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State Management of the System of Rational Environmental Use in the Context of Commercial Development of the Bioeconomy: Ecological Aspect

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ABSTRACT

The purpose of the article is to improve the state management of the system of rational environmental use in the context of commercial development of the bioeconomy. The focus of the study is the system of state management of rational environmental use. The scientific task is to model the process of making and implementing managerial decisions on the implementation of state management of the system of rational environmental use in the context of commercial development of the bioeconomy. Modelling was used within the context of commercial development of the bioeconomy for EU member. To achieve this task, two key methodologies were used: The modeling method BPMN (Business Process Model and Notation) and the method of hierarchy analysis (MHA). Thus, using the BPMN method and the MHA, we have modelled the stages of environmental management in the context of commercial development of the bioeconomy for EU member states by using key criteria. Based on these results, a number of management solutions were proposed. The innovativeness of the study lies in the fact that a qualitatively new modeling method was used to improve the implementation of the state management of the system of rational environmental use in the context of commercial development of the bioeconomy. In addition, a model specific to EU countries has been developed but with limited scope of use. In future studies, it is planned to expand the list of criteria that will be used to further develop the model, as well as unify it for a larger number of countries.

1. INTRODUCTION

Bioeconomics is an interdisciplinary field that studies economic processes and policies in the context of biological resources. It includes the production, use, and conservation of biological products and services, with particular attention to environmental sustainability, careful use of natural resources, and environmental safety.

The bioeconomy takes an integrated approach that combines the production of biological resources from agriculture, forestry, and fisheries with biotechnology to create food, energy, and industrial goods. The basis is sustainable development, harmoniously combining human needs with the preservation of natural ecosystems. The bioeconomic system takes into account the cyclicality and renewability of biological resources, as well as the efficiency of their use. The bioeconomy provides links between different economic sectors such as agriculture, chemicals, energy, and healthcare, creating synergies to achieve sustainable development goals. It operates based on a circular economy, where each element of the system interacts with others to create a closed loop of resources with minimal waste and pollution.

The principle of social responsibility in the bioeconomy influences the tax system and incentives by stimulating investment in sustainable development and environmentally friendly technologies. Governments can use tax instruments to encourage businesses to adopt practices that reduce their environmental impact, improve biodiversity, and ensure ethical production and consumption. This could include reducing the tax burden for companies investing in clean technology research and development and implementing energy-saving measures.

A state regulatory framework for bioeconomy development is a set of policies, rules, instruments, and institutions that manage the interaction between three main areas: economy, environment, and society, intending to achieve sustainable development. Regulating the bioeconomy in a national context aims to harmonize these subsystems so that economic growth does not harm the environment and ensures social justice.

To form a model of state regulation of bioeconomy development, it is necessary to find specific objects and regulatory tools. The objects of influence of state authorities are determined by a system of strategic goals formed in the process of building a national economic policy for the

development of the bioeconomy.

The algorithm for forming a mechanism for state regulation of the system of rational environmental use in the context of commercial development of the bioeconomy consists of the following stages: 1) identification of specific objects of regulation and goals that are transformed into regulatory criteria; 2) identification of optimal methods of influencing objects of regulation; 3) analysis of the levers (instruments) of regulation that determine the impact on the elements of the object of regulation and their relationships; 4) determination of the totality of necessary resources.

When creating a mechanism for state regulation of a system of rational environmental use in the context of commercial development of the bioeconomy, first of all, it is necessary to determine specific objects of regulation and goals that need to be transformed into regulatory criteria.

To determine more effective methods and tools for regulating the development of the bioeconomy, it is necessary to consider its components and relationships. The components of the bioeconomy are the agricultural sector producing biomass, the manufacturing sector (enterprises processing biomass and producing biotechnological products (enterprises in the chemical, energy, pharmacological, and food industries)), the research sector (a system of research institutes, educational institutions at various levels), and the consumer sector (consumers of biotechnological products, public society). Therefore, regulatory levers should be aimed at the development of these sectors and the formation of effective relationships between them (for example, the development of logistics schemes for the supply of biomass to its processing centers, the development of direct links between research institutions and the production sector), the formation of principles of social responsibility of the bioeconomy, the creation of a favorable tax policy, as well as other measures to improve business conditions.

An important step is to establish optimal methods of influencing the objects of regulation, specifying the tools, methods, and technologies for achieving the assigned tasks.

