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METHODOLOGICAL ASSESSMENT FRAMEWORK OF SOCIOECONOMIC SYSTEMS' BIO-ECONOMIC TRANSFORMATION MANAGEMENT

VIKTORIIA VOSTRIAKOVA

Abstract. Assessment of the process of bio-economic transformation of socioeconomic systems and its consequences in various countries, and in Ukraine in particular, is quite problematic since the existing methodology of the State Statistics bodies does not meet its needs and therefore is not able to cover its development based on domestic data adequately. The biggest obstacle on this path is the lack of separation of economic activity types into the production of the products using materials of biological and fossil origin in the process of collecting and processing official data, which further complicates the assessment of bioeconomic processes along supply chains and its impact on sustainable economic development. Paper research has been conducted through a mixed-methods approach to reach the following objectives, including desktop research using general scientific methods and content and comparative analysis with further conceptual framework adoption. To simplify the process of developing a methodological assessment framework, at the initial stage of the bioeconomic transformation assessment system formation, we proposed an adapted framework and indicators that can be obtained from existing statistical information supplemented with data from other alternative sources. This approach assumes the use of formal data collection methods, assuming they will remain unchanged for the foreseeable future. We have systematized assessment indicators into three dimensions of its maturity: indicators of bioeconomic potential, development, and sustainability, specific to Ukrainian organizations, as these combined indicators can provide an understanding of the current state, compromises, and the likelihood of sustainable bio-economy transformation. Practical implementation of the obtained results and elimination of identified shortcomings and gaps in the assessment of bioeconomic transformation will contribute to developing bioeconomic strategies based on sustainable development.

Keywords: bio-economic transformation, assessment framework, bio-based share; sustainability, potential, innovations.

JEL Classification: Q5, M11, C13; P28

1. INTRODUCTION

Bioeconomic transformation assessment and its impact on national economy development is a rather complicated and complex task, as it is difficult to make it based on national statistical data. This task is especially difficult for Ukraine since the State Statistics Service of Ukraine adheres to a

specific methodology and indicators system for assessing the national economic development, which does not provide for the separation of production data on a biological basis from conventional ones, like in the European Union (EU).

Bioeconomy assessment is becoming very important since the demand for bio-based products is growing rapidly, and other new bio-technologies are being explored in various fields. The European Commission report notes that there is growing interest at the national level in establishing bioeconomy assessment systems that enable the measurement and monitoring of bioeconomy supply chains — from biomass production to consumption and processing — and their impact on sustainable development to ensure the establishment of a balanced state policy in this area (European Commission, 2017). It is necessary to develop such a mechanism for assessing bioeconomic transformation, which can be adapted to the indicators already available in the statistical system and data from other alternative sources, assuming that the official data collection methods will not be changed shortly.

Quantitative assessment of the bioeconomic development (D'Adamo et al., 2020) allows for assessing the effectiveness of bio-economic process and contributing to sustainable transformation. Analysis of bioeconomy sectors provides an opportunity to identify sectors to which biomass flows can be best directed to use it most efficiently and effectively in terms of sustainability. However, assessing the bioeconomy and its economic, ecological, and social components can be challenging, because of their controversy.

2. THEORETICAL BACKGROUND

The bioeconomy is an interdisciplinary economy (an economy that covers different sectors), similar to the ecological economy. Therefore, the effectiveness of the bioeconomy needs to be reflected in official statistics, which complicates its assessment. Consequently, those responsible for implementing coherent and systematic assessment of the bioeconomy transformation will have to deal with different and often conflicting reports regarding the bioeconomy, as it involves sectoral demarcation. The sectors included in the various studies and the assessment systems used by the countries differ significantly, as they are oriented towards different goals (Schanz et al., 2019). According to the approach used by the European Commission, the bioeconomy can be divided into three sectors: primary, partial, and indirect sectors of the bioeconomy (Haarich et al., 2017). There are primary bioeconomy sectors (e.g., agriculture, forestry, or biofuels), partial sectors of the bioeconomy (e.g., chemicals, plastics, or construction), and indirect bioeconomy sectors (e.g., engineering, commercial, or public services). Primary or core sectors of the bioeconomy use almost 100% bio-based materials and are entirely dependent on biomass. In these sectors, bio-production is the only possible option. In sectors of the partial bioeconomy, products can be produced on bio-based or fossil-based materials, and the transition to bioresources has occurred partially. If these sectors start to use only bio-based materials, they will move to the primary sector of the bioeconomy. Indirect sectors of the bio-economy are considered ancillary because they provide equipment and services for industrial processes without using the biological resources themselves. At the same time, in Germany, for example, ten economic sectors are identified that are related to the bioeconomy, but do not belong to it entirely (BMBF, 2014), and the German Council for the Bioeconomy recommends including all chains of added value — from biomass production in agriculture and forestry, fishing, aquaculture, and waste management, to the production of final products made from it (Bioökonomierat et al., 2010). Although the primary sector of the economy (Lier et al., 2017), which includes agriculture and forestry, is always included in the system of bioeconomy assessment indicators, other sectors, like chemicals for example, are at least partially taken into account in most international assessment systems, methods and results, in general, differ (Tab. 1).

