Mini-MOOC: DESIGNING NATURE-BASED SOLUTIONS WITH CIRCULAR AND BIO-SOURCED MATERIALS

info@institute-urbanex.org
www.institute-urbanex.org

Mini-MOOC: DESIGNING NATURE-BASED SOLUTIONS WITH CIRCULAR AND BIO-SOURCED MATERIALS

New European Bauhaus Academy

INDEX

1. OVERVIEW

Content of the mini-MOOC	Designing Nature-Based Solutions with Circular and Bio-Sourced Materials
Duration of the MOOC	3 Modules Self-paced
Location of the course	New European Bauhaus Academy
Course organizers	THE INSTITUTE FOR URBAN EXCELLENCE (iUE) & STUDIO BARNARD
Course trainers	Tannya Pico, Mia Barnard and Alexander Jachnow

INTRODUCTION

In the face of escalating climate, resource, and biodiversity crises, city-makers are increasingly called upon to shape urban environments that are not only resilient but regenerative. This course introduces the foundational principles of nature-based solutions (NbS) and material circularity, with a particular focus on mycelium, a rapidly emerging, biologically sourced material with profound potential for sustainable urban design.

Over three dynamic modules, participants will explore the integration of NbS into urban systems, gain literacy in bio-based and circular materials, and understand the design and application of mycelium in the built environment. Combining theoretical framing with real-world case studies, this training provides both knowledge and tools to rethink how we develop and interact with materials.

The course intends to support professionals in aligning with the values of the New European Bauhaus (NEB): sustainability, inclusion, and aesthetics. The life session will be delivered live in September 2025, and all content and supporting materials adapted into a self-paced mini-MOOC uploaded on the NEBA digital platform.

LEARNING OBJECTIVES

By the end of this course, participants will be able to:

- **Understand urban systems and NbS:** Grasp the systemic role of nature-based solutions in urban environments, including their benefits for resilience, climate adaptation, and quality of life.
- **Build material literacy:** Identify the characteristics, potential, and limitations of bio-based and circular materials, with a specific focus on mycelium.
- **Apply circular design principles:** Integrate circular thinking into design processes, from concept to construction, considering environmental, social, and aesthetic impacts.

LEARNING OUTPUTS

Upon completion of the course, participants will be equipped to:

- Describe the role and value of nature-based solutions within urban systems.
- Explain the life cycle and design possibilities of bio-based materials, with a deep dive into the properties and applications of mycelium.
- Contribute to interdisciplinary and community-based design processes that advance the NEB vision.

PARTNERS

THE INSTITUTE FOR URBAN EXCELLENCE (iUE)

iUE is an independent think tank and knowledge broker focused on research, citizen engagement, advocacy, and professional training in urban-related fields. Positioned at the intersection of theory and practice, the Institute for Urban Excellence supports the NEB vision by facilitating cross-sectoral and transdisciplinary knowledge exchange to foster inclusive, sustainable, and innovative urban transformation.

For more information visit: https://www.institute-urbanex.org/

STUDIO BARNARD

Studio Barnard is Mia Barnard's private practice: an "interdisciplinary" architecture & design studio. Their work and research focus on urbanisation, climate change, migration, post-colonial studies, and circular design in Sub-Saharan Africa. Their work has been exhibited internationally at the 18th Venice Biennale (2023) and the 10th International Architecture Biennale Rotterdam (2022).

CiTra - CIty Transitions

CiTra is a Belgian enterprise that provides advisory services on urbanisation of the Global South to municipalities, national governments, and development cooperation agencies. CiTra has been actively involved in informal settlement upgrading, risk-informed urban planning and urban policies. Their services focus on rapid urbanisation, working with transitory urban management, planning and policies which are based on circularity, Nature-based solutions and spatial justice.

2. PROFILE OF COURSE TRAINERS

Tannya Pico Parra

Dr. Tannya Pico is Project Manager at the Institute for Urban Excellence. She is an architect with 25 years of experience in architectural design, construction, research and higher education. She has work experience in the United States, Spain, the Netherlands, Germany, Mexico, Ghana, Bangladesh and her homeland Ecuador. She has worked for international organisations such GCA, UNDP, GFA, and GIZ on diverse topics such as sustainable urban development, design and implementation of higher education programs, capacity building for municipalities, and research for climate adaptation and resilient infrastructure. Tannya holds a PhD in Urban Governance and Development from the Institute for Housing and Urban Development Studies (IHS) at Erasmus University Rotterdam in the Netherlands. She works on HORIZON 2020 research projects on Nature-based Solutions in urban environments and has been an evaluator of BIODIVERSA research project proposals, both programs funded by the European Commission.