The development of the bioeconomy requires an optimal combination of direct and indirect methods of regulation, which, while leveling out the failures of the market economy, will contribute to the effective development of the bioeconomy. In addition to these traditional methods of government regulation, the system includes institutional methods. This type of method regulates the activities of the main subjects of the bioeconomy and also structures the course of development of the bioeconomy, which reduces information uncertainty. Legislative norms play a crucial role as one of the main elements in the institutional environment where the key economic entities interact. At the present stage, the most effective and efficient instrument of state regulation of the development of the bioeconomy is the mechanism of social partnership, which provides an optimal solution to the interests of each subject and ensures the achievement of the strategic goals of the state's development. Based on voluntary interaction between the state, business structures, and the public, this tool helps to harmonize sometimes opposing goals, and thanks to the synergistic effect, contributes to the development of the bioeconomy at the present stage.

To implement the mechanism of state regulation of the development of the bioeconomy, a certain set of resources (material and technical, financial, social, institutional, etc.) is required, with the use of which regulatory methods are implemented and the implementation of strategic goals is ensured. In this crucial step, the state budget is crafted with careful consideration of allocating funds for fostering innovative potential. This investment is key to driving the growth of the bioeconomy and facilitating the development of specific structures within it (such as for example, the provision of the latest biotechnologies, financing of innovative developments, training highly qualified specialists in the field of bioeconomy, using social marketing measures, etc.).

When exploring this topic, it will be important to explore natural and environmental assets for EU countries, which will be the subject of interest for our research (Figure 1).

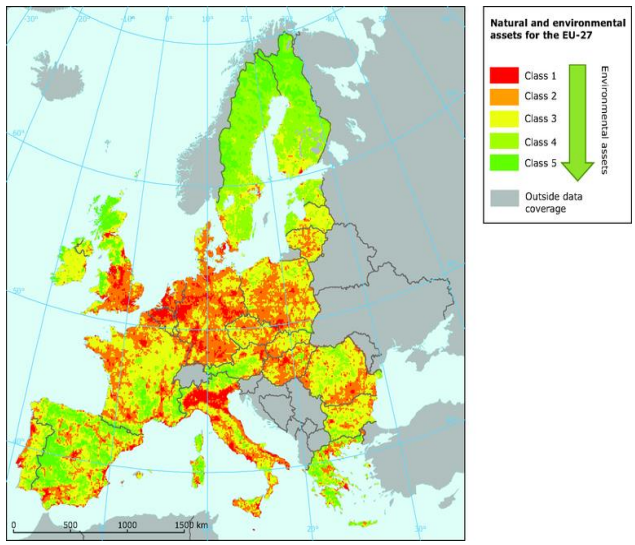

Figure 1. Natural and environmental assets for the EU [1]

The purpose of the article is to improve the state management of the system of rational environmental use in the context of commercial development of the bioeconomy. The object of the study is the system of state management of the system of rational environmental use.

Thus, we have proposed a model for rational environmental use in the context of commercial development of the bioeconomy for EU countries, which will become the foundation for increasing the efficiency of public administration.

The structure of the article consists of an introduction, which briefly describes the essence of the bioeconomy, its implementation features in commercial activities, as well as the key mechanisms of state management of rational environmental use in this area, a literature review, a description of the methodology and research results. The final part of the study presents comparisons of the study with existing studies, as well as conclusions with the results obtained and a description of the prospects for further research.

2. LITERATURE REVIEW

Although the ideas of bioeconomy originated in the twentieth century, there is no single approach to defining its essence. In subsequent stages, the importance of the social and environmental components of the concept was somewhat leveled, and the main attention was focused on the task of sustainable economic growth. However, in the 21st century, attention has again begun to be paid to these components. This is how the concepts of bioeconomy and green economy

emerged. The bioeconomy is based on the widespread use of biotechnologies, the main disadvantage of which is the risk of biological threats. The rapid growth of biotechnology in the world is driven by the desire to take leading positions in new markets. In such conditions, environmental and social components are not taken into account. The basis of the green economy is the environmental aspect; the social aspect in this case is not considered necessary to achieve balanced development [1, 2].

Scientists studying this topic note that bioeconomy has a direct relationship with economics, ecology, and biodiversity. In addition, it is involved in the environmental-economic and bio-economic sectors, as well as the socio-economic component of human life. The implementation of this concept must be carried out at all levels, but a special role belongs to business. Issues of rational use of resources and the peculiarities of legislative support for this are actively considered in the works of Mahler and Ghimir [3]. This work is devoted to legal security and rational use of water resources in the context of bioeconomy development. They note the importance of effective water management, training local residents to protect water achievements and the formation of a new water use system.