Tab. 1

Overview of modern methodological approaches to the formation of indicators of bioeconomic transformation by sectors

COVERAGE OF SECTORS	ECONOMIC INDICATORS	ENVIRONMENTAL INDICATORS	INNOVATIVE INDICATORS
BIO-BASED SECTORS WITH THE POTENTIAL TO REPLACE FOSSIL RESOURCES *Wackerbauer et al. (2019); Jander and Grundmann (2019)*	number of employees, gross value added, turnover, exports, investments, the share of fossil resources replacement	energy consumption, ecological footprint, saving/substitution of fossil resources	publications, patents
PRIMARY AND HIGH-TECH SECTORS OF THE BIO-ECONOMY *Biber-Freudenberger et al. (2018); Frietsch et al. (2016)*	value added, employment, exports	individual indicators related to sustainable development goals (SDGs)	Patents
BIORESOURCE SECTORS *Capasso and Klitkou (2020); D'adamo et al. (2020); Efken et al. (2016); Iost et al. (2019); Loizou et al. (2019); Ronzon and M'barek (2018); Wydra et al. (2020)*	value added, employment, productivity, turnover, income multipliers, labor productivity, location coefficient	- / -	R&D expenses, patents
NOT SPECIFIED *Egenolf and Bringezu (2019); Fuentes-Saguar et al. (2017)*	production and employment multipliers	the ecological footprint of agricultural land use, forest, and water resources, the impact on the climate	- / -
BIOTECHNOLOGICAL SECTORS AND BIOENERGY *Wen et al. (2019)*	value added	- / -	- / -

Source: summarized by author

Having conducted a comprehensive analysis of existing methodological approaches, we have systematized and defined the main indicators that can be used in Ukraine following the available statistical information, which includes employment, value-added, and turnover of the main bioeconomic sectors. However, determining the share of bio-based industries in the partial and indirect sectors of the bioeconomy remains a critical issue for discussion. In addition, a significant gap in the delivering of bioeconomic transformation assessment indicators is the need for a comprehensive approach. Economic or ecological efficiency is measured in most considered methods, but not both indicators together. Above all, most existing assessment systems still concentrate on economic indicators, especially in bio-resource sectors. Others focus more on environmental sustainability, such as bio-based sectors with the potential to replace fossil resources and primary and high-tech sectors. This gap indicates the need for a coherent structure and appropriate indicators that could reflect the alignment of two or more goals.

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

Main goal of the article was to develop an adapted framework of bioeconomic transformation assessment indicators that can be obtained from existing national statistical data. Paper research have been conducted through a mixed-methods approach to reach following objectives, including a desktop research using general scientific methods like analysis and synthesis, induction and deduction. The literature review has examined theoretical framework of bioeconomic transformation assessment indicators and its relevance to Ukraine's State Statistic Agency methodology. Content analysis involves systematically categorizing and analyzing the content of existed academic researches of modern methodological approaches to the formation of indicators of bioeconomic transformation. It was used to identify patterns, themes, and trends related to bioeconomic monitoring indicators. As there are multiple studies have been defined the comparative analysis of different bioeconomic monitoring indicators have been conducted. This involves examining the similarities and differences between the indicators in terms of their objectives and sector coverage. Comparative analysis helped to identify the most suitable indicators for Ukrainian contexts or the research paper. Next step of the research is conceptual framework analysis which involves developing a framework or model that captures the relationships between different bioeconomic monitoring indicators, variables, or concepts. This method provided us with adoption of visual representation of the indicators' interconnections with Systems analysis framework for the bioeconomy, developed by SAT-BBE Consortium (Van Leeuwen et al., 2015) and assist in understanding their conceptual foundations and applications on Ukrainian national level.