Mia Barnard

Mia Barnard is a South African-Dutch architect and researcher working between South Africa and the Netherlands. She holds a cum laude MSc in Architecture from TU Delft (other: University of the Free State, RSA & University of Melbourne, AUS) and focuses on circular design, bio-based materials, and nature-based solutions (NbS) in rapidly urbanising contexts across the Global South. Her work explores how bio-design; through living materials like mycelium and regenerative systems, can inform more just and resilient spatial futures. She combines material prototyping, ethnographic research, and mapping to address housing, waste ecologies, and climate adaptation. She teaches courses on African urbanism, bio-design, circular construction, and 1:1 prototyping with biomaterials. At TU Delft, she contributes to EXTREME Architecture and Circular Product Design. At the University of Pennsylvania, she guest lectured as part of the DumoLab* research group's Biomaterial Architectures series. Her forthcoming peer-reviewed article, "Beyond the Loop: Waste Ecologies and Incremental Housing Futures in the Global South", will appear in Dimensions: Journal of Architectural Knowledge.

Alexander Jachnow

Dr. Alexander Jachnow is the ED of CiTra and a passionate urban development expert with almost 30 years of working experience as a researcher and advisor in the fields of urban capacity development and governance in urban development processes in Asia, Africa and LAC. His work mainly focuses on enhancing the capacities of institutions and individuals by enabling changes in urban management practices and policy frameworks. He works on urban policies, planning and strategies, including urbanisation research and National Urban Policies. He was heading the Urban Strategic Planning Master Track at IHS, Erasmus University Rotterdam, and led the Urban Development Technical Facility for the European Commission in Brussels. He advises and collaborates with organizations and DC agencies such as Cities Alliance, DFID, the European Commission, GIZ, KfW, OECD, SDI, UN Habitat and UNESCO as well as local and national governments worldwide and supports the creation of relevant knowledge for a sustainable urban future.

GUEST SPEAKERS

Gert van der Merwe

Architecture, Planning & Construction, NUST & Faculty of Architecture & the Built Environment, TU Delft, The Netherlands. Gert's focus on primarily on water and its role in the sympoietic relationships between species, technology, and the environment. At Namibia University of Science and Technology - NUST, he's the departmental research coordinator with active involvement in the Technicities, Ecologies, and Flows and Assemblages research clusters, as well as teaching courses on environmental design, urbanism and housing. He collaborates with the Swedish University of Agricultural Sciences and the Gobabeb Namib Research Institute on evaluating a solar-thermal and wind-driven urine evaporator. He's pursuing a PhD at TU Delft, where he is active in the Philosophy and Theory of Architecture Research Group, the Ecologies of Architecture Research Group. He also serves on the editorial board of Footprint - Delft Architecture Theory Journal.

Andy Cartier

Andy Cartier is a multidisciplinary designer and founder of Studio Cartier, a creative design studio known for its innovative work at the intersection of art, nature, and sustainability. Specializing in bio-design and material innovation, Andy explores the use of organic materials, particularly fungi, to create eco-friendly products that challenge traditional manufacturing processes. By blending science, art, and design, Studio Cartier pushes the boundaries of sustainable craftsmanship, offering visionary solutions that inspire a deeper connection with the natural world. Studio Cartier has gained recognition for advancing eco-conscious design and material research.

3. MODULES & SESSIONS DESCRIPTION

3.1. MODULE 1: URBAN SYSTEMS AND NATURE-BASED SOLUTIONS: GRIDS, FLOWS AND INFRASTRUCTURAL FUTURES

Cities are facing mounting ecological, climatic, and social pressures. In this context, there is an urgent need to rethink how urban flows (water, energy, materials) are organised, managed, and potentially transformed through integrated, hybrid approaches. The dynamic interplay between urban systems and Nature-based Solutions (NbS), focusing on how infrastructures (both visible and hidden) can shape the metabolism of cities.

We will explore the conceptual frameworks of grids and flows as a means to understand how urban systems function: grids as structured, often centralised networks (e.g., electricity, sewage, transit), and flows as dynamic, often decentralised or distributed movements (e.g., water cycles, pedestrian movement, mobility streams, energy flows). Crucially, we examine how these systems can be made more resilient, equitable, and regenerative through the strategic implementation of NbS.