Business entities should include in their own management concepts issues related to productivity, and promotion of economic and social activities for intelligent integrated sustainable development at all levels. But at the same time, they must receive greater support to increase their competitiveness and development. This can be possible through unlimited access to sources of financing, promotion of international relations through the use of the principles of commercial diplomacy, and constant improvement of the competence of entrepreneurs and enterprises. Increased competence can be developed through the intelligent continuous development of human resources and the reduction of bureaucratic barriers facing them. In addition, an important issue in this is professional development and innovative approaches, stimulating the implementation of concepts related to organizational improvement and the implementation of quality management systems.

According to the study of Tavoni et al. [4] and Schöggl et al. [5], the basis of the bioeconomy is the processes of sustainable development, ensuring the relationship between three subsystems: economic, environmental, and social. The transition to a bioeconomy aims to efficiently utilize natural resources, promote the growth of the bioeconomy, ensure fair use of resources for future generations, foster social partnerships, and cultivate ecological and economic awareness among the population. These efforts align with sustainable development principles and contribute to national security. According to most scientists [6, 7], the bioeconomy is based on bioresources (bioresources of the earth and ocean, organic waste generated as a result of production and consumption). These resources are used for industrial and energy production and normal business activities. Taking this into account, a complex question and problem of optimizing environmental use arises.

Thus, scientists [8, 9] note that the bioeconomic direction of scientific research has been identified as relevant, covering many subject areas and has broad interdisciplinary connections, which at the same time, has not yet been sufficiently researched. This thematic area is closely related to the concepts of circular economy, green economy, sustainable development, and knowledge-based systems. In addition to these terms, it is crucial to address various concerns such as environmental impact, energy and food security, resource availability, waste management, and energy efficiency.

Considering the existing gaps in the scientific literature on environmental management systems in the system of commercial development of the bioeconomy, Bazyliuk et al. [10] and Bonaiuti [11] note that most of the problems related to the gap between theoretical research and their practical application in the bioeconomy. This is manifested in the fact that management theories are often not adapted to the real conditions and needs of the industry.

In addition, scientists [12, 13] determine that today there is a need to develop and implement unified standards for assessing the effectiveness of environmental management systems in bioeconomic projects.

Considering the analysis of the existing literature, it can be said that in the field of state management of the system of rational environmental use in the context of commercial development of the bioeconomy, there are a number of gaps that are relevant today (Figure 2).

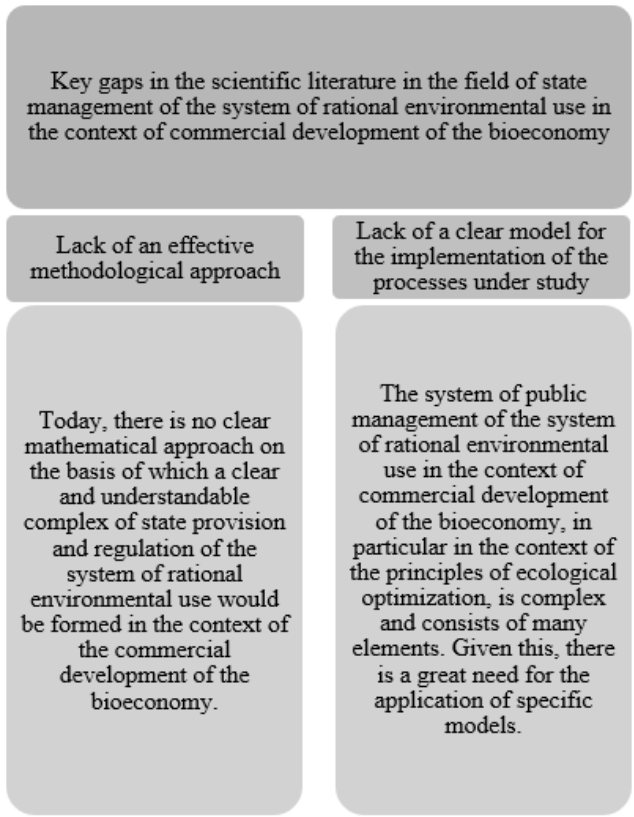

Figure 2. Key gaps in the scientific literature in the field of state management of the system of rational environmental use in the context of commercial development of the bioeconomy

After carefully reviewing the research on environmental management in relation to the commercial development of the bioeconomy, it is apparent that most studies tend to concentrate on optimizing resource utilization, investigating energy sustainability and renewable sources, implementing bioinnovations, and achieving maximum economic gain and social impact. Given this, in our opinion, the crucial focus of our research should be on enhancing the management of the system for rational environmental use amidst commercial development within the bioeconomy.