4. RESULTS AND DISCUSSION

To develop a system for assessment the bioeconomic transformation of socioeconomic systems, we were being guided by a broad definition of bioeconomy to build an objective, comprehensive and universal system for assessment bioeconomic transformation. This approach involves the inclusion of all value-added chains that use biological resources. We consider taking into account both already quantified industrial sectors (primary), such as the forest industry or the agri-food sector, as well as new sectors (partial and indirect), which have not yet reached significant production volumes but have high innovation potentials, such as biological polymers and plastics. All biological resources must be considered, including all types of biomass: plant, animal, and waste biomass, and other organisms or their parts are used in the production process. Our study is based on the expanded interpretation of the concept of bioeconomic transition presented by Jander and Grundmann (2019). When studying bioeconomic transformations, such a structure becomes necessary to ensure a common understanding between developers and users of indicators regarding assessing complex and dynamic socioeconomic systems with different goals, development factors, limitations, and possible solutions. In Fig. 1, a logical assessment framework of socioeconomic systems bio-economic transformation is presented, which makes it possible to take into account not only the transition from a traditional economy based on fossil fuels to bio-based economy and biotechnologies but also other directions of transformation (Dietz et al., 2018), such as ensuring food security or another vision such as the development of environmentally safe ways of producing goods (Bugge et al., 2016).