Topics include:

- Urban metabolism and infrastructural ecologies
- Centralised vs. decentralised (on-grid/off-grid) models in water, energy.
- The role of NbS in decentralised water treatment and stormwater management
- Urban energy transitions: passive cooling, energy-saving NbS, and renewable integration
- Micro-interventions and site-scale design: rooftop gardens, vertical greening, pocket parks, urban heat island mitigation

Attendants will learn to analyse the interdependencies of urban infrastructure and propose scalable, nature-based interventions that work both within and outside conventional grids. Module 1 invites

info@institute-urbanex.org
www.institute-urbanex.org

attendants to think critically about where and how NbS can be most transformative—not as add-ons, but as integral components of future-proof urban systems.

Learning Outcomes:

By the end of this module, students will be able to:

- Analyse urban systems using the conceptual lenses of flows and grids
- Identify appropriate contexts for implementing NbS at various scales
- Design integrated solutions that combine technical and ecological knowledge

3.2. MODULE 2: BIO-BASED MATERIALS

This course module explores based materials, a term encompassing bio-based, abundant, sustainable, ethical, and durable materials. Through the lens of circularity principles and urban sustainability. Students will examine the fundamental properties, production pathways, and life cycle of such materials, and critically assess their role in transforming conventional urban development and industrial systems.

Through theory and real-world case studies, learners will gain the skills to evaluate the suitability of bio-based materials in various contexts, particularly in architecture, design, construction, and manufacturing. Emphasis is placed on regenerative practices and responsible sourcing.

Topics include:

- Urban metabolism and infrastructural ecologies
- Materials science foundations
- Bio-based and recycled material systems
- Local vs global resource strategies
- Life cycle assessment (LCA)
- Urban metabolism
- Circular design principles

Learning Outcomes:

By the end of this module, students will be able to:

- Understand the theory and properties of bio-based and circular materials
- Analyse real-world case studies of based materials applied in urban systems
- Evaluate the sustainability performance of materials using tools such as LCA.

info@institute-urbanex.org
www.institute-urbanex.org

3.3. MODULE 3: MYCELIUM

This module provides an in-depth exploration of mycelium (the root-like structure of fungi) as a transformative biological material in sustainable design, construction, and systems thinking. Mycelium has emerged as a regenerative material with vast potential across multiple industries due to its biodegradability, self-healing properties, and capacity for low-impact cultivation.

Students will engage with the theoretical foundations of fungal biology, the material properties of mycelium composites, and innovative applications within the built environment and circular economy. Through case studies and critical discussions, this module will explore how mycelium can reshape practices in architecture, product design, and waste valorisation, offering ecological alternatives to carbon-intensive materials.

This module also examines how mycelium fits into circular systems, encouraging regenerative practices that go beyond sustainability to actively restore ecosystems and urban metabolisms.

Topics include:

- Introduction to Fungal Biology
- Material Properties of Mycelium
- Mycelium Composites and Biofabrication
- Applications in Architecture and Design
- Circular Economy and Urban Sustainability
- Ethics, Scale, and Feasibility
- Futures Thinking: Mycelium as Infrastructure

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the biological and ecological foundations of mycelium as a living material.
- Identify the material properties and growth conditions required for producing mycelium-based composites.
- Evaluate the environmental benefits and limitations of mycelium in comparison to conventional materials.
- Analyse case studies that demonstrate real-world mycelium applications in architecture, product design, and packaging.

3.3.1. CASE STUDIES

- **Studio Cartier:** R&D with mycelium design, bridging art, architecture and construction. Mycelium as *future design language.* Helping companies and governments to research and develop their own mycelium solutions. Experimentations, industrialisation and scaling-up.

info@institute-urbanex.org
www.institute-urbanex.org

- **MycoHab & NUST:** A pilot project of a collaboration between MIT's Center for Bits and Atoms, Standard Bank Group, and redhouse studio. The project mandate was to prove that we can convert Namibia's encroacher bush into food AND humanitarian housing. The key ingredient is fungi. Namibia is thinning the bush all over their grasslands to combat desertification. This bush can be used as the substrate to grow gourmet mushrooms, and the waste of the cultivation can be used to make carbon storing structural materials. The materials that have been made in Namibia from mushroom cultivation waste rival concrete blocks and use truly circular and regenerative resources.