3. METHODOLOGY

To achieve our goals, research-specific methods were selected. The first method used was the BPMN (Business Process Model and Notation) modeling method. BPMN (Business Process Model and Notation) is used in scientific research as a standardized graphical method for modeling business processes. Research authors use this method to visualize, analyze and optimize business processes in organizations. They use different elements of BPMN to create clear diagrams that show sequences of actions, interactions between different parts of the process. These diagrams allow researchers to illustrate complex business processes in a clear and standardized form, facilitating better understanding and communication of these processes [14, 15].

The BPMN (Business Process Model and Notation) today is a universal standard for visualizing various types of business processes in different fields of science and practice. When forming the key stages of rational environmental use in the context of commercial development of the bioeconomy, public administration needs to ensure a clear and consistent display of all key processes, their interrelations, and interaction with other elements of the environmental use system in the country. As such, BPMN is neither a purely qualitative nor a purely quantitative research method, but can incorporate elements of both approaches in different contexts.

Active and correct use of this technique allows one to fully visualize complex processes at different levels of their implementation at the macro level, as well as highlight the key roles and responsibilities of all participants in this complex process. Thus, when analyzing the impact of government regulation on the rational management of natural resources, BPMN helps to identify current “weak points”, optimize resource provision and resource use, and also organize the interaction between various elements of the system as efficiently as possible.

Moreover, another outstanding characteristic of the BPMN method is that it provides the ability to integrate other analysis and evaluation techniques, such as SWOT analysis or life cycle cost analysis. Such an opportunity will be useful in the context of comprehensive research in the context of commercial development of the bioeconomy.

The reason for choosing this method is that it has a large number of advantages compared to others:

1. Standardization. BPMN is included in the list of generally accepted methods that are part of the international standard for modeling business processes. This advantage ensures a unified understanding and interpretation of models, regardless of geographic location and the characteristics of doing business in different countries [16, 17].

2. Flexibility. The BPMN method can be used to map both simple and complex processes in a bioeconomy business development system and provide principles and aspects of sustainability, including parallel and conditional flows of activities.

3. Intuitiveness. Graphically generated BPMN elements are easily perceived and interpreted by experienced scientists and ordinary practitioners, which allows them to quickly navigate the structure of the process.

4. Integration. The BPMN method integrates well with other technologies and techniques. Such techniques may include SOA (Service-Oriented Architecture) or ERP systems, allowing the creation of connected information systems. In the case of practice, there is a need to improve the existing methodology or detail it.

5. Detailing. Using the BPMN method, it is possible to form clear and detailed models with a vector based on a multidimensional and multi-aspect explanation of a role, interaction, event, condition, etc., which reflects the full depth and breadth of the process.

Taking this into account, the BPMN (Business Process Model and Notation) modeling method is found to be the most effective one in the process of modeling the paradigm of public management of a system of rational environmental use in the context of commercial development of the bioeconomy in the context of ensuring ecological standards of the present.

To detail the existing model of state management of the system of rational environmental use in the context of the commercial development of the bioeconomy, we used another method - the method of analyzing hierarchies, which allows for systematizing and isolating the most important criteria for forming a model of state management of the system of rational environmental use in the context of the commercial development of the bioeconomy. The hierarchy analysis method in scientific research is used to solve complex decision-making problems where many criteria must be taken into account. The authors use this method to refine a general problem into a hierarchy of subproblems, allowing complex solutions to be systematized and analyzed. They identify the main criteria and alternatives and then use even comparison to evaluate the importance of these criteria [18].

The reason for choosing this method was that the method of hierarchical ordering allows to systematization the system under study into a hierarchy of elements, which will demonstrate their importance or significance of influence on the functioning of the system. This is especially important in the area of public management of commercial development of the bioeconomy since this area includes many elements with complex influences.

Thus, the use of the hierarchical analysis method will allow responsible persons to obtain a reasonable assessment of various scenarios for the development of the bioeconomy, taking into account ecological interests. This comprehensive assessment helps make the best decisions that will contribute not only to commercial success but also to environmental sustainability.

To implement the proposed method, in the area of identifying the most relevant criteria, we involved experts in this field. A total of 30 experts took part in the study (10 experts each from three EU countries that already have generally recognized success in the field of environmental use in the context of commercial development of the bioeconomy in connection with compliance with ecological standards).

Each expert who participated in the assessment process of rational resource utilization and commercial development of the bioeconomy needed to meet specific selection criteria. These criteria included having relevant higher education in fields such as ecology, bioeconomics, environmental use, or related disciplines. Additionally, practical experience in environmental use or bioeconomic project management was also required for each expert.