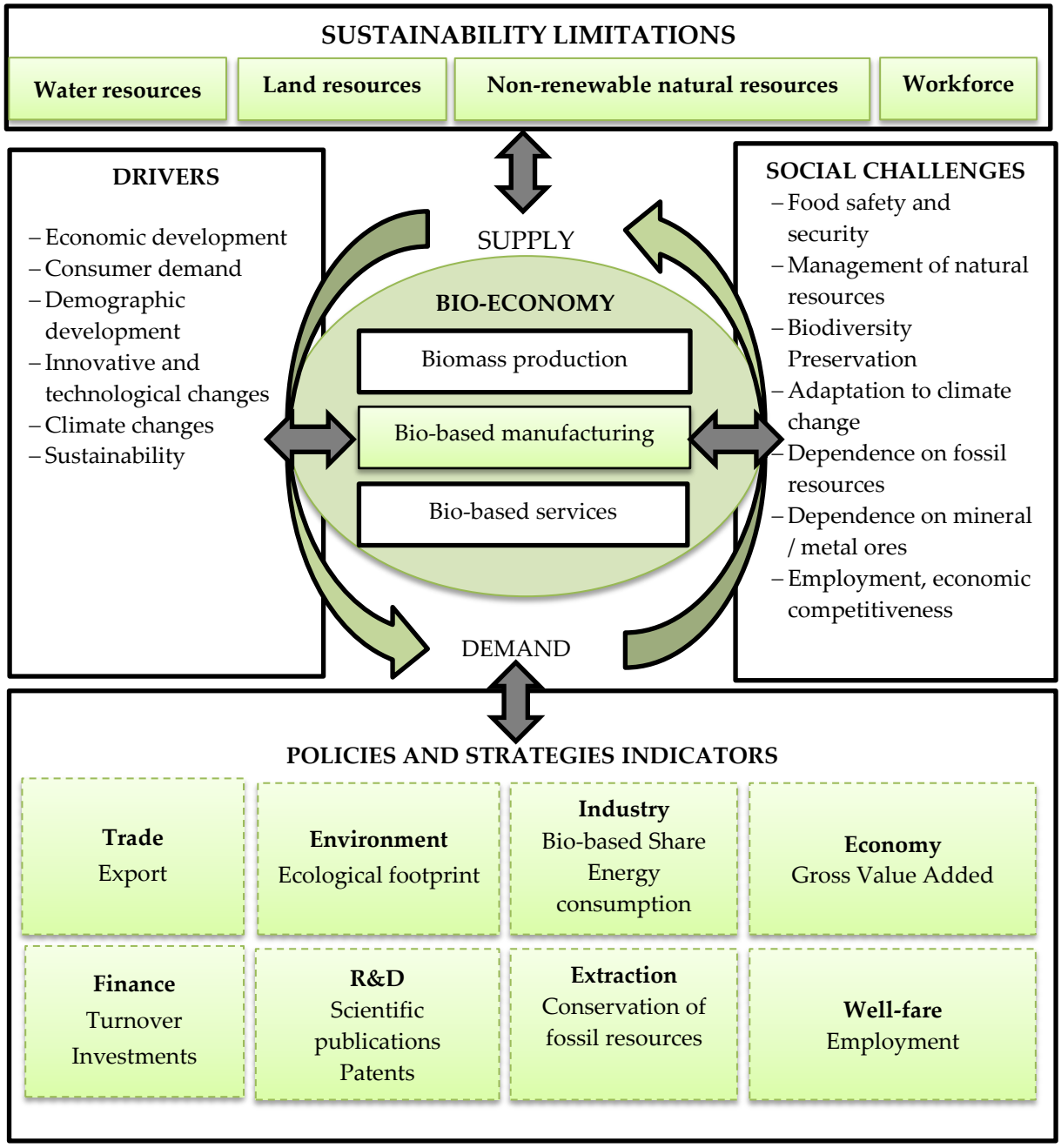

Fig. 1. Logical assessment framework of socioeconomic systems bio-economic transformation
Source: adapted from (Van Leeuwen et al., 2015)

According to the generally accepted economic classification, the bioeconomy is divided into three sectors: the primary sector is biomass production, the secondary sector is bio-resource manufacturing, and the tertiary sector includes bio-based services such as trade. The assessment system should cover all of them. The drivers, or driving forces, should cover all bioeconomy sectors, including partially or indirectly bio-based sectors, not just the primary sector comprising bio-replaceable commodities (i.e., biomaterials and bioenergy). Considering the latest concepts of bioeconomic transformation, when forming assessment indicators, it is vital to pay considerable attention to the innovative bioproducts transition (for example biorefinery), which can contribute to economic growth and often replace fossil resources. It is important not to focus on increasing agricultural production or imports to ensure the sustainable development of circular bioeconomic

systems because this does not always correspond to the goals of sustainable development, which in our logical assessment framework are summarized under the name social challenges (Fig. 1).

Important to consider that the development of the bioeconomy takes place at different levels, which determines the limits of the analysis of assessment systems. Depending on the specific assessment objectives, appropriate levels may include local, sectoral, national, regional, or global levels. The European Commission has developed reliable and comprehensible criteria (RACER) "for assessing the relevance of bioeconomic policy monitoring indicators" (European Commission, 2017, p. 308), which are used to analyze the efficiency of resource use. This list was recently supplemented with environmental impact indicators (Eisenmenger et al., 2016). Given the current limitations of statistical data availability in Ukraine, we propose to form a narrow set of core indicators covering the economic, environmental, and innovation spheres — two to four indicators each — to ensure the assessment of critical aspects of the bio-economic transformation. When choosing indicators for our study, we consider their relevance and practicality, determining them by a clear connection with the observed phenomenon, the bioeconomy policy and strategy, and its consequences. Defined indicators should contribute to the problem understanding and generate ideas for its solution. Practicality or "comprehensibility" means data collection and statistical information are possible in Ukrainian realities.

To the selected indicators of "value-added," "turnover," and "number of employees," which are used most in foreign literature, we added the indicator of "export" and "investment." In the EU have been proposed to bring all economic indicators of the partial and indirect bioresource sectors to a single value through the indicator of the " bio-based share", which demonstrates bioeconomic growth in physical terms. We summarized the economic and ecological indicators according to the data of the reviewed studies under the general name of sustainability indicators of the bioeconomy. This will make it possible to reflect and monitor the interdependence between often opposing goals and balance them. For example, an increase in the value-added of bioproducts can lead to an increase in energy consumption if, for example, bioprocesses are more energy intensive than processes involving the use of fossil fuels. Energy consumption is the most harmful factor of climate change. Despite the active development of renewable energy, the issue of reducing fossil energy consumption and using more and more biogenic resources in the production process remains relevant. Bioeconomic transformation should not occur at the expense of using more energy-intensive production processes because the sustainable development of the bioeconomy, which is worth striving for, involves, in particular, reducing the impact of climate change by reducing energy consumption. The following sustainability indicator is the ecological footprint of the Earth's resources use at the macro level, the ecological footprint of the organization at the meso level, and the product's ecological footprint at the micro level. The growth of the bioeconomy is likely to increase the use of land resources compared to the traditional economy. Because of this, there is a threat of irrational use of biological resources, leading to inevitable adverse effects on the environment, from biodiversity loss to soil degradation and erosion. We recommend including an ecological footprint indicator for using land resources to monitor the biomass production sectors, reflecting the number of land resources used for production.

