SYLLABUS

BIOECONOMY

3 ECTS

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1. Description of the course and its goals

The BIOERA+ project has evolved from the need to develop, reinforce, and make teaching methodology in the field of Bioeconomy more flexible. Bioeconomy remains crucial for sustainable development of Europe. The Covid-19 pandemic confronted the academic community with the necessity to adapt rapidly to the demands of online work.

For many lecturers and students, the lack of face-to-face contact resulted in less effective and less engaging classes. However, this experience can also be treated as an opportunity to enhance teaching methodology, alter the approach to the methods of motivating, activating as well as evaluating students' work.

In accordance with the objectives of the BIOERA+ project, an innovative course of Bioeconomy has been developed. The comprehensive Bioeconomy course comprises 9 modules assembled to meet the needs of a multidisciplinary approach. The course incorporates modern Design Thinking and Agile teaching methods, combining both in-person and online learning.

2. Authors / Teachers:

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Module 9: Anna Gorczyca (University of Agriculture in Kraków), Tomáš Kopta (Mendel University in Brno)

3. Modules' description:

I. MODULE

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Modules title	**Introduction to sustainability and circular bioeconomy concepts**
Objectives	The objective of Module 1 is to introduce the subject and idea behind the course and build a base for the entire course that embeds the Bioeconomy in the concept of sustainable development and circular economy.
Learning outcomes	• *Knowledge:* Students know what sustainable development is and how it is manifested in economic concepts. They understand the relationships between sustainable development, circular economy, and Bioeconomy. They know what the Sustainable Development Goals are. • *Skills:* Students can indicate the value of sustainable development goals and are able to determine the value of bio-based products within the context of the biomass value pyramid. They can articulate and argue the importance of the Sustainable Development Goals. • *Social competences:* Students are able to participate in substantive discussions on sustainable development and the principles of Bioeconomy.
Literature and materials	1. 'Climate, inequality, hunger: which global problems would you fix first?' Global development. Garry Blight, Liz Ford, Frank Hulley-Jones, Niko Kommenda and Lydia McMullan, https://www.theguardian.com/global-development/ng-interactive/2020/jan/15/environment-inequality-hunger-which-global-problems-would-you-fix-first. 2. Sustainable Development Goals: time lapse to the future, Leen Zevenbergen, TEDx 2018. 3. SDG Impact - Michael Porter's TED, 2021. 4. United Nations, 2023, The Sustainable Development Goals Report. Special Edition. 5. United Nations, The Sustainable Development Goals, https://dashboards.sdgindex.org/chapters. 6. Tan ECD and Lamers P (2021) Circular Bioeconomy Concepts—A Perspective. Front. Sustain. 2:701509. doi: 10.3389/frsus.2021.701509. 7. Marc Palahí (2020) Why the world needs a 'circular bioeconomy' - for jobs, biodiversity and prosperity, World Economic Forum, https://www.weforum.org/agenda/2020/10/circular-bioeconomy-nature-reset/. 8. Ellen MacArtur on the basics of the circular economy https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview 9. Dedicated case studies.

