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17TH INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION

CONFERENCE PROCEEDINGS

11-13 NOVEMBER 2024
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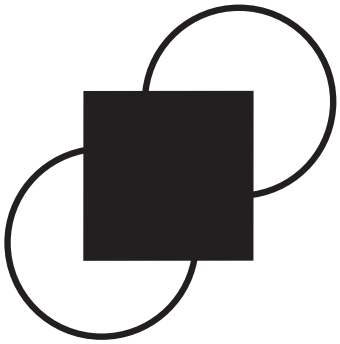

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Preface

The ICERI2024 Conference Proceedings contain the papers presented at the 17th annual International Conference of Education, Research and Innovation. This conference was held in Seville from the 11th to 13th of November 2024.

This annual conference was attended by educators, researchers and technologists from more than 70 countries with the purpose of networking with other professionals and sharing their knowledge about education, pedagogical technologies, and educational innovations. To fulfil this goal, networking activities, plenary sessions, parallel thematic sessions, and networking activities and workshops were offered. Keynote speeches were delivered by global educational experts. You can see their talks at IATED Talks: https://iated.org/talks/.

ICERI2024's scope was focused on the topics listed here: Pedagogical Methods and Innovations, Technology in Teaching and Learning, Inclusive Learning, Special Education, Emerging Technologies in Education, International Cooperation, Teacher Training and Educational Management, Curriculum Design, Accreditation and Quality in Education, University-Industry Cooperation and Open Educational Resources.

The ICERI2024 International Program Committee is composed of lecturers and researchers from across the world. A blind peer review process was followed to ensure the quality of the final publication. During this process, the following criteria were evaluated: content relevance, clear structure, clarity, originality, and alignment with the conference topics and disciplines.

As IATED strives to guarantee high technical and professional quality of the publications, and that good practice and ethical standards are maintained, all authors included in this publication signed the copyright transfer agreement. More information about our publication ethics is available at: https://iated.org/publication_ethics. As always, we wish to extend our most sincere thanks and best wishes to all members and delegates who have contributed to the ICERI2024 Conference Proceedings.

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PERCEPTIONS AND EXPECTATIONS OF AFRICAN HIGHER EDUCATION STUDENTS ABOUT BIOECONOMY

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Abstract

Bioeconomy offers new approaches to dealing with environmental challenges, such as replacing fossil fuels with sustainable and renewable resources and fuels. So, knowing how African higher education students perceive Bioeconomy is important. To achieve this objective, an exploratory and quantitative study based on a convenience sample of 407 students was conducted. The data was collected using an adapted questionnaire and analyzed using descriptive statistics. The majority of students came from rural areas (88.0%), were female (56.'%), and were between 18 and 22 years old (52.3%). Students favor replacing fossil resources with renewable ones so that the transition to a sustainable Bioeconomy can be achieved (89.2%). The three main measures to be implemented if students were responsible for preparing a transformation plan for the Bioeconomy, are: (1) improvement of knowledge and information about Bioeconomy; (2) improving the participation of the population and companies in the transformation process; (3) developing of recycling and reuse of materials. Furthermore, the majority of students consider that the transition to the Bioeconomy could reduce the amount of plastic waste in the environment and oceans (67.1%), the loss of natural environments (55.4%), the emission of carbon (54.1%), species extinction (52.6%) and particle pollution (52.3%). Regarding students' perceptions about the beneficial contributions that Bioeconomy can provide, in economic, social, and environmental terms, students believe that Bioeconomy is capable of promoting major improvements, namely, creating new jobs (78.1%), achieving a more sustainable international development model (68.1%), improving access to new areas of research and education (64.6%), improving economic performance and regional and international competitiveness (63.6%), reducing dependence energy (58.7%) and ensuring the security and stability of the energy network (56.5%). This study also shows that students do not consider themselves adequately informed about pertinent topics related to the Bioeconomy since only around 27% reported being quite familiar with the sustainable development objectives defined by the United Nations. Furthermore, topics such as genetic engineering in agriculture, the cultivation of energy crops, and the digitalization of agriculture are only familiar to just over 10% of respondents. When asked which sources of information about the Bioeconomy they trust most, environmental and farmer organizations stand out positively, and national and local governments negatively. Regarding pro-environmental actions carried out by students in the last 12 months, the majority highlights the conscious purchases of regional food products (63.4%), neglecting other types of equally important actions, namely, the change in mobility behavior, the abandonment of packaged products, the use of renewable energy, the purchase of green products, among others. Finally, concerning interests and values, students believe that it is possible, by managing resources well, to avoid environmental catastrophes even though they realize that the environment is very fragile and that any human interference can result in devastation. Perhaps for this reason, the majority are not defenders of the free market and economic growth at the expense of the environment. There are gaps in understanding the advantages, visions, and topics associated with the Bioeconomy.