4. RESULTS OF RESEARCH

To begin with, let us present the basic model of the stages of rational environmental use in the context of commercial development of the bioeconomy for EU member countries

(Figure 3).

From Figure 3, it can be seen that the first stage of our research addresses the formation of an integrated system of state regulation of commercial bioeconomic development. Accordingly, to consider the above-mentioned system, it becomes important to rethink those approaches used in the use of resources as constantly renewable assets. Modern commercial development of the bioeconomy involves the use of a qualitatively new approach to production and logistics, which involves rationalization and optimization of resource use. According to this, the governments of the EU countries must, within the limits of their powers, formulate such regulations that would encourage manufacturers to green production and create new capacities based on bio-based raw materials. Thus, the key task of the state apparatus in this context is to form a powerful relationship between government bodies, the commercial sector, and the public in the context of ensuring environmental safety, in particular, rationalizing the use of natural resources, taking into account the current situation in the world, the consequences of the pandemic and innovative production models.

This can be supported by the use of modern information and communication technologies, such as blockchain, artificial intelligence, and the Internet of Things, which will ensure transparency, democracy, and sustainability of the commercial development of the bioeconomy [19].

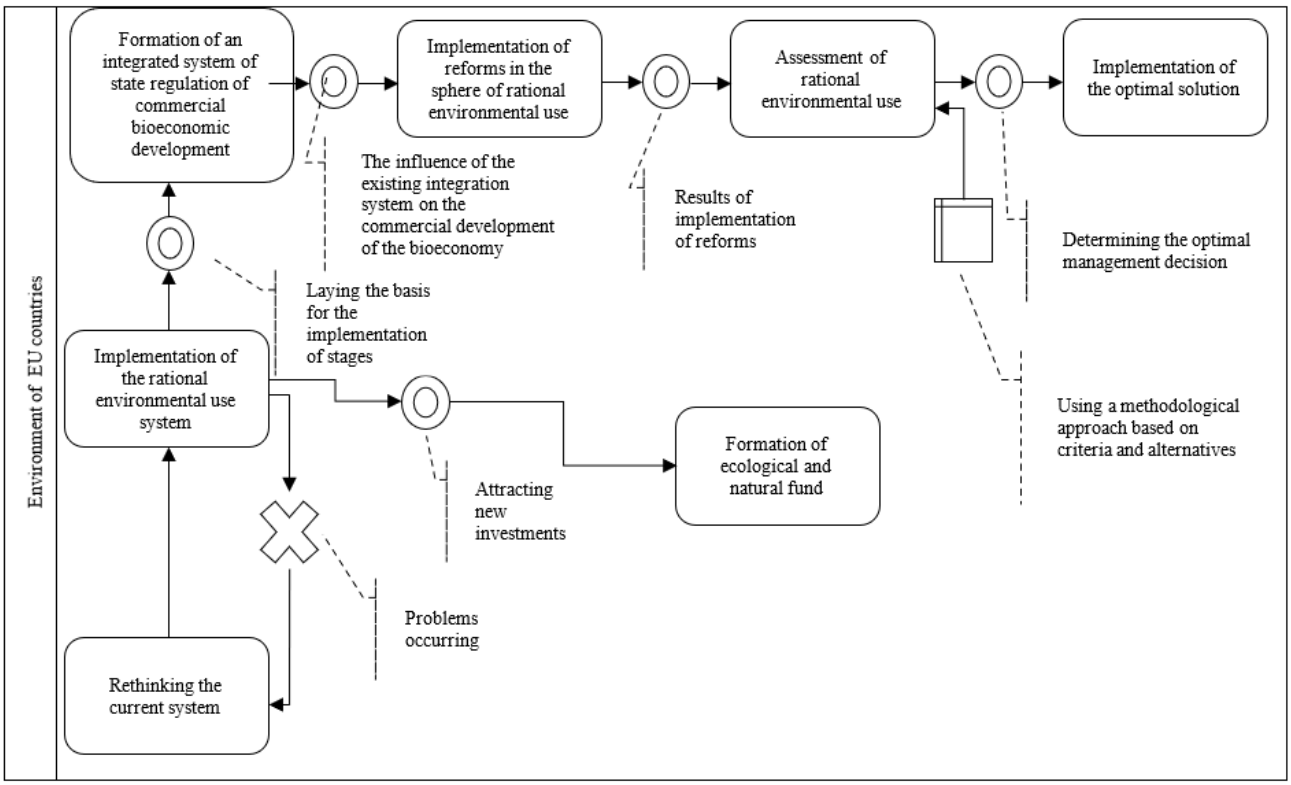

Figure 3. Model of stages of rational environmental use in the context of commercial development of the bioeconomy for EU member countries

Note: The circle is a symbol of the intermediate goal, while the failure process is depicted in the form of an 'x'.

