. Weight (lb)
CMG 30H-15	30	15 x 15	6 to 12	6	1.25	42 x 40	72	1,850

2. Bench top hot press-Carver (https://www.carverpress.com/products/benchtop-manual/heated)

Carver Bench Top Standard Heated Presses: 7.5, 12, 25 and 30 Ton Capacity

Model 5420 Bench Top Laboratory Manual Press with Electrically Heated Platens

(Model Mini CH) Twelve ton manual, two-column hydraulic lab press with digital heated platens. Easy-to-read dual scale analog gauge, reading in pounds force and metric tons. Electrically heated platens for temperatures up to 650 deg F (343 C upon request) with digital controller per platen. (picture shown with analog gauge)

Request A Quote

Specifications of the Bench Top Manually Heated Mini CH 5420 Model Press:

- Manually operated
- Clamping force 12 tons
- Daylight opening 0" – 4" (Factory set at 4")
- Stroke 5-1/8"
- Two (2) fully threaded columns
- Heated platen package, including:
  - Two (2) 6" x 6" electrically heated steel platens
  - Temperature range up to 650 deg F

4. Bench top lab twin screw extruder -ThermoFisher Scientific (https://www.thermofisher.com/order/catalog/product/554-1137#/554-1137)

Thermo Scientific™

EuroLab 16 XL Twin-Screw Extruder

Thermo Scientific™ EuroLab 16 XL is an extendable, modular, bench top twin-screw extruder for research, development, quality control, and small-scale production. Academic customers are using EuroLab 16 XL twin-screw extruders in research and teaching laboratories, where many different, small samples can be prepared in a short time with minimum product waste.

Contact us for support ›

	Catalog number	Unit Size	Description	Price (CAD)
☆	554-1137	Each	EuroLab XL; 16mm, 25 L/D (extendable) - 500 rpm, 1.25 kW	Request A Quote

Full specifications ▼

Barrel Length L/D	25 to 1 XL
Max. Screw Speed	500rpm
Barrel Bore Diameter	16mm
Center Line Spacing	12.5mm
Center to Radius Ratio	1.56
Channel Depth	3.3mm
Description	EuroLab XL; 16mm, 25 L/D (extendable) - 500 rpm, 1.25 kW
Die Heater Rating	250W
Extruder Cooling Water 20 Degrees Celsius	5L/min.
Height (Metric)	150cm
Length (Metric)	150cm
Screw Diameter	15.6mm
Surface Are per Unit Free Volume	0.47m²/L
Torque	6.1 (C-line3) Nm/cm3
Torque per Shaft	12Nm
Width (Metric)	70cm
Unit Size	Each

5. floor stand Lab twin screw extruder- Brabender (https://www.brabender.com/en/chemical/products/extrusion/twin-screw-extruders/stand-alone/stand-alone-drive-twinlab-c-20-40/)

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Brabender GmbH & Co KG - Home / Chemical / Products / Extrusion / Twin Screw Extruders / Stand-Alone / Twinlab-C 20/40

TwinLab-C 20/40 Stand-Alone extruder: Space-saving application development

Intended use

TwinLab-C 20/40 is a stand-alone twin screw extruder. The drive contains an integrated motor.
Due to extensive configuration possibilities, the solution can be used for a wide variety of materials. The directly driven extruder is designed for use in **material development**, **-testing** and **smallest production**

TwinLab-C 20/40

- **NEW - Enhanced options:** Use of a replaceable L-liner & compact liner possible
- **Space saving & cost efficient:** Compact solution with wide range of applications
- **Improves your analysis conditions:** Process monitoring via horizontally split liner, 6 openings for raw material addition
- **Modern project workflow:** Location-independent live monitoring, multiple access, networking of multiple devices possible
- **User-friendly:** Touchscreen operation, annotation function in diagram, diagram parameters can be individually set
- **Easy to clean:** Horizontally folding liner, optimized screw configuration for easy removal
- **Individualizable:** Configuration adjustable to your individual needs

You have a specific type of problem or need a special configuration?