Keywords: Perceptions, Expectations, Students, Bioeconomy, Sustainability.

1 INTRODUCTION

Growing concerns about environmental degradation and climate change, resource depletion, and social inequality have given rise to several policy visions that allow for the transition to a more sustainable economy and society [1]. The progressive and positivist development logic centered on economic growth as the driver of societal improvements has proven unsustainable and inconsistent globally [2]. Bioeconomy is considered an economic paradigm that focuses on the sustainable use of renewable biological

resources to produce goods, services, information, and energy. It is essentially a two-way interaction between nature and society, which places biodiversity and equity at the center of sustainable growth [3].

The Bioeconomy offers new approaches to dealing with environmental challenges, replacing fossil fuels with sustainable and renewable resources and fuels [4]. The next generations of scientists, engineers, entrepreneurs, and policymakers are immersed in a new world of unprecedented biological innovation, shaping academic and professional activities. As a result, the Bioeconomy is being driven by a positive cycle of change that includes increasingly creative perspectives from young teams in various sectors of the economy, namely agriculture and forestry, the food industry, fisheries, aquaculture, parts of the chemical, pharmaceutical, cosmetic, paper and textile industries, as well as the energy industry [5]. The implementation of the Bioeconomy is usually related to positive expectations, namely, reduction of environmental impacts, especially concerning the use, conservation, and regeneration of resources, and positive socioeconomic effects, such as job creation, improvement of economic performance and competitiveness, and the emergence of new products and processes [6].

A study based on an empirical survey involving 464 students from universities in Poland, the Czech Republic, Spain, and Portugal confirmed that the academic community still has a very traditional view of the Bioeconomy, associating it with agriculture and ecological aspects [7]. Perhaps for this reason, respondents believe in the positive environmental impacts of the Bioeconomy, although they are less frequently aware of its importance from a socioeconomic perspective. Interestingly, the researchers did not confirm the association between the existence of a national Bioeconomy strategy and awareness of the Bioeconomy. Similar results were supported in several studies [4, 8, 9], which associate the Bioeconomy with biotechnology or environmentalism. Furthermore, in the study, which included 1,400 students in the areas of forestry engineering and silviculture at undergraduate, master's, and doctoral levels from 9 European countries, the authors found that 63% of respondents acknowledged that they were not aware of the Bioeconomy strategies supported by the European Union, which can cause strangeness and lack of adherence to the programs [9].

This study's main objective was to explore how higher education students from five African countries that speak Portuguese (Cape Verde, Guinea, Sao Tome, Angola, and Mozambique) perceive Bioeconomy and their expectations.

2 METHODOLOGY

Due to the novelty of the topic and the consequent exploratory research approach, the quantitative method was chosen using descriptive analysis. A convenience sampling process involves selecting participants based on their availability and willingness. It's important to note that convenience sampling is a quick and cost-effective way to gather data, but it may introduce bias and limit the generalizability of the findings [10].