For a better understanding, we will give an example of such systems for a specific country. Considering that at the moment the authors of the study work closely with government authorities in the field of ecology and bioeconomy, we chose Croatia as an example to better demonstrate the existing model.

Thus, in the context of this stage, an option for Croatia could be the creation of specific bioinnovation clusters. The system of these clusters must involve a diverse group of individuals, including scientists, private sector representatives, the public, and officials. Through collaborative and efficient interaction and discussion, they can collectively create effective government programs and regulations to promote the development of modern biotechnologies and optimize production processes while utilizing existing resources more efficiently. All this information was obtained through communication with experts involved in the research process

Within the context of the next stage of the model - the Implementation of reforms in the sphere of rational environmental use, the key element here is the formation and implementation of specific reforms related to the area of rational use of resources. Such reforms will guarantee the creation of a favorable environment for commerce in the context of introducing sustainable development practices, greening production, and logistics. At the same time, each reform must be flexible and adaptive in its structure, which will allow it to quickly adapt to the changing realities of the external and internal environment of the bioeconomy. A striking example of this need for adaptability was the deployment of pandemic restrictions, which challenged most government regulatory systems in the world.

As for the previous stage, an example of such implementation for Croatia could be the development of "Green packages for regulating the bioeconomy". The formation of these regulatory legal acts can occur both in the usual mode based on both legislative institutions and the above-mentioned "Bioinnovation clusters". These packages must have specific laws, and political initiatives aimed at optimizing production and logistics of the business sector, as well as greening principles of consumption of resource raw

materials or finished products. One of the key areas of these packages should be the introduction of "ecological" or "green" benefits for businesses that decide to use environmental, resource-saving technologies in their activities, or convert their production facilities to use bio-raw materials. Another direction that could be included in these packages could be the digitalization of the monitoring system for the commercial development of the bioeconomy.

One of its blocks is the assessment of rational environmental use, which later turns into making a management decision based on an assessment. To do this, one needs to apply the method of hierarchy analysis. To proceed, it is hereby imperative to define a specific set of criteria that encompass various aspects of environmental utilization in EU countries. For this purpose, an expert method was used, the description of which was indicated in the previous section. The professionalism of the expert was assessed by taking into account various parameters, including their level of education and work experience. This evaluation was conducted for numerous countries in central Europe, with the assistance of experts who categorized the criteria accordingly.

The basic conditions for conducting the assessment are defined in Table 1.

Table 1. Basic conditions for conducting an environmental use assessment

Terms	Characteristic
Purpose	Assessment of rational environmental use in the context of commercial development of the bioeconomy
Technological Criteria	Low innovative development of the bioeconomy
Economic Criteria	Low level of investment in the development of the bioeconomy Corruption at the state level
Environmental Criteria	Low level of ecological safety Lack of resources to protect the environment. Constant climate change
Alternatives	Possible options for action that can be taken to solve the problem, for example: introducing new technologies, attracting foreign investment

We evaluate the importance or high impact of a particular criterion by pairwise comparison thanks to the opinions and considerations of the experts who helped determine it.

According to the method followed, it is essential to conduct a thorough comparison of the criteria in order to determine their relative importance. This step will help assess the weight each criterion carries. For comparison, the Saaty scale was used:

1 - two elements have the same value,
3 - one of the elements is slightly predominant,
5 - one of the elements strongly predominates,
7 - one of the elements is very dominant,
9 - one of the elements is absolutely dominant.

In this case, 2, 4, 6, 8 are used for intermediate judgments.

A, B, and C denote the technological, economic, and environmental criteria, respectively, thus obtaining an even comparison matrix (Table 2). Let's consider these alternatives in detail.

1. Alternative A - Making management decisions to attract technological innovations.
2. Alternative B - Introduce economic incentives for businesses operating in the environmental sector.
3. Alternative C - Making management decisions on the implementation of new environmental standards.

Table 2. Matrix of paired comparisons of criteria for determining rational environmental use in EU countries

	Technological Criterion (A)	Economic Criterion (B)	Ecological Criterion (C)
Technological Criterion (A)	1	?	?
Economic Criterion (B)	?	1	?
Ecological Criterion (C)	?	?	1

It has been determined by experts that if someone believes that the environmental factor is of lesser importance compared to the economic factor, then its value will be assigned as 3. However, if the individual holds the opposite view and considers the environmental criterion to be more important than the economic one, its value will be drastically reduced to a mere 1/3. On the other hand, if it is very significant, then a value of 5 and 1/5 were allocated respectively. Next, the weights of each criterion were calculated (Table 3).