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II. MODULE

Modules title	**Earth**
Objectives	Module 2 aims to provide students with an understanding of the environmental constraints associated with the global changes from a temporal and spatial perspective. Additionally, it seeks to instil a critical perspective on potential mitigation strategies and solutions.
Learning outcomes	• *Knowledge:* Students comprehend the concepts of planetary boundaries, anthropogenic pressure, climate change, earth science, and recognise environmental threats. • *Skills:* Students can see well the possibility to reuse natural resources; they know and can analyse resources and thus exhibit critical judgment. • *Social competences:* Students gain awareness of time-space dimension, they develop critical thinking and leadership.
Literature and materials	1. Bijlsma, L., Ehler, C. N., Kulshrestha, S. M., Mclean, R. F., Mimura, N., Nicholls, R. J., Nurse, L. A., Stakhiv, E. Z., Turner, R. K., & Warrick, R. A. (1995). Coastal Zones and Small Islands. Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses, December 2013, 289–324. 2. Candela, L., von Igel, W., Javier Elorza, F., & Aronica, G. (2009). Impact assessment of combined climate and management scenarios on groundwater resources and associated wetland (Majorca, Spain). Journal of Hydrology, 376(3–4), 510–527. https://doi.org/10.1016/j.jhydrol.2009.07.057 3. Cruz-Pérez, Noelia; Martín-Rodríguez, Jesica; García, Celso; Ioras, Florin; Christofides, Nicholas; Vieira, Marco; Bruccoleri, Manfredi; Santamarta, J. C. (2021). Comparative study of the environmental footprints of marinas on European Islands. Scientific Reports, 11, 1–10. https://doi.org/10.1038/s41598-021-88896-z 4. Gruber, N., & Galloway, J. N. (2008). An Earth-system perspective of the global nitrogen cycle. Nature, 451(7176), 293–296. https://doi.org/10.1038/nature06592 5. Haan, C.D.; Steinfeld, H.; Blackburn, H. D. (1997). Livestock & the environment: finding a balance. 6. IPCC. (1997). Introducción a los Modelos Climáticos simples utilizados en el segundo informe de evaluación del IPCC. 7. IPCC. (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability (and L. L. W. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy S. MacCracken, P.R. Mastrandrea (ed.)). Cambridge University Press. 8. Miola, A., Marra, M., & Ciuffo, B. (2011). Designing a climate change policy for the international maritime transport sector: Market-based measures and technological options for global and regional policy actions. Energy Policy, 39(9), 5490–5498. https://doi.org/10.1016/j.enpol.2011.05.013 9. Richardson, J., Steffen W., Lucht, W., Bendtsen, J., Cornell, S.E., et.al. 2023. Earth beyond six of nine Planetary Boundaries. Science Advances, 9, 37. 10. Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., … Foley, J. A. (2009). A safe operating space for humanity. Nature, 461(7263), 472-475. doi:10.1038/461472a 11. Smith, J. B., Schneider, S. H., Oppenheimer, M., Yohe, G. W., Hare, W., Mastrandrea, M. D., Patwardhan, A., Burton, I., Corfee-Morlot, J., Magadza, C. H. D., Füssel, H. M., Pittock, A. B.,

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Rahman, A., Suarez, A., & Van Ypersele, J. P. (2009). Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "'reasons for concern.'" Proceedings of the National Academy of Sciences of the United States of America, 106(11), 4133–4137. https://doi.org/10.1073/pnas.0812355106

12. UN. (1992). United Nations Framework Convention on Climate Change (p. 25). United Nations.
13. UNCTAD. (2018). 50 Years of Review of Maritime Transport, 1968-2018: Reflecting on the past, exploring the future. 50 Years of Review of Maritime Transport, 1968-2018: Reflecting on the Past, Exploring the Future, 812, 86p.
14. Xu, J., Yao, L., & Lu, Y. (2014). Climate Change Management Innovative Approaches Towards Low Carbon Economics. http://www.springer.com/series/8740

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III. MODULE

Modules title	**Socio–economic system**
Objectives	The primary objective of Module 3 is to elucidate the correlation between sustainable development and Bioeconomy.
Learning outcomes	• *Knowledge:* Students have understanding of the economic world; they can perform a social and economic analysis of the current global situation in the Bioeconomy context; they have knowledge of the SDG and Bioeconomy in the EU; they can show interdependence in social, environmental, and economic activities; students have knowledge of Circular Economy, Sustainable Tourism, and Sustainable Entrepreneurship. • *Skills:* Students can apply legal framework and see connections interdisciplinary, they can demonstrate sustainable behaviours in daily life and can analyse and learn vocabulary. • *Social competences:* Students develop empathic social responsibility, wide looking, they believe in the sense of change and see the rationality of the circular Bioeconomy and they can explain it. They can be critical, innovative and be leaders.
Literature and materials	1. Aguilar, A., Twardowski, T. and Wohlgemuth, R .Bioeconomy for Sustainable Development Biotechnol. J., 2019: https://doi.org/10.1002/biot.201800638. 2. Cave J., Dredge D., Regenerative tourism needs diverse economic practice, 2020. 3. Kneese A., V., Economic Efficiency and Social Welfare, Routledge, Selected Essays on Fundamental Aspects of the Economic Theory of Social Welfare, 1981. 4. Lewandowski I., "Bioeconomy: Shaping the Transition to a Sustainable, Biobased Economy" 2018. 5. Krugman P., Wells R. Macroeconomics, Worth Publishers, 2017 6. Krugman P., Wells R. Microeconomics, Worth Publishers, 2017. 7. Loretta Bellato, Niki Frantzeskaki & Christian A. Nygaard, Regenerative tourism: a conceptual framework leveraging theory and practice, 2023. 8. Marshall T., The Power of Geography: Ten Maps That Reveal the Future of Our World, Elliott & Thompson Limited, 2021. 9. Stahel W., R., The Circular Economy A User's Guide, Routledge 2019. 10. Udaya Sekhar Nagothu & Takanori Nagano, The Bioeconomy Approach, Book chapter: The bioeconomy approach and sustainable development: A review of the concept, opportunities and constraints, 2020. 11. United Nations Environment Programme, "Bioeconomy for Sustainable Development", 2020.