4. GLOSSARY

Bio-based Materials	Materials derived from renewable biological resources, such as plants, fungi, or agricultural waste, are used in place of synthetic or non-renewable materials.
Bio-fabrication	The use of biological processes and organisms to produce materials and structures, often used in biotechnology and sustainable design.
Circular Economy	An economic system aimed at eliminating waste and promoting the continual use of resources through reuse, recycling, and regeneration.
Decentralised Systems	Infrastructure systems that operate locally or off-grid, such as rainwater harvesting or solar panels, reduce reliance on central networks.
Ethical Sourcing	The procurement of materials and products in a way that considers environmental and social impacts, including labour practices and resource sustainability.
Flows	Dynamic and often decentralised movements of materials, energy, people, or information through urban systems (e.g., pedestrian flows, water cycles).
Futures Thinking	A strategic approach to exploring and envisioning possible future scenarios, often used in planning, innovation, and policy development.
Grids	Structured and often centralised infrastructure systems (e.g., electricity, sewage, transit) that deliver essential urban services through connected networks.
Infrastructural Ecologies	The interconnected systems of infrastructure that support urban life, considered in relation to environmental and social ecosystems.
Life Cycle Assessment (LCA)	A method to evaluate the environmental impacts associated with all stages of a product's life, from raw material extraction to disposal.

Material Science	The study of the properties, performance, and applications of materials in engineering and design contexts.
Micro-Interventions	Small-scale urban design actions (e.g., pocket parks, vertical gardens) that can have significant ecological and social impacts.
Mycelium	The thread-like vegetative part of fungi, capable of forming dense networks that can be grown into sustainable, biodegradable materials.
Mycelium Composites	Engineered materials made by combining mycelium with agricultural or organic waste, forming lightweight, strong, and biodegradable structures.
Nature-based Solutions (NbS)	Strategies that use natural processes and ecosystems to address societal challenges such as climate change, water management, and biodiversity loss.
On-grid/Off-grid	Terms describing whether infrastructure is connected to central networks (on-grid) or operates independently (off-grid).
Passive Cooling	Building design strategies that reduce heat without mechanical systems, such as shading, natural ventilation, and thermal mass.
Recycled Material Systems	Materials repurposed from waste into new products, reducing the demand for virgin resources and lowering environmental impact.
Regenerative Practices	Approaches that restore, renew, or revitalize ecosystems and resources, going beyond sustainability to produce net-positive impacts.
Urban Energy Transitions	The shift from fossil fuel-based energy systems to renewable and energy-efficient alternatives in urban areas.
Urban Heat Island Effect	The phenomenon where urban areas become significantly warmer than surrounding rural areas due to human activities and built surfaces.
Urban Metabolism	The study of material and energy flows within cities, viewing urban areas as living systems that consume, transform, and release resources.
Urban Sustainability	Strategies and systems that ensure cities are environmentally sound, socially inclusive, and economically viable over the long term.
Waste Valorisation	The process of reusing, recycling, or converting waste materials into more useful products or energy.

info@institute-urbanex.org
www.institute-urbanex.org

5. QUESTIONNAIRE

To approve the mini-MOOC, participants must correctly answer at least 20 out of 30 questions of the questionnaire designed in a format of multiple-choice.

MODULE 1

Section 1: Urban Transitions & Systems Thinking

1. What does the term urban transition refer to?

A) Building more skyscrapers
B) Shifting urban systems toward sustainable futures
C) Expanding city borders
D) Increasing industrialisation
Answer: B

2. Why are cities described as dynamic systems?

A) Because they are constantly changing and evolving
B) Because they never change
C) Because they depend on static infrastructure
D) Because they are only economic entities
Answer: A

3. What is a key reason to seek alternatives in urban development?

A) To preserve the status quo
B) To maintain old technologies
C) To promote circular, resource-efficient innovation
D) To reduce diversity in materials
Answer: C

4. What is the main role of innovation in urban transitions?

A) Replace sustainability
B) Enable new solutions for resource efficiency
C) Increase construction speed only
D) Support industrial expansion
Answer: B

5. How can participatory planning improve urban transitions?

A) By excluding stakeholders
B) By involving communities in sustainable decision-making
C) By prioritising private developers
D) By reducing transparency
Answer: B

info@institute-urbanex.org
www.institute-urbanex.org

Section 2: Nature-Based Solutions (NbS)