Combined indicators are important because they provide an opportunity to balance some indicators. If, for example, one indicator value has decreased, another value can compensate for such a decrease with a more significant increase. The sustainability indicators of the bioeconomy presented in the table refer to the goals of natural resource management and reducing dependence on fossil resources in our logical framework (see Tab. 2).

Tab. 2

Systematization of assessment indicators of bio-economic transformation

No	*Indicator*	*Description*	*Application*
	Indicators of bioeconomic potential		
1.	**Bio-based Share**	The share of biological products in the industry	Determination of the proportion for the bio-based share for further assessment of the general economic indicators of the sector
2.	**Number of Employees**	The number of the estimated labor force in the production of bioproducts. This is of great political interest as it demonstrates the bioeconomy contribution to the overall economic goals.	Assessment policy measures aimed at securing or creating employment opportunities, and measuring the impact of new activities, such as biotechnological innovations, on the labor market.
3.	**Gross Value Added**	The total monetary production value of goods and services minus the value of used resources.	The indicator is relevant for formulating and focusing policies and other measures to maximize economic growth.
4.	**Turnover**	The sum of the value of all products and services sold during a certain period of time. This indicator represents the market share of the company.	Understanding of the economic importance of various branches of the bioeconomy.
	Indicators of bioeconomic development		
5.	**Export**	Foreign sales, which include goods and services sold to exporters who export goods without further processing or to customers abroad. It represents an international market share of the company or industry and its international competitiveness.	Assessment the concentration of political measures and other measures related to the development of exports.
6.	**Investments**	Include the expenditure of financial funds on tangible investments, intangible assets, or financial investments.	Assessment of information on the development of medium and long-term production capacities
7.	**Scientific Publications**	The number of scientific publications in the bio-economy sector in the country over a certain period of time	Assessment the development of scientific thought and promising directions for future research
8.	**Patents**	The absolute number of patents for a certain period of time	Assessment of economically significant results of innovative activity or measurement of technological competitiveness in international comparison.
	Sustainability indicators of the bioeconomy		
9.	**Energy Consumption**	Energy consumption of the bio-based sector for a certain period of time, which is determined by multiplying the annual energy consumption of the entire sector by its bioresource component. If you combine this indicator with gross value added (GVA), you can get an indicator of "energy productivity", which will show how much economic output can be generated from one unit of energy.	Allows you to track relative and absolute deviation. An increase in GVA or a decrease in energy consumption will increase energy productivity.

10.	**Ecological Footprint**	The number of hectares of land resources, that is, the biologically productive surface of the Earth, necessary for the reproduction of consumed resources and waste processing	It makes it possible to estimate human consumption of the Earth's resources in the process of life
11.	**Conservation of fossil resources**	Fossil resource savings in the sector(s) – a quantitative reflection of the saved volume of crude oil, natural gas and coal in energy units due to the use of bio substitutes during the year. It is calculated as the sum of the products of the volume of production of products using biosubstitutes and the reduction of the amount of fossil fuel used.	Assessing the potential to reduce dependence on fossil resources by replacing fossil fuels with biofuels

Source: summarized by the author

Given the limited funding for future assessment needs of the bioeconomy, scientists still need to consensus on which assessment areas should be prioritized in the short term and which should be left for the long term. At the initial stage, it is essential to identify the most critical sectors and indicators for assessment and then gradually expand them. It is evident that at the early stage of the transformation of bio-economic systems, we have to focus on the determination of bio-economic potential indicators, which we propose to include employment, added value, turnover, and determination of the bio-resource component for partially or indirectly bio-economic sectors. To determine the level of bioeconomic development, it is crucial, in addition to the already proposed indicators, to add such indicators as the level of investments, exports, and the number of patents and scientific works in the bio-economy. Even though we propose to focus on the development of basic indicators of bioeconomic transformation, it is crucial to complete the list of indicators with indicators of sustainable development of the bioeconomy. Sustainable development indicators include energy consumption, the ecological footprint of a product or organization (depending on the level of assessment), and the conservation/substitution of fossil resources. It necessary to consider the indicator of the substitution of fossil resources in more detail due to its insignificant distribution and use in Ukraine. One of the main arguments favoring bioeconomic transformation is its potential to reduce dependence on fossil fuels by creating bio-substitutes. Since the production process of biological products may also include fossil resources as energy carriers or other additional resources, it is necessary to calculate their net replacement. Foreign scientists develop several indicators for such purpose. Fossil resource substitution (FRS) (Jander & Grundmann, 2019) in the sector(s) shows the amount of crude oil, natural gas, or coal, expressed in energy units, that has been saved due to the use of bio-substitutes (Xb) during the year. Fossil resource equivalents (FREs) reflect the amount of fossil resources used along the supply chain of products based on fossil and biological resources, which can be obtained from the ECOINVENT product life cycle database (Ecoinvent Database, 2023). The volume of production of bio-substitutes products is determined, taking into account the bio-based share mentioned above, more details in the paper Jander and Grundmann (2019).