Table 3. Completed matrix of paired comparison criteria for determining rational environmental use in EU countries

	Technological Criterion	Economic Criterion	Ecological Criterion
Technological Criterion	1	3	5
Economic Criterion	1/3	1	3
Ecological Criterion	1/5	1/3	1

The sum for each column therefore is as follows:

1. Sum for Technological criterion=1+1/3+1/5=1.53
2. Sum for Economic criterion=3+1+1/3=4.33
3. Sum for Environmental criterion=5+3+1=9

The next step of this method was to normalize the matrix by dividing each element by the corresponding column sum (Table 4).

Table 4. Normalized matrix of paired comparisons criteria for determining rational environmental use in EU countries

	Technological Criterion	Economic Criterion	Ecological Criterion
Technological Criterion	1/1.53	3/4.33	5/9
Economic Criterion	1/3/1.53	1/4.33	3/9
Ecological Criterion	1/5/1.53	1/3/4.33	1/9

Moving on, it is important to calculate the average value for each of the lines. To avoid unnecessary calculations, it is worth pointing out that the technological criterion holds the highest

weight at 0. 63, while the economic criterion has a weight of 0.26, and the technological criterion has a minimum weight of 0.11. These weights were then used to further evaluate alternatives that are built according to each of the established criteria. It is evident here that there is a need to come up with different management solutions for the public administration system in order to effectively optimize the rational use of the environment and promote the development of the bioeconomy. These solutions must be tailored to address the aforementioned problems and meet specific criteria for each group involved, which were described above.

Each such alternative is assessed on a scale from 1 to 10 (Table 5).

Table 5. Assessment of alternatives for making management decisions regarding rational environmental use and bioeconomy development

	Technological Criterion	Economic Criterion	Ecological Criterion
Alternative A	8	6	5
Alternative B	6	9	4
Alternative C	7	7	9

To calculate the total score for each alternative, the score of each alternative must be multiplied by the weight assigned to a specific criterion, and then sum up these products. It is worth noting that the weight assigned to each criterion is determined through expert judgment and proposed methods. Results show that Alternative C is by a slight margin, the most preferable for the development of the bioeconomy and rational environmental use, taking into account the specified criteria and their weights. This means that by introducing new environmental standards, public administration can better contribute to the rational use of natural resources. Taking this into account, Alternative C can become an important tool for the state in ensuring effective environmental use aimed at the conservation and rational use of natural resources, while promoting the socio-economic development of EU member countries.

5. DISCUSSION

According to scientific sources [20-22], the bioeconomy relies heavily on knowledge. Therefore, the argument is made that investing in education as a public good will play a crucial role in fostering the growth of the bioeconomy. It is suggested that only highly educated individuals are capable of making meaningful contributions to both fundamental and applied scientific knowledge. It is argued that the state has a crucial role to play in stabilizing macroeconomic fluctuations and addressing the inherent challenges of developing the bioeconomy, which are not easily resolved through market mechanisms. This is because the activities of the modern economic system have led to the emergence of negative externalities. These include the use of non-renewable natural resources, climate change, pollution of the natural environment, a decrease in the ability of subsequent generations to satisfy their needs, etc. Reducing the negative impact of these external effects during the development of the bioeconomy is possible only through government regulation. The state must also ensure a competitive situation in the development of the bioeconomy by preventing monopolies in the market, protecting national producers, reducing barriers to entry into the field of bioeconomy, and stimulating mixed entrepreneurship for the implementation of bioeconomy development projects.

According to various authors [23, 24], it has been concluded that the bioeconomy can only thrive if specific territorial structures and infrastructure are established and functioning properly. The interests of entrepreneurs, and other economic actors in the bioeconomy are supposedly met through the consumption of biomass and biotechnological products. Which in turn, is primarily tied to both the agricultural sector and the social sphere of the population. Economic activity within the bioeconomy can be ensured by the state, namely the formation and support of the development of bioregions with the possibility of long-term economic development of territories while preserving the natural environment, providing employment, income growth, and infrastructure development. In addition, the involvement of local governments in this process will be able to stimulate the development of territorial communities. Since each territory has its characteristics and requires individual study and understanding, each territorial community must develop its approach associated with unique conditions. The local scale allows people and local communities to work together, make their own decisions, and use predominantly local resources to develop the bioeconomy.