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IV. MODULE

Modules title	**Evolution effects**
Objectives	The primary objective of Module 4 is to clarify the significance of labour market and value chain considerations within the framework of the circular and Bioeconomy.
Learning outcomes	• *Knowledge:* Students comprehend labour market and value chain. • *Skills:* Students can cooperate, be critical, and create economic symbioses models. • *Social competences:* Students are environmentally friendly, tolerant, engaged, aware/convinced of pushing others to adopt sustainable behaviours.
Literature and materials	1. Anouk Mertens, Jonas Van Lancker, Jeroen Buysse, Ludwig Lauwers, Jef Van Meensel (2019) Overcoming non-technical challenges in bioeconomy value-chain development: Learning from practice, Journal of Cleaner Production, Volume 231, Pages 10-20, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2019.05.147. 2. Delchet-Cochet, K. (2020). Circular economy: From waste reduction to value creation. John Wiley & Sons. ISBN 978-1-78630-573-2. 3. Dries, L., Heilman, W., Jongeneel, R., Purnhagen, K., & Wesseler, J. (2019). EU bioeconomy economics and policies:. Volume II. Palgrave Macmillan. ISBN 978-3030286415. 4. Eisenriegler, S. (2020). The circular economy in the European Union: An interim review. Springer. ISBN 9783030502386 5. Ghosh, S. K., & Ghosh, S. K. (2021). Circular economy: Recent trends in global perspective. Springer. ISBN 978-981-16-0912-1. 6. Jorge Cristobal , Cristina T. Matos, Jean-Philippe Aurambout, Simone Manfredi, Boyan Kavalov, Environmental sustainability assessment of bioeconomy value chains European Commission, Joint Research Centre (JRC), Institute for Environment and Sustainability (IES), Sustainability Assessment Unit, Via E. Fermi, 21027, Ispra, VA, Italy 7. Lanzerath, D., Schurr, U., Pinsdorf, C., & Stake, M. (2022). Bioeconomy and sustainability: Perspectives from natural and social sciences, economics and ethics. Springer. ISBN 978-3030874018. 8. Zörb, C., Lewandowski, I., Kindervater, R., Göttert, U., Patzelt, D. (2018). Biobased Resources and Value Chains. In: Lewandowski, I. (eds) Bioeconomy. Springer, Cham. https://doi.org/10.1007/978-3-319-68152-8_5.