6. According to IUCN, what are NbS?
A) Purely technological systems
B) Actions that work with nature to address societal challenges
C) Industrial recycling processes
D) Fossil-fuel mitigation technologies
Answer: B

7. NbS help cities adapt to climate change by:
A) Increasing urban heat islands
B) Providing green infrastructure that regulates temperature and water
C) Reducing vegetation cover
D) Promoting deforestation
Answer: B

8. How do NbS assist with water management?
A) By increasing runoff
B) By enhancing natural infiltration and storage
C) By replacing rivers with pipes
D) By preventing evaporation
Answer: B

9. How much did Medellín's Green Corridors lower city temperatures?
A) 0.5°C
B) 2°C
C) 10°C
D) 5°C
Answer: B

10. Which NbS benefit contributes to "public health and well-being"?
A) Reduced urban greenery
B) Improved air quality and climate comfort
C) Increased urban traffic
D) Expansion of impervious surfaces
Answer: B

Section 3: Ecosystem Services & Scales

11. How many main categories of ecosystem services exist?
A) Two
B) Three
C) Four
D) Five
Answer: C

info@institute-urbanex.org
www.institute-urbanex.org

12. Which of these is a provisioning service?

A) Flood regulation
B) Food and raw materials
C) Spiritual value
D) Cultural heritage
Answer: B

13. What is an example of a regulating service?

A) Climate control and air purification
B) Art and recreation
C) Tourism
D) Education
Answer: A

14. Which service type relates to recreation and aesthetics?

A) Cultural
B) Provisioning
C) Supporting
D) Regulating
Answer: A

15. Supporting services are important because they:

A) Provide the foundation for all other services
B) Are not essential
C) Focus only on tourism
D) Apply only to rural areas
Answer: A

MODULE 2

Section 4: Materials and Circularity

16. What are bio-based materials?

A) Materials derived from living organisms like plants or fungi
B) Synthetic materials
C) Metallic compounds
D) Petroleum-based plastics
Answer: A

17. Which statement best defines circularity?

A) Linear production and disposal
B) Continuous reuse and regeneration of materials
C) Mass production
D) Planned obsolescence
Answer: B

18. Which material has the lowest CO_2 emission per kilogram?

A) Aluminium
B) Mycelium
C) Cement
D) Concrete
Answer: B

19. Which material has the highest CO_2 emission?

A) Hemp insulation
B) Foam insulation
C) Wood
D) Bricks
Answer: B

20. A limitation of bio-based materials is:

A) Certification and durability challenges
B) Lack of aesthetic value
C) High carbon output
D) Non-biodegradability
Answer: A

Section 5: Design, Society & Regeneration

21. Which factor most hinder material adoption in cities?

A) Cultural acceptance and policy support
B) Random chance
C) Industrial secrecy
D) Fashion trends
Answer: A

22. Vernacular architecture is often used:

A) Local, bio-based materials
B) High-tech imported steel
C) Only glass and concrete
D) No sustainable methods
Answer: A

23. What historical shift reduced the use of natural materials?

A) Industrialisation and modern architecture
B) Cultural revival
C) De-urbanisation
D) Sustainable farming
Answer: A

24. Why might some cities resist bio-based materials today?

A) Lack of regulations and certifications
B) Overabundance of forests
C) Excess mycelium production
D) Too much demand
Answer: A

25. What is meant by regenerative sourcing?

A) Harvesting materials in ways that restore ecosystems
B) Extracting faster than replenishment
C) Using only synthetic substitutes
D) Ignoring ecological impacts
Answer: A

MODULE 3

Section 6: Mycelium and Its Applications

26. What is mycelium?

A) Underground root system of fungi
B) Plant leaves
C) Mineral structure
D) Artificial polymer
Answer: A

27. How does mycelium grow?

A) Through hyphae that digest organic matter
B) By crystallisation
C) By photosynthesis
D) By oxidation
Answer: A

28. What environmental benefit does mycelium cultivation provide?

A) Absorbs CO_2
B) Releases methane
C) Emits toxic gases
D) Requires fossil fuels
Answer: A