Between April and May 2022, the data was collected using an adapted questionnaire [11] that was applied to higher education African students, allowing the collection of 407 valid responses. Google Forms was used to develop the questionnaire, which was later applied to the researchers' social networks: Facebook, Twitter, Instagram, and WhatsApp.

The questionnaire was organized into two sections. The first section contained questions about respondents' characteristics, such as nationality, rural or urban area where they live, gender, age, household size, number of household dependent members, monthly net income, and higher education institution attended. The second section included questions about measures that would be implemented if students were responsible for developing a transformation plan for the Bioeconomy; environmental concerns that the Bioeconomy may impact; students' perceptions of the beneficial contributions of the Bioeconomy; Information about topics related to Bioeconomy; trust in information sources about Bioeconomy; pro-environmental actions carried out by students in the last 12 months; and, finally, interests, values and nature of the Bioeconomy.

Later, the data was analyzed using IBM SPSS Statistics version 29 software. The data analysis process involved descriptive statistics as a sample characterization technique. This included the calculation of the mean and the median (measures of central tendency) and the standard deviation (measure of dispersion) for ordinal and superior variables, as well as the calculation of absolute (n) and relative (%) frequencies for nominal and ordinal variables [10].

3 RESULTS AND DISCUSSION

Of the total number of respondents, the majority came from rural areas (88%), were female (56%), and were between 18 and 22 years old (52.3%). The sample included respondents of five nationalities, namely Cape Verdean (50.9%), Guinean (20.1%), Santomean (14.0%), Angolan (11.8%) and Mozambican (3.2%). Most students lived in households with 4 or more people (52.6%) with a monthly household income of less than 705 euros. They also attended an undergraduate degree at the Instituto Politécnico de Bragança (65.8), as shown in Table 1.

Table 1. Socioeconomic characterization of the sample (n = 407).

Variables	***Categories***	***Frequencies***	
		n	***%***
Gender	Female	228	56.0
	Male	179	44.0
Nationality	Cape Verdean	207	50.9
	Guinean	82	20.1
	Santomean	57	14.0
	Angolan	48	11.8
	Mozambican	13	3.2
Household size	1 person	102	25.1
	2 people	40	9.8
	3 people	49	12
	4 people	91	22.4
	> 4 people	125	30.7
Household income level (euros/month)	< 705	260	63.9
	705 - 1410	89	21.9
	1411 - 2115	32	7.9
	2116 - 3525	17	4.2
	> 3525	9	2.2
Number of household dependent members	None	134	32.9
	1 person	86	21.1
	2 people	76	18.7
	3 people	50	12.3
	> 3 people	61	15
Higher education institution	Instituto Politécnico de Bragança	268	65.8
	Other	139	34.2
Provenance	Rural	358	88.0
	Urban	49	22.0
Age	18 to 22 years old	213	52.3
	> 22 years old	194	47.7

Figure 1 shows that students favor replacing fossil resources with renewable ones so that the transition to a sustainable Bioeconomy can be achieved (89.2%). It should be noted that 19 students did not respond to this question. This result is consistent with the findings of other studies [11-13], showing that the transformation towards the Bioeconomy is seen among stakeholders, citizens, and young higher education students as a desirable change.

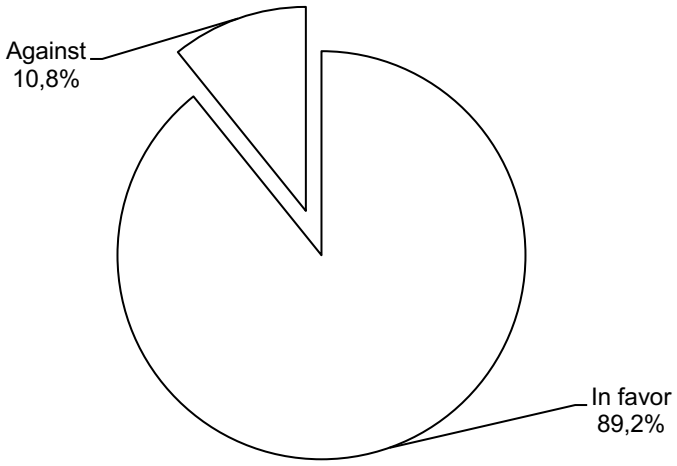

Figure 1. Transition to the sustainable Bioeconomy (n = 388).