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V. MODULE

Modules title	**Business and consumer**
Objectives	Module 5 is dedicated to teaching the project management process and the business plan procedure, with a specific emphasis on circular Bioeconomy projects. The primary objective of this module is to underscore the distinctive characteristics inherent in such projects, and to explore the role of Corporate Social Responsibility in project management. Additionally, the module seeks to augment the understanding of global agricultural production.
Learning outcomes	• *Knowledge:* Students learn how to describe the project management process and define business plan and CSR. • *Skills:* Students know how to manage projects and know what a business plan consists of, they can identify circular and linear economy. • *Social competences:* Students are more active in leading Bioeconomy projects, they become more sensitive and responsible for the circular Bioeconomy ideas.
Literature and materials	1. A guide to the project management body of knowledge: (PMBOK® guide). 2017. Project Management Institute, Newtown Square, Project Management Institute, Pennsylvania. 2. Bogner, K., & Dahlke, J. (2022). Born to transform? German bioeconomy policy and research projects for transformations towards sustainability. Ecological Economics, Vol. 195, article 107366. 3. Cristache, N., Năstase, M., Petrariu, R. and Florescu, M., 2019. Analysis of Congruency Effects of Corporate Responsibility Code Implementation on Corporate Sustainability in Bio-Economy. Amfiteatru Economic, 21(52), pp. 536-553. 4. Geissdoerfer M., Pieroni M.P., Pigosso D.C., Soufani K. 2020. Circular business models: A review. Journal of Cleaner Production, 277, 123741. 5. GPM Global 2022. Insights into Sustainable Project Management. GPM Research Institute. Retrived from: https://greenprojectmanagement.org/images/PDF/2022%20Insights%20into%20Sustainable%20Project%20Management.pdf 6. Heagney J. 2015. Fundamentals of Project Management, 5th edition. AMACOM, American Management Association, Washington DC. 7. Høgevold, Nils, Göran Svensson, Beverly Wagner, Daniel J. Petzer, H. B. Klopper, Juan Carlos Sosa Varela, Carmen Padin, and Carlos Ferro. "Sustainable business models." Baltic Journal of Management 9, no. 3 (July 1, 2014): 357–80. http://dx.doi.org/10.1108/bjm-09-2013-0147. 8. Husárová, P. Theoretical aspects of CSR on the context of bioeconomy. 2022. Visegrad Journal on Bioeconomy and Sustainable Development, 11 (2), pp. 100–103. 9. Lancker J.V. Wauters E., Huylenbroeck G.V. 2016. Managing innovation in the bioeconomy: An open innovation perspective, Biomass and Bioenergy, vol. 90, 60-69. 10. Linder M., Williander M. 2017. Circular business model innovation: inherent uncertainties. Business Strategy and the Environment, 26(2), 182–196. 11. Maksymiv, Y.; Yakubiv, V.; Pylypiv, N.; Hryhoruk, I.; Piatnychuk, I.; Popadynets, N. 2021. Strategic Challenges for Sustainable Governance of the Bioeconomy: Preventing Conflict between SDGs. Sustainability, 13, 8308. https://doi.org/10.3390/su13158308 12. Mort, Gillian Sullivan. "Sustainable Business." Journal of World Business 45, no. 4 (October 2010): 323–25. http://dx.doi.org/10.1016/j.jwb.2009.08.011 13. Neal J., Harpham A. 2016. The spirit of project management. Routledge, London.

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	14. Osterwalder, A., & Pigneur, Y. (2010). Business model generation. John Wiley & Sons. 15. PM² Project management methodology. Guide 2.0. 2018. European Commission. Retrived from: https://op.europa.eu/en/publication-detail/-/publication/0e3b4e84-b6cc-11e6-9e3c-01aa75ed71a1 16. Roberts P. 2013. Guide to Project Management. The Economist, Profile Books Ltd., London. 17. Seroka-Stolka, Oksana, Anna Surowiec, Paweł Pietrasieński, and Anna Dunay. "SUSTAINABLE BUSINESS MODELS." Zeszyty Naukowe Politechniki Częstochowskiej Zarządzanie 27, no. 2 (December 2017): 116–25. http://dx.doi.org/10.17512/znpcz.2017.3.2.11 18. The GPM P5 Standard for Sustainability in Project Management. 2018. Green Project Management Institute, USA.

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VI. MODULE

Modules title	**Agroecosystem**
Objectives	The primary objective of Module 6 is to elucidate the significance of diverse agricultural production systems and technological prerequisites for agricultural production, and to evaluate environmental risks associated with the utilization of conventional cropping systems.
Learning outcomes	• *Knowledge:* Students know the concepts and problems of agricultural and related sciences on sustainable production of renewable biological resources and their use in accordance with the principles of sustainable development; they understand the complexity of natural phenomena and natural biotechnological processes occurring and used in the Bioeconomy. • *Skills:* Students can assess the environmental, social and economic impact of production systems and products; they can supervise and conduct biomass production in accordance with the principles of sustainable development. • *Social competences:* Students are able to consciously pursue and implement the ideas of sustainable development.
Literature and materials	1. Hyunjin P., Grundmann P. What does an inclusive bioeconomy mean for primary producers? An analysis of European bioeconomy strategies, Journal of Environmental Policy & Planning, 2022, DOI: 10.1080/1523908X.2022.2094353 2. Melicher, J.; Špulerová, J. Application of Landscape-Ecological Approach for Greenways Planning in Rural Agricultural Landscape. Environments 2022, 9, 30. https://doi.org/10.3390/environments9020030