Suppose the indicator of FRS is combined with the cost of intermediate consumption, which reflects the cost of resources in the sector(s). In that case, substitution can occur due to higher prices for raw materials, especially if the increase in demand for biomass leads to higher prices for these resources, and, as a result, value-added may decrease. An increase in the FRS or a decrease in the cost of resources (that is, costs) will lead to an increase in the FRS by UAH 1 expenses, reflecting the profitability of replacing fossil resources.

Indicators of sustainable bioeconomic development reflect actual transition processes and solutions, while indicators of bioeconomy development demonstrate areas where new incentives for bioeconomic transformation can emerge. We agree with other authors that innovations are the basis of bioeconomic transformation (Sanz-Hernández, 2019), and their use in the assessment system of bioeconomic transformation provides an opportunity to demonstrate the transition process to sustainable bioeconomic development.

5. CONCLUSION

Within this paper we systematized scientific research on developing and measuring relevant economic and environmental indicators in the bioeconomy. Based on the generalization of the obtained data, we formed a system of indicators for assessment bioeconomic transformation, which consists of three groups of indicators: bioeconomic potential, development, and sustainability of the bioeconomy. The study's results will contribute to creating a theoretical and analytical basis for forecasting and analyzing future scenarios of bioeconomic transformation and assessing the impact of bioeconomy development on the national economy.

In developing a bioeconomic transformation strategy, high priority should be given to identifying and evaluating options and methodological approaches to improving and adapting information databases at all levels involved in implementing the bioeconomy assessment system. In the short term, it is possible to adapt existing statistical data to monitor the potential and development of the bioeconomy of the primary sector. In contrast, indicators of the sustainability of the bioeconomy and assessment of partial and indirect bio-based sectors require the integration of additional data sources that can clarify the results and extend them to other sectors of the bioeconomy. In addition to the possible positive influence on decision-making in practice, the proposed approach also makes it possible to conduct a more in-depth preliminary analysis of the process of bioeconomic transformation and predict positive or negative effects. A significant achievement of the research is the integration of ecological indicators into the assessment system, which helps to reveal the socio-ecological consequences of the bio-economic transformation, which are mostly neglected. The limitations of this study also determine the need for further verification of the reliability and the possibility of applying the proposed indicators and methodological approaches in other sectors of industry, especially partial and indirect (to define bio-based share), and the bioeconomy as a whole. In addition, it is essential to emphasize the need to review the values of indicators for research activities and their compliance with the tasks set in practice. In the medium term, we should expect the creation of several bioeconomy assessment systems as a result of the implementation of several national, European, and global initiatives, which will require proper coordination of activities and even different tools and approaches harmonization at all levels, ensuring synergy, exchange, and comparability of results.

REFERENCES

[1] Biber-Freudenberger, L., Basukala, A., Bruckner, M., & Börner, J. (2018). Sustainability performance of national bio-economies. *Sustainability, 10(8),* 2705. https://doi.org/10.3390/su10082705

[2] Bioökonomierat. (2010). *Forschungs - und Technologierat Bioeconomy. Gutachten des Bioökonomierats* 2010— Innovation Bioökonomie, Berlin. http://surl.li/ifvjp (in German)

[3] BMBF, BMEL. (2014). *Bioökonomie in Deutschland— Chancen for one biobasierte und nachhaltige Zukunft*, Bonn. https://www.fona.de/medien/pdf/Biooekonomie_in_Deutschland.pdf (in German)