As shown in Table 2, the three main measures to be implemented and considered if respondents were responsible for preparing a transformation plan for the Bioeconomy, are in descending order of priority from 1 (would not apply) to 7 (would apply in any case):

1 Improve knowledge and information about the Bioeconomy (Mean = 4.24; SD = 2.291).

2 Improve the population and companies' participation in the transformation process (Mean = 4.20; SD = 2.295).

3 Develop recycling and circular use of materials (Mean = 4.07; SD = 2.256).

The values found in this study were lower than those found in a study that involved German citizens [11] and another study that included Brazilian higher education students [12]. Thus, it can be understood that despite favoring the Bioeconomy implementation process, many African students do not know specifically what this means in practice.

Table 2. Measures should be implemented to develop a transformation plan for the Bioeconomy.

Measures	***Mean***	***Median***	***Standard deviation***
Biogas	3.43	3	2.133
Biofuels	3.66	3	2.125
Everyday products made from renewable energy	3.94	4	2.213
Building materials made from renewable raw materials	3.90	3	2.234
Organic farming	4.01	4	2.232
Genetically Modified Organisms: Agriculture	3.70	3	2.154
Genetically Modified Organisms: Medicine	3.70	3	2.235
Genetically Modified Organisms: Industry	3.72	3	2.128
Recycling and reuse	4.07	4	2.256
Improve knowledge about Bioeconomy	4.24	4	2.291
Improve popular and business participation in the transformation process	4.20	4	2.295

Implementing management methods that facilitate the use and production associated with Biogas were the least listed, corroborating the results obtained by other researchers [11, 12]. In addition, the best-evaluated measures were those of a social nature to improve the general population's knowledge about the Bioeconomy, corroborating the results obtained in other studies [9, 11, 12].

Furthermore, the majority of participants consider that the transition to the Bioeconomy could reduce the amount of plastic waste in the environment and oceans (67.1%), reduce the loss of natural environments (55.5%), reduce the carbon emission (54.1%), reduce species extinction (52.6%) and particle pollution (52.3%), as shown in Table 3. Similar results were obtained in a study carried out in Brazil [12]. According to the study, Brazilian students demonstrate greater confidence in the Bioeconomy as a promoter of improvements in current environmental conditions, mainly in reducing the disposal of plastic waste in the environment and oceans (87.2%), reducing the extinction of animal and plant species (reducing biodiversity loss), reducing carbon emissions (84%), (79%) and reducing the loss of natural environments (ecosystem degradation) (78.5%).

Table 3. Environmental concerns that may be impacted by the Bioeconomy (%).

Concerns	*Can reduce*	*No impact*	*Can increase*
Plastic waste in the environment and oceans	67.1	22.1	10.8
Extinction of species	52.6	36.6	10.8
Loss of natural environments	55.5	33.2	11.3
Carbon emissions	54.1	30.7	15.2
Particle pollution	52.3	34.9	12.8
Infiltration of nitrates into water	48.5	33.2	18.3

Regarding students' perceptions about the beneficial contributions that Bioeconomy can provide, in economic, social, and environmental terms, students believe that Bioeconomy is capable of promoting major improvements, namely, creating new jobs (78.1%), achieving a more sustainable international development model (68.1%), improve access to new areas of research and education (64.6%), improve economic performance and regional and international competitiveness (63.6%), reduce energy dependence (58.7%) and ensure the security and stability of the energy network (56.5%), as shown in Figure 2.

Figure 2. Students' perceptions of the beneficial contributions of the Bioeconomy.