29. Mycelium can replace which material?

A) Plastics and foam
B) Concrete foundations
C) Metals
D) Glass windows
Answer: A

info@institute-urbanex.org
www.institute-urbanex.org

30. Mycelium-based materials are:
A) Lightweight, biodegradable, and fire-resistant
B) Heavy and non-degradable
C) Metal-based
D) Toxic
Answer: A

6. RECOMMENDED LITERATURE

1. Holden, N. M., Neill, A. M., Stout, J. C., & others. (2023). *Biocircularity: A framework to define sustainable, circular bioeconomy. Circular Economy and Sustainability, 3*(1), 77–91. https://doi.org/10.1007/s43615-022-00180-y
2. Oliver-Cuenca, V., Salaris, V., Muñoz-Gimena, P. F., & others. (2024). *Bio-based and biodegradable polymeric materials for a circular economy. Polymers, 16*(21), 3015. https://doi.org/10.3390/polym16213015
3. Atanasova, N., Castellar, J. A., Pineda-Martos, R., & others. (2021). *Nature-based solutions and circularity in cities. Circular Economy and Sustainability, 1*(3), 319–332. https://doi.org/10.1007/s43615-021-00024-1
4. Brunklaus, B., & Riise, E. (2018). *Bio-based materials within the circular economy: Opportunities and challenges.* In E. Benetto, K. Gericke, & M. Guiton (Eds.), *Designing sustainable technologies, products and policies* (pp. 43–47). Springer. https://doi.org/10.1007/978-3-319-66981-6_5
5. Hassegawa, M., Van Brusselen, J., Cramm, M., & Verkerk, P. J. (2022). *Wood-based products in the circular bioeconomy: Status and opportunities towards environmental sustainability. Land, 11*(12), 2131. https://doi.org/10.3390/land11122131
6. Ondrasek, G., Meriño-Gergichevich, C., Manterola-Barroso, C., & others. (2024). *Bio-based resources: Systemic and circular solutions for (agro)environmental services. RSC Advances, 14*(38), 23466–23482. https://doi.org/10.1039/D4RA03506B
7. Le, D. L., Salomone, R., & Nguyen, Q. T. (2024). *Sustainability assessment methods for circular bio-based building materials: A literature review. Journal of Environmental Management, 351,* 120137. https://doi.org/10.1016/j.jenvman.2024.120137
8. Piro, P., & others. (2020). *Enhancing the circular economy with nature-based solutions in the built urban environment: Green building materials, systems and sites. Agris: International Information System for the Agricultural Science and Technology.* https://agris.fao.org/search/en/providers/125165/records/67497baa7625988a372245af
9. Quinn, E. C., Knauer, K. M., Beckham, G. T., & Chen, E. Y.-X. (2023). *Mono-material product design with bio-based, circular, and biodegradable polymers. One Earth, 6*(5), 582–586. https://doi.org/10.1016/j.oneear.2023.05.019
10. Fiandra, E. F., Shaw, L., Starck, M., McGurk, C. J., & Mahon, C. S. (2023). *Designing biodegradable alternatives to commodity polymers. Chemical Society Reviews, 52*(20), 8085–8105. https://doi.org/10.1039/D3CS00556A
11. Caldas, L. R., Saraiva, A. B., Lucena, A. F. P., & others. (2021). *Building materials in a circular economy: The case of wood waste as CO_2-sink in bio-concrete. Resources, Conservation and Recycling, 170,* 105346. https://doi.org/10.1016/j.resconrec.2020.105346

12. Ramírez-Escamilla, H. G., Martínez-Rodríguez, M. C., Domínguez-Solís, D., & others. (2025). *Identifying circularity in nature-based solutions: A systematic review. Sustainability, 17*(19), 8722. https://doi.org/10.3390/su17198722
13. Shurpali, N., Li, Y., Tampio, E., & others. (2025). *From fossil-based to circular bioeconomy: A Swedish and Finnish pathway. Environmental Science and Pollution Research, 32,* 11308–11316. https://doi.org/10.1007/s11356-025-36336-0
14. Ellen MacArthur Foundation. (2015). *Bio-based materials in a circular economy: Workshop summary.* https://emf-assets.s3.amazonaws.com/media/14/Biobased-material.pdf
15. Shafei, B. (2025). *Bio-based polymer composites used in the building industry: A review.* In M. Kioumarsi & B. Shafei (Eds.), *Proceedings of the 1st International Conference on Net-Zero Built Environment* (pp. 957–968). Springer. https://doi.org/10.1007/978-3-031-69626-8_71