[4] Bugge, M., Hansen, T., & Klitkou, A. (2016). What is the bioeconomy? A review of the literature. *Sustainability*, *8(7),* 691. https://doi.org/10.3390/su8070691

[5] Capasso, M., & Klitkou, A. (2020). Socioeconomic indicators to monitor Norway's bioeconomy in transition. *Sustainability*, *12(8),* 3173. https://doi.org/10.3390/su12083173

[6] D'Adamo, I., Falcone, P. M, & Morone, P. (2020). A New socio-economic indicator to measure the performance of bioeconomy sectors in Europe. *Ecological Economics*, *176*. https://doi.org/10.1016/j.ecolecon.2020.106724

[7] Dietz, T., Börner, J., Förster, J., & Von Braun, J. (2018). Governance of the bioeconomy: A global comparative study of national bioeconomy strategies. *Sustainability*, *10(9),* 3190. https://doi.org/10.3390/su10093190

[8] Ecoinvent Database. (n.d.). https://ecoinvent.org/the-ecoinvent-database/

[9] Efken, J., Dirksmeyer, W., Kreins, P., & Knecht, M. (2016). Measuring the importance of the bioeconomy in Germany: Concept and illustration. *NJAS Wagening. Journal of Life Sciences*, *77*, 9–17. https://doi.org/10.1016/j.njas.2016.03.008

[10] Egenolf, V., & Bringezu, S. (2019). Conceptualization of an Indicator system for assessing the sustainability of the bioeconomy. *Sustainability*, *11(2),* 443. https://doi.org/10.3390/su11020443

[11] Eisenmenger, N., Giljum, S., Lutter, S., Marques, A., Theurl, M., Pereira, H., & Tukker, A. (2016). Towards a conceptual framework for social-ecological systems integrating biodiversity and ecosystem services with resources efficiency indicators. *Sustainability*, *8(3),* 201. https://doi.org/10.3390/su8030201

[12] European Commission. (2017a). *Better Regulation Toolbox*. European Commission: Brussels, Belgium, http://surl.li/ifxjl

[13] European Commission. (2017b). *Bioeconomy Development in EU Regions—Mapping of EU Member States'/Regions' Research and Innovation Plans & Strategies for Smart Specialization (RIS3) on Bioeconomy.* Final Report, EC: Brussels, Belgium.

[14] Frietsch, R., Neuhäusler, P., Rothengatter, O., & Jonkers, K. (2016). Societal Grand Challenges from a technological perspective perspective: Methods and identification of classes of the International Patent Classification IPC. In Fraunhofer ISI Discussion Papers—Innovation Systems and Policy Analysis; Fraunhofer ISI: Karlsruhe, Germany, 53.

[15] Fuentes-Saguar, P. D, Mainar-Causapé, A. J, & Ferrari, E. (2017). The role of bioeconomy sectors and natural resources in EU economies: A social accounting matrix-based analysis approach. *Sustainability*, *9(12),* 2383. https://doi.org/10.3390/su9122383

[16] Haarich, S., Kirchmayr-Novak, S., Fontenla, A., Toptsidou, M., & Hans S. (2017). Bioeconomy development in EU regions. In: Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialization (RIS3) on Bioeconomy. Final Report. https://ec.europa.eu

[17] Iost, S., Labonte, N., Banse, M., Geng, N., Jochem, D., Schweinle, J., Weber, S., & Weimar, H. (2019). German bioeconomy: Economic importance and concept of measurement. German Journal of Agricultural Economics, *68(4),* 275–288. http://surl.li/ifzax

[18] Jander, W., & Grundmann, P. (2019). Monitoring the transition towards a bioeconomy: A general framework and a specific indicator. *Journal of Cleaner Production*, *236(1),* 117564. https://doi.org/10.1016/j.jclepro.2019.07.039

[19] Lier, M., Aarne, M., Kärkkäinen, L., Korhonen, K. T., Yli-Viikari, A., & Packalen, T. (2018). Synthesis on Bioeconomy Assessment Systems in the EU Member States—Indicators for Assessment the Progress of Bioeconomy. https://jukuri.luke.fi/handle/10024/542249

[20] Loizou, E., Jurga, P., Rozakis, S., & Faber, A. (2019). Assessing the potentials of bioeconomy sectors in Poland employing input-output modeling. *Sustainability*, *11(3),* 594. https://doi.org/10.3390/su11030594