Regarding the beneficial contributions of the Bioeconomy to demands strictly linked to economic and social development, the creation of new jobs and the promotion of improved access to new areas of research and innovation are presented as the most optimistic for Africans, in line with other studies [11, 12, 14]. There is a great expectation that the Bioeconomy will generate better economic performance of economies, increasing their international competitiveness through the differentiation of its products and services due to technological advances, ensuring leadership positions in the international technological field [14]. Therefore, as elucidated by another researcher [8], many may not be familiar with the Bioeconomy but associate it with job creation.

This study also shows that students do not consider themselves adequately informed about pertinent topics related to the Bioeconomy since only around 27% reported being quite familiar with the Sustainable Development Objectives (SDO) defined by the United Nations. Furthermore, topics such as

genetic engineering in agriculture, the cultivation of energy crops, and the digitalization of agriculture are only familiar to just over 10% of the students (Figure 3).

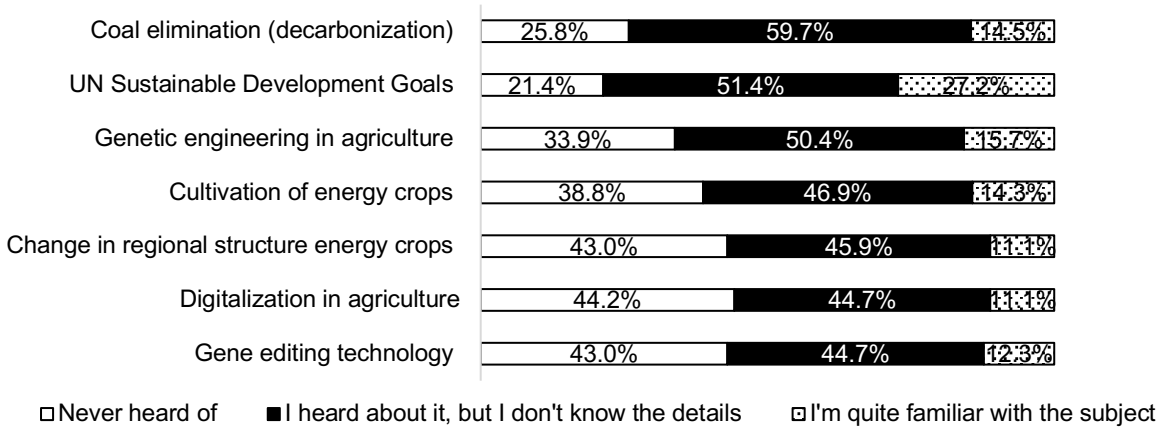

Figure 3. Information about topics related to Bioeconomy.

The topic of decarbonization (eliminating the use of charcoal and other fossil fuels as a way to reduce CO_2 emissions, mitigating the adverse effects of the greenhouse effect) was better known to most African students, as well as to the German population [11] and to Brazilian higher education students [12]. However, one of the topics most unfamiliar to students is the cultivation of energy crops, which in turn can replace fossil resources, demonstrating that, most likely, students have broader knowledge about the consequences of global warming but know little about viable alternatives to reduce it.

Digitalization in agriculture concerns the development and/or incorporation of new technologies in the field to optimize processes, reduce hardships, and contribute to the sustainability of agriculture, enabling ecological production systems and access to information and communication technologies by the rural population. In other words, this topic is linked to 'changes in regional structure', as both relate to changes in society that can improve the management of natural resources and benefit marginalized populations, such as family farmers. However, this topic (changes in regional structure) is also unknown to a significant portion of respondents (44.7%) as in a study conducted in Brazil [12].

When asked which sources of information about the Bioeconomy they trust the most, on a scale ranging from 1 (I don't trust it at all) to 7 (I completely trust), environmental and farmer organizations, scientists, and journalists stand out positively. Therefore, as for African students, German citizens [11], and Brazilian students [12], the highest degree of trust is observed in scientists, followed by environmental organizations. On the negative side, the national and local governments are the sources of information with less credibility (Figure 4).