The scientific work of other authors [25, 26] mentions that the current state of affairs demands some adjustments in terms of the goals and instruments used for regulating the economy. This supposedly needs to be done to align with the requirements of the new technological era and the growth of the knowledge-based economy. State regulation has always been a necessary condition for the progressive development of the country, but the state, along with the traditional functions of maintaining order, legality, and organizing national defense today must, first of all, provide conditions for sustainable economic development. In modern times, states regulate the national economy with varying degrees of intervention in its functioning on an institutional basis. For example, France, as a leading EU member, exercises significant government control over strategic sectors such as energy and transport and has a history of government interventions to support national champions in various industrial sectors.

In the work of Krivtsov et al. [27], special emphasis is placed on the formation of complex models of management and education in the field of bioeconomy. These models, which are formed by the Teaching Systems Thinking and System Dynamics method, make it possible to create complex successful management systems that can be used both at the level of environmental management bodies and for education. But such models are difficult to form, and changing them requires special knowledge and skills. While the methods we have chosen are easy to use and have the ability to make quick changes.

Others argue in their works [28-30] that the role of the state is to form the institutional and macroeconomic environment for the balanced development of the bioeconomy. The main task of the state during the development of the bioeconomy is to determine legitimate and effective norms and rules of interaction between economic and legal entities and control their implementation. Based on this, we draw a conclusion that can be taken as the basis for the institutional transformation of the national economy during the development of the

bioeconomy, namely: the development of the bioeconomy requires institutional support, and the bioeconomy itself is, first of all, established norms, principles, and rules of interaction between the main subjects.

In order to enhance the comparison of the present findings, these have been organized systematically in the form of the Table 6 that highlights both the unique and shared characteristics of our study.

The study is seen as innovative because it utilized a "qualitatively new" modeling and mathematical method to enhance the implementation of the model of rational environmental use. This was done specifically within the context of commercial development in the bioeconomy for EU member countries by using the.

Table 6. The main differences and similarities of our study

Similarities	Differences
Most scientists studying public management of environmental use in the context of commercial development of the bioeconomy acknowledge the complexity and comprehensiveness of this process. They emphasize the need to consider the interests of the state, commerce, and global ecological trends when rationalizing resource utilization.	In order to justify the chosen methodology, this study employed a particular mathematical approach. This method enabled the consideration of both the current state of the field being studied and all the intricate aspects involved in managing the system of rational environmental use within the context of bioeconomic commercial development. Use of a visualizing language method to present results.

6. CONCLUSIONS

We have developed a model for the stages of rational environmental use in the context of commercial development of the bioeconomy for EU member countries. This was achieved through the use of BPMN (Business Process Model and Notation) and MHA (method of hierarchy analysis).This study used these models with a particular focus on Croatia so as to better demonstrate their effectiveness.

It should be noted that the development of the bioeconomy can be ensured by certain forms of organization of production and management: organizational structures for managing bioeconomy enterprises, effective forms of intersectoral relationships (for example, between biomass producers and processors, research structures and biotechnological enterprises), social partnership, and territorial organization of production (for example, agrobioclusters).

The investigation into existing methodological approaches for determining the essence of state regulation reveals a concerning lack of consensus among scholars. It was noted that there is no unified understanding when it comes to defining the various forms and methods of state regulation. Some authors differentiate between short-term and long-term types, while others emphasize administrative and legal distinctions or direct and indirect economic regulation. This inconsistency leads to confusion as some scholars even equate these concepts together. One method employed by the state to regulate the development of the bioeconomy is a social partnership. This system relies on voluntary collaboration between the government, businesses, and the public to align their often conflicting objectives. By leveraging synergistic effects, this approach supposedly aids in advancing the bioeconomy during its current phase. Today, there is an institutional insufficiency in ensuring effective interaction between the public, private, and public sectors of the economy in the context of the development of the bioeconomy. In particular, the availability and dissemination of information about the development of the bioeconomy, biotechnological products, and their reliability are of key importance for decision-making both in conditions of market interaction and in the implementation of government regulation. In conditions of insufficient development of the institutions of the rule of law and an undeveloped civil society, the market environment is not able to ensure the positive socio-economic consequences of the development of the bioeconomy.

The practical value of the results obtained lies in the fact that a qualitatively new modeling method was used to improve the implementation of the state management of the system of rational environmental use in the context of commercial development of the bioeconomy. The study is limited in its scope, as it only considers a select number of criteria while ignoring others. Furthermore, the model created is specific to EU countries, which greatly restricts its applicability. In future research, there should be an effort to include a wider range of criteria and make the model more universally applicable across various countries.

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