[21] Ronzon, T., & M'Barek, R. (2018). Socioeconomic Indicators to Monitor the EU's Bioeconomy Transition. *Sustainability*, *10(6),* 1745. https://doi.org/10.3390/su10061745

[22] Sanz-Hernández, A., Sanagustín-Fons, M. V., & López-Rodríguez, M. E. (2019). A transition to an innovative and inclusive bioeconomy in Aragon, Spain. *Environmental Innovations and Societal Transitions 33*, 301–316. https://doi.org/10.1016/J.EIST.2019.08.003

[23] Schanz, H., Federer, J., & Wilczynski, M. (2019). Markets as leverage points for transformations of economic systems: The example of the German bioeconomy. *Environmental Innovations and Societal Transitions*, *33*, 140–161. https://doi.org/10.1016/j.eist.2019.04.003

[24] Van Leeuwen, M., Van Meijl, H., & Smeets, E. (2015). Design of a Systems Analysis Tools Framework for a EU Bioeconomy Strategy (Deliverable 3.3): Overview ofWP3in the EUFP 7 SAT-BBE Project; Funded by the European Commission, DG Research; European Commission: Brussels, Belgium, http://www3.lei.wur.nl (accessed on 4 June 2020).

[25] Wackerbauer, J., Rave, T., Dammer, L., Piotrowski, S., Jander, W., Grundmann, P., Wydra, S., & Schmoch, U. (2019). Investigation economic Kennzahlen und Indicatoren for ein Assessment des Voranschreitens der Bioökonomie if Forschungsberichte 104. https://www.ifo.de

[26] Wen, X., Quacoe, D., Quacoe, D., Appiah, K., & Danso, B. A. (2019). Analysis on bioeconomy's contribution to GDP: Evidence from Japan. *Sustainability*, *11(3),* 712. https://doi.org/10.3390/su11030712

[27] Wydra, S. (2020). Measuring innovation in the bioeconomy–Conceptual discussion and empirical experiences. *Technology in Soc*iety, *61*, 101242. https://doi.org/10.1016/j.techsoc.2020.101242

Viktoriia Vostriakova, PhD in Economics, Senior Doctorate Student, Vinnytsia National Technical University, Vinnytsia, Ukraine.

ORCID ID: 0000-0002-4161-7483

Address: Viktoriia Vostriakova, Vinnytsia National Technical University, Khmelnytsky highway 95, Vinnytsya, 21021, Ukraine.

E-mail: vikazataydukh@gmail.com

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Моніторинг процесу біоекономічної трансформації соціально-економічних систем та її наслідків у різних країнах, і в Україні зокрема, є доволі проблематичним, оскільки існуюча методологія органів Державної статистики не відповідає її потребам, а відтак не в змозі належним чином охопити її розвиток на основі вітчизняних даних. Найбільшою перешкодою на цьому шляху є відсутність поділу видів економічної діяльності на виробництво продукції з використанням сировини біологічного та викопного походження в процесі збору та обробки офіційних даних, що ще більше ускладнює оцінку біоекономічних процесів вздовж ланцюгів постачання їх вплив на сталий економічний розвиток. Для досягнення поставленої мети дослідження було використано окрім загальнонаукових методів, змістовний та порівняльний аналіз існуючих наукових досліджень та кращих практик з подальшим прийняттям концептуальної основи системи індикаторів для українських реалій. Для спрощення процесу розробки обґрунтованої методологічної рамки моніторингу, на початковому етапі формування системи моніторингу біоекономічної трансформації запропоновано запровадження адаптованої основи, відповідних секторів та показників, які можна отримати з існуючої статистичної інформації з доповненням даними з інших альтернативних джерел. Такий підхід передбачає використання офіційних методів збору даних, з припущенням, що вони залишаться незмінними в найближчому майбутньому. Нами систематизовано три рівні індикаторів моніторингу біоекономічної трансформації: індикатори біоекономічного потенціалу, розвитку та сталості,

специфічні для українських організацій, оскільки ці комбіновані індикатори можуть надати розуміння фактичних подій, компромісів і ймовірності переходу біоекономіки в даному секторі. Практичне значення отриманих результатів полягає в усунені виявлених недоліків і прогалин в оцінці біоекономічної трансформації, що сприятиме розробці біоекономічних стратегій у відповідності до принципів сталого розвитку.

Ключові слова: біоекономічна трансформація, система моніторингу, біологічна складова; сталий розвиток, потенціал, інновації.