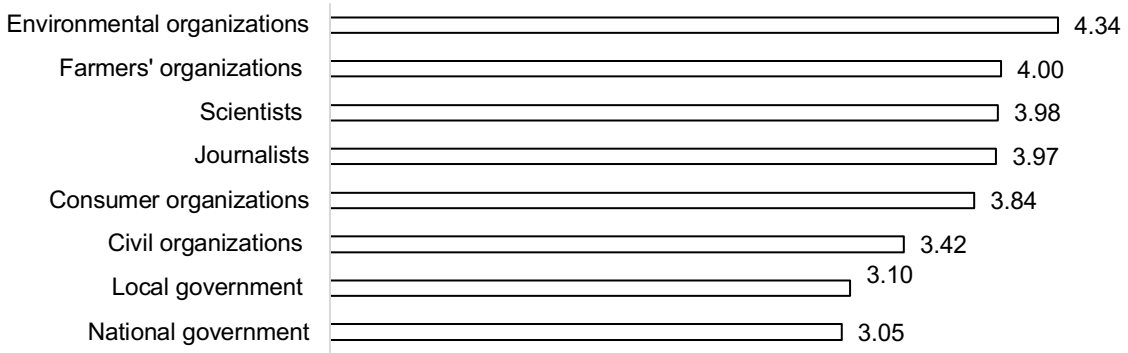

Figure 4. Trust in information sources about Bioeconomy.

Regarding pro-environmental actions carried out by students in the last 12 months, the majority highlights the conscious purchases of regional food products (63.4%), neglecting other types of equally important actions, namely, the change in mobility behavior, the abandonment of packaged products, the use of renewable energy, the purchase of green products, among others (Table 4).

Table 4. Pro-environmental actions carried out by respondents in the last 12 months (%).

Actions	*Yes*	*No*	*I do not know*
Conscious purchases of regional food products	**63.4**	18.7	17.9
Conscious purchasing of packaging	46.7	31.9	21.4
Use of renewable energies	34.2	42.5	23.3
Abandonment of packaged products	16.7	79.8	12.5
Changing mobility behavior	34.4	52.1	13.5
Buying green products	49.6	32.7	17.7
Purchase of CO_2 compensation/credit	20.4	58	21.6

In the Brazilian study [12], the concrete pro-environmental actions most frequently carried out by students were purchasing regional products (65.5%), followed by purchasing organic products (62.7%).

Finally, concerning interests and values of Bioeconomy, on a scale ranging from 1 (totally disagree) to 7 (totally agree), the majority of students show not to be defenders of the free market and economic growth at the expense of the environment (Figure 5). Students believe that it is possible, by managing resources well, to avoid environmental catastrophes even though they realize that the environment is very fragile and that any human interference can result in devastation.

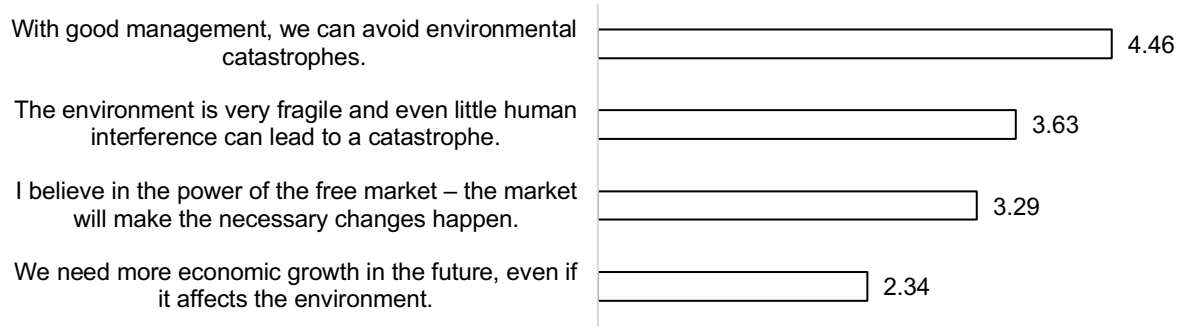

Figure 5. Interests, values, and nature of Bioeconomy.