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VII. MODULE

Modules title	**Water**
Objectives	Module 7 focuses on the comprehensive management of water resources incorporating groundwater, surface water, water footprint, and wastewater. This holistic approach is imperative to guarantee the sustainable availability of this crucial resource in a continually expanding urban and population-centric world. Moreover, the implementation of sustainable urban drainage systems has become pivotal in addressing the challenges related to flooding and contamination in urban areas. This involves promoting practices such as green roofs and permeable pavements which mitigate runoff and improve water quality. Consequently, these measures contribute to the preservation of ecosystems and human well-being within an ever-expanding urban environment.
Learning outcomes	• *Knowledge:* In scope of Water Resources: students show understanding of the availability, distribution and management of water sources; In scope of Natural Resources Management: students exhibit knowledge of sustainable practices for managing natural resources with a specific emphasis on water; In scope of Water Reuse: students are familiar with the concept of reusing water and its implications in various contexts; In scope of Hydric Footprint: students show awareness of the impact of individual and collective water consumption on the environment; In scope of Good Practices: students know how to adopt and promote best practices in water management and conservation. • *Skills:* students gain the ability to effectively assess and evaluate water-related issues; in terms of Water Cleaning students show proficiency in techniques and methods for purifying water; in terms of Field-Worthy Water Safety students are capable of ensuring water safety under field conditions. • *Social competences*: students can think critically; they are aware of water problems and develop a participative approach and social responsibility.
Literature and materials	1. Calvo-Flores, F.G., Isac-García, J., Dobado, J. A. (2017). Emerging Pollutants: Origin, Structure, and Properties. Wiley. 2. Franco, A. A., Arellano, J. M., Albendín, G., Rodríguez-Barroso, R., Zahedi, S., Quiroga, J. M., & Coello, M. D. (2020). Mapping microplastics in Cadiz (Spain): Occurrence of microplastics in municipal and industrial wastewaters. Journal of Water Process Engineering, 38(June), 101596. https://doi.org/10.1016/j.jwpe.2020.101596 3. Hernández-Sánchez, C., González-Sálamo, J., Ortega-Zamora, C., Jiménez-Skrzypek, G., & Hernández-Borges, J. (2020). Microplastics: An Emerging and Challenging Research Field. Current Analytical Chemistry, 17(7), 894–901. https://doi.org/10.2174/1573411016999201029194655 4. Jiang, J. Q., Zhou, Z., & Sharma, V. K. (2013). Occurrence, transportation, monitoring and treatment of emerging micro-pollutants in waste water - A review from global views. Microchemical Journal, 110, 292–300. https://doi.org/10.1016/j.microc.2013.04.014 5. Plattard, N., Dupuis, A., Migeot, V., Haddad, S., & Venisse, N. (2021). An overview of the literature on emerging pollutants: Chlorinated derivatives of Bisphenol A (ClxBPA). Environment International, 153. https://doi.org/10.1016/j.envint.2021.106547 6. Zhou, S., Di Paolo, C., Wu, X., Shao, Y., Seiler, T. B., & Hollert, H. (2019). Optimization of screening-level risk assessment and priority selection of emerging pollutants – The case of

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	pharmaceuticals in European surface waters. Environment International, 128(April), 1–10. https://doi.org/10.1016/j.envint.2019.04.034.

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VIII. MODULE:

Modules title	**Closing the loop**
Objectives	The primary objective of Module 8 is to elucidate the significance of proper waste management within the context of a circular economy framework.
Learning outcomes	• *Knowledge:* Students know and understand the issues related to the following areas: waste management; waste valorisation: recycling; energy; composting; anaerobic digestion, biomass valorisation techniques. • *Skills:* Students can use technical tools; they can manage in a sustainable way; they are skilful in 3 Rs and waste management hierarchy and they can argue this issue. • *Social competences:* Students can work in pairs.
Literature and materials	1. Ahmed, I.; Zia, M.A.; Afzal, H.; Ahmed, S.; Ahmad, M.; Akram, Z.; Sher, F.; Iqbal, H.M.N. (2021) "Socio-Economic and Environmental Impacts of Biomass Valorisation: A Strategic Drive for Sustainable Bioeconomy". Sustainability, 13, 4200. https://doi.org/10.3390/ su13084200. 2. Bar-On YM, Phillips R, Milo R. (2018) "The biomass distribution on Earth". Proc Natl Acad Sci U S A. 2018 Jun 19; 115(25):6506-6511. doi: 10.1073/pnas.1711842115. Epub 2018 May 21. PMID: 29784790; PMCID: PMC6016768. www.pnas.org/cgi/doi/10.1073/pnas.1711842115 3. Bing Song, Richen Lin , Chun Ho Lam , Hao Wu , To-Hung Tsui , Yun Yu (2021) "Sugar monomers". Renewable and Sustainable Energy Reviews 135 (2021) 110370. 4. Chapuis, A., J. Blin, P. Carré, and D. Lecomte. (2014). "Separation Efficiency and EnergyConsumption of Oil Expression Using a Screw-Press: The Case of Jatropha Curcas L. Seeds."Industrial Crops and Products 52: 752–61. https://doi.org/10.1016/j.indcrop.2013.11.046. 5. del Mar Contreras, et. al. (2022). "Residues from grapevine and wine production as feedstock for a biorefinery". Food Bioprod. Process. 134, 56–79. 6. Elhacham, E., Ben-Uri, L., Grozovski, J. et al (2020). "Global human-made mass exceeds all living biomass". Nature 588,442–444. https://doi.org/10.1038/s41586-020-3010-5 https://www.nature.com/articles/s41586-020-3010-5#citeas. 7. Fernandes, Maria da Conceição (2023). "Valorização dos Subprodutos do Sector Vitivinícola". Seminar Bioeconomia circular no setor vitivinícola". CEBAL e MED. Beja. 8. https://www.epa.gov/recycle/composting-home 9. Kaltschmitt, M. (2013) "Renewable energy from biomass, Introduction. In Renewable Energy Systems"; Kaltschmitt, M., Themelis, N.J., Bronicki, L.Y., Söder, L., Vega, L.A., Eds.; Springer: New York, NY, USA, 2013; pp. 45–71. 10. Keng, Zi Xiang; Chong, Siewhui; Ng, Chee Guan; Ridzuan, Nur Izzati; Hanson, Svenja; Pan, Guan-Ting; Lau, Phei Li; Supramaniam, Christina Vimala; Singh, Ajit; Chin, Chiew Foan; Lam, Hon Loong (2020) "Community-scale composting for food waste: A life-cycle assessment-supported case study". Journal of Cleaner Production 261 121220. https://doi.org/10.1016/j.jclepro.2020.121220. 11. María Diaz-Montaño, D. (2022). "Valorization of Biomass as a Raw Material to Obtain Products of Industrial Interest. In Biomass, Biorefineries and Bioeconomy" ed. by Mohamed Samer. IntechOpen. doi: 10.5772/intechopen.104108. https://www.intechopen.com/chapters/81150.

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12. Shahbeig H., Shafizadeh A., Rosen M.A., Sels B.F. (2022) “Exergy sustainability analysis of biomass gasification: a critical review”. Biofuel Research Journal 33 1592-1607. DOI: 10.18331/BRJ2022.9.1.5 https://doi.org/https://doi.org/10.1016/j.fbp.2022.05.005.
13. Uwineza, Pascaline Aimee, and Agnieszka Waśkiewicz. 2020. "Recent Advances in Supercritical Fluid Extraction of Natural Bioactive Compounds from Natural Plant Materials" Molecules 25, no. 17: 3847. https://doi.org/10.3390/molecules25173847.
14. Vera, David; Jurado, Francisco; de Mena, Bárbara and Hernández, Jesús C. (2019). “Distributed Generation Hybrid System for Electric Energy Boosting Fueled with Olive Industry Wastes”, Energies 2019, 12, 500; doi:10.3390/en12030500.

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IX. MODULE

Modules title	**Biotechnology and agricultural innovations**
Objectives	Module 9 is dedicated to elucidating biotechnology in the context of Bioeconomy, with a deeper focus on subtopics such as fermentation and composting. The second part concentrates on modern methods of plant food production through vertical farming systems and explores the ethical dilemma associated with insect consumption.
Learning outcomes	• *Knowledge:* Students know innovative solutions such as vertical farming, aquaponics, biotechnology processes. • *Skills:* Students can connect information, give examples and discover opportunities. • *Social competences:* Students develop communication skills, teamwork and networking skills.
Literature and materials	1. Barcelos M.C.S., Lupki F.B., Campolina G.A., Nelson D.L., Molina G. The colors of biotechnology: General overview and developments of white, green and blue areas (2018) FEMS Microbiology Letters, 365 (21), art. no. fny239 2. Bernstein, S. 2011. Aquaponic gardening: a step-by-step guide to raising vegetables and fish together. Gabriola Island: New Society Publ. ISBN 978-0-86571-701-5. 3. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M., 2019. Aquaponics Food Production Systems: Combined Aquaculture and Hydroponic Production Technologies for the Future, Springer International Publishing. Springer International Publishing, Cham, Switzerland. https://doi.org/10.1007/978-3-030-15943-6. 4. Munroe, G. (2007) Manual of on-farm vermicomposting and vermiculture. Organic Agriculture Centre of Canada, Nova Scotia.

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