+ CONTACT US NOW

TwinLab-C: Optimizing compact and cost-efficient materials

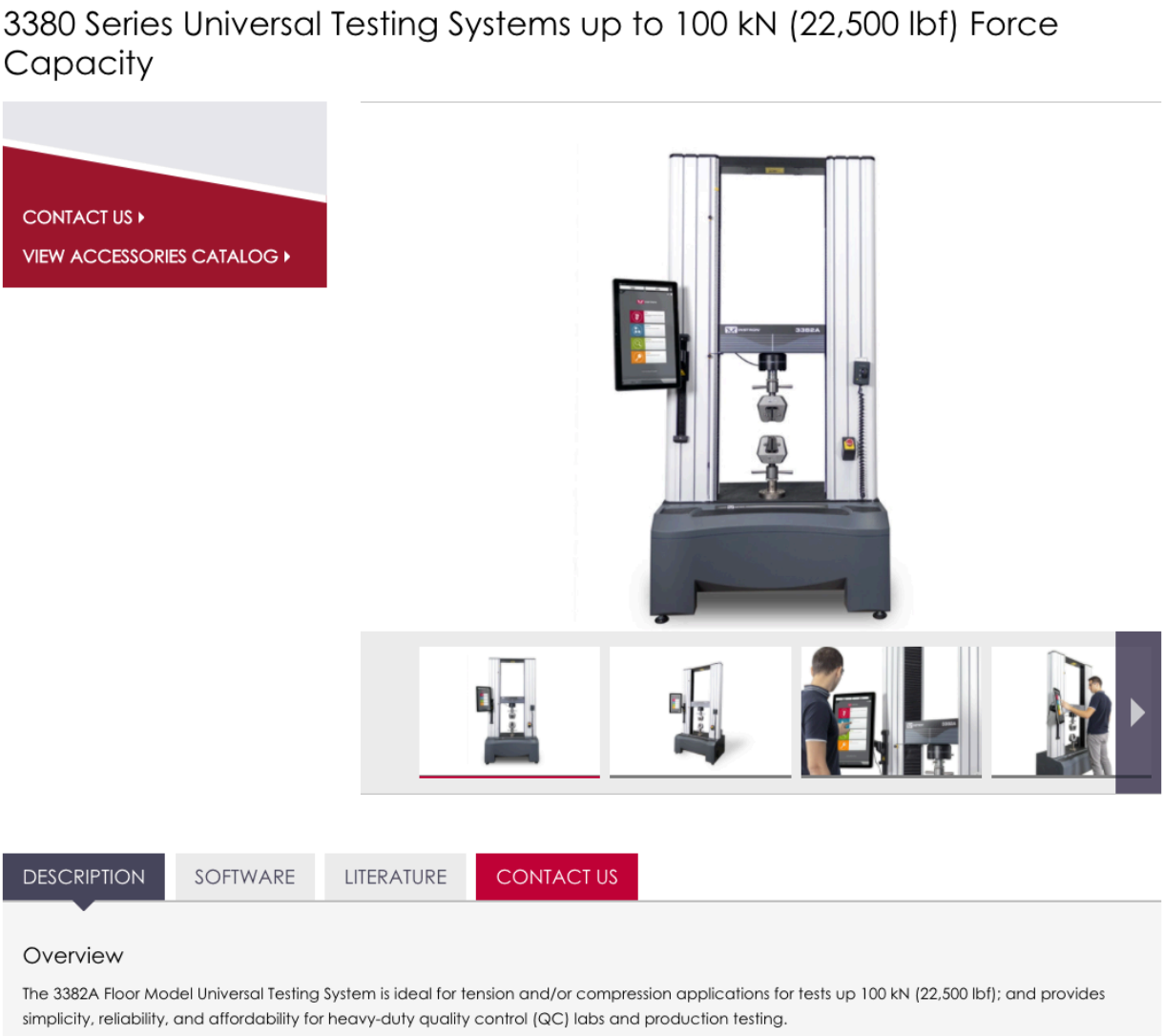
With the compact TwinLab-C 20/40 twin-screw extruder, you can analyze a wide range of materials in a space-saving and cost-efficient way.

The newly designed compact extruder offers the possibility of using an L-liner or also a compact liner.

The liner can be opened horizontally, providing an optimal view of the entire process. At the same time, you also have easier access for cleaning, which is additionally accelerated by the easy removal of the screws.

You benefit from a modern project workflow through the possibility of location-independent access by several users with different end devices. The web-based software MetaBridge also offers the option of online updates. Expand your analysis options by accessing

6. Universal testing machine-Instron
(https://www.instron.us/products/testing-systems/universal-testing-systems/high-force-universal-testing-systems/3380-floor-model)



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