Based on the responses obtained, it can be concluded that there is a great concern for the environment and greater confidence in human actions in favor of the environment.

4 CONCLUSION

The present study explored the perception of the Bioeconomy and the expectations of young higher education students from five African countries that speak Portuguese, namely Cape Verde, Guinea, Sao Tome, Angola, and Mozambique.

The results indicate that students are, globally, in favor of replacing fossil resources with renewable ones so that the transition to a sustainable Bioeconomy can be achieved. The three main measures to be implemented if respondents were responsible for developing a transformation plan for the Bioeconomy, are, in descending order of priority, to improve knowledge and information about the Bioeconomy, to improve the participation of the population and companies in the transformation process, and, to develop the recycling and circular use of materials.

Furthermore, most students believe that the transition to the Bioeconomy could reduce the amount of plastic waste in the environment and oceans, reduce the loss of natural environments, reduce carbon emissions, and reduce species extinction and particle pollution.

Regarding the benefits that the Bioeconomy can provide, in economic, social, and environmental terms, students believe that the Bioeconomy is capable of contributing to the creation of new jobs, achieving a more sustainable international development model, improving access to new areas of research and

innovation, improve economic performance, improve regional and international competitiveness, reduce energy dependence and ensure the security and stability of the energy grid.

Students do not consider themselves properly informed about topics related to the Bioeconomy since only a few reported being familiar with the SDO defined by the United Nations. Otherwise, topics such as genetic engineering in agriculture, the cultivation of energy crops, and the digitalization of agriculture are only familiar to just over 10% of the students.

Environmental and farmer organizations, scientists, and journalists stand out as credible sources of information about Bioeconomy. On the contrary, the national and local governments were considered less credible. Most students considered the conscious purchases of regional food products as the pro-environmental action they carried out in the last 12 months. They believe it is possible to manage resources well and avoid environmental catastrophes even though they realize that the environment is fragile and that any human interference can result in devastation. Maybe for this reason, the majority are not a defender of the free market and economic growth at the expense of the environment.

The use of convenience samples constitutes a methodological limitation, as it does not allow the generalization of results. However, given the results obtained, it is evident that there are gaps in understanding the benefits, visions, and topics associated with Bioeconomy. Consequently, there is a need for this topic to be discussed more by the general population, and in particular, by young people of current and future generations, so that the Bioeconomy is successful. The transition to the Bioeconomy depends not only on the effort and enthusiasm of experts and policymakers but also on the acceptance and involvement of society [15]. In this context, environmental education must be implemented and developed in different countries earlier, if feasible, in the first years of school.

This study used a convenience sample of individuals aged between 18 and 28 years old from African countries and higher education students from various fields of knowledge. Therefore, different age groups with different professional occupations and of other nationalities were excluded. Including these groups would allow a better understanding of the perceptions, perspectives, and expectations of different generations with diverse experiences in sustainability and the Bioeconomy. To overcome these limitations, in future research, it is suggested that this study be extended to other strategic audiences from different generations selected at random, namely, individuals who have influence and who work directly in sectors more related to the Bioeconomy, namely the agricultural and forestry sectors, and could even involve workers and managers of organizations in these sectors, to observe better whether or not there are differences in perceptions and expectations about the Bioeconomy compared to the sample studied.

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REFERENCES

[1] S. Dieken, M. Dallendörfer, M. Henseleit, F. Siekmann and S. Venghaus, “The multitudes of bioeconomies: A systematic review of stakeholders’ bioeconomy perceptions,” *Sustainable Production and Consumption*, vol. 27, pp.1703-1717, 2021.

[2] A. Thomas, “Development as practice in a liberal capitalist world,” *Journal of International Development*, vol. 12, no. 6, pp. 773-787, 2000.

[3] Nature Finance and Getúlio Vargas Foundation, *The Global Bioeconomy: Preliminary Stocktake of G20 Strategies and Practices: a contribution to the Brazilian G20 presidency's*, Nature Finance and Centro de Estudos em Sustentabilidade, 2024.

[4] T. Stern, U. Ploll, R. Spies, P. Schwarzbauer, F. Hesser and L. Ranacher, “Understanding Perceptions of the Bioeconomy in Austria: Explorative Case Study,” *Sustainability*, vol. 10, no. 11, pp. 1-17, 2018.

[5] E. Xinyi E. Chen, S. King, S. Ng, P. Salman, J. Schwab, P. Sekhon, “Chapter 4 - Young innovators and the bioeconomy” in *Translational and Applied Genomics, Genomics and the Global Bioeconomy* (C. Correa and A. Suarez-Gonzalez, Eds.), pp. 83-100, Academic Press, 2023.

[6] BioökonomieRat, *Combine disciplines, improve parameters, seek out international partnerships: first recommendations for research into the bio-economy in Germany*, Berlin: BioökonomieRat, 2009.

[7] M. Pink, B. Kiełbasa, V. Tamáš, F. Pereira, J. Santamarta, N. Cruz Pérez, J. Rodríguez-Alcántara and L. Luty, "Perception and awareness of the bioeconomy: an empirical study of chosen European academia," *International Journal of Sustainability in Higher Education*, vol. 25, no. 6, pp. 1137-1155, 2024.

[8] N. Drejerska, "Employment in vs. Education for the bioeconomy," in *Proceedings of the 8th International Scientific Conference Rural Development* (A. Raupelienė, Ed.), pp. 991-998, Akademija: Aleksandras Stulginskis University, 2017.

[9] M. Masiero, L. Secco, D. Pettenella, R. Da Re, H. Bernö, A. Carreira, A. Dobrovolsky, B. Giertlieova, A. Giurca, S. Holmgren, C. Mark-Herbert, L. Navrátilová, H. Pülzl, L. Ranacher, A. Salvalaggio, A. Sergent, J. Sopanen, C. Stelzer, T. Stetter, … and I. Wallin, "Bioeconomy perception by future stakeholders: Hearing from European forestry students," *Ambio*, vol. 49, no. 12, pp. 1925–1942, 2020.

[10] J. Marõco, *Estatística com o SPSS statistics*, Pero Pinheiro: ReportNumber, 2021.

[11] M. Dallendörfer, S. Dieken, M. Henseleit, F. Siekmann and S. Venghaus, "Investigating citizens' perceptions of the bioeconomy in Germany – High support but little understanding," *Sustainable Production and Consumption*, vol. 30, pp. 16-30, 2022.

[12] C. Tomazini, M. Perondi, A. Fernandes and M. Ribeiro, "Knowledge level and perceptions of Brazilian university students about Bioeconomy," *IBIMA Business Review*, vol. 2024, pp. 1-17, 2024.

[13] J. Výbošťok, L. Navrátilová, Z. Dobšinská, B. Dúbravská, B. Giertliová, P. Aláč, M. Suja and J. Šálka, "Bioeconomy perception by students of different study programs – study from Slovakia," *Central European Forestry Journal*, vol. 68, no. 2, pp. 91–100, 2022.

[14] M. Bugge, T. Hansen and A. Klitkou, "What Is the Bioeconomy? A Review of the Literature," *Sustainability*, vol. 8, no. 7, pp. 1-22, 2016.

[15] E. Woźniak, A. Tyczewska and T. Twardowski, "Bioeconomy development factors in the European Union and Poland," *New Biotechnology*, vol. 60, pp. 2-8, 2021.