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Bioeconomía y TIC, transformando la educación para el desarrollo sostenible

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RESUMEN

En estos tiempos, donde el cambio climático es muy agresivo y la escasez de alimentos es cada día más difícil de producir, es innegable que ya no se puede esperar más tiempo, es momento de hacer un alto y reflexionar sobre las necesidades urgentes que se deben de entender antes de que ya no se pueda hacer nada al respecto y llevarnos a una catástrofe mundial. Ante esto se plasma en el siguiente documento la importancia que tiene la bioeconomía en estos tiempos, su significado por varios autores reconocidos, así también la importancia de analizar sus posibilidades y limitantes y cómo las TIC y la educación junto con la bioeconomía pueden ayudar para lograr un desarrollo sostenible. El objetivo de este trabajo es analizar mediante una revisión documental las consecuencias que se pueden tener si no se actúa en beneficio de un crecimiento económico, no es más que buscar el beneficio en mejorar la vida de los habitantes de una región o un país. Lo anterior suena algo inalcanzable por las condiciones actuales que prevalecen a nivel mundial en cuanto al deterioro de los recursos naturales y el cambio climático. A pesar del escenario que no es gratificante, todavía se puede lograr avanzar y disminuir el daño que se le ha estado haciendo al planeta y a la humanidad entera.

Palabras clave: Educación, TIC, desarrollo sostenible, bioeconomía

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Bioeconomy and ICT, transforming education for sustainable development

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ABSTRACT

In this time, where climate change is very aggressive and food shortages are becoming increasingly difficult to produce, it is undeniable that we can no longer wait any longer, it is time to stop and reflect on the urgent needs that must be understood before we can no longer do anything about it and lead us to a global catastrophe. In view of this, the following document describes the importance of the bioeconomy at this time, its meaning by several renowned authors, as well as the importance of analyzing its possibilities and limitations and how ICT and education together with the bioeconomy can help to achieve sustainable development. The objective of this work is to analyze through a documentary review the consequences that can occur if we do not act for the benefit of economic growth, which is nothing more than seeking the benefit in improving the lives of the inhabitants of a region or a country. This sounds unattainable due to the current conditions that prevail worldwide in terms of the deterioration of natural resources and climate change. Despite the scenario that is not gratifying, it is still possible to make progress and reduce the damage that has been done to the planet and to humanity as a whole.

Keywords: Education, ICT, sustainable development, bioeconomy

Fechas importantes

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Bioeconomy concept

Georgescu-Roegen (1975) stated that the term "bioeconomy" is intended to recall the biological origin of the economic process, thus highlighting the problem of humanity's existence with a limited amount of accessible, unequally located and appropriated resources. On the other hand, the German Council for the Bioeconomy, which pioneered the development of a National Research Strategy for the Bioeconomy in 2010, defined this concept as "the knowledge-based production and utilization of biological resources, principles and processes to provide products and services to all sectors of trade and industry within the context of an economic system fit for the future" (Development, 2008). This strategy laid the foundation for the transformation of industry and society.

Likewise, the European Union (2012), in its report "Innovating for Sustainable Growth: A Bioeconomy for Europe", included in its definition of bioeconomy the "production of renewable biological resources and the conversion of these resources and waste streams into value-added products such as food, feed, bio-based products and bioenergy". In addition, the European Union was the first to promote the term "bioeconomy" as an opportunity to develop biotechnology and replace the use of fossil derivatives with bio-based resources. For the EU, the bioeconomy is divided into two pillars: first, innovation in the field of biotechnology, which is indispensable to achieve sustainable growth by 2030; and second, the use of crops as renewable feedstock for biofuels, biopolymers and chemicals (Birner, 2018).

Brambila defines the bioeconomy as the production and distribution of goods and services obtained from the directed transmutation of living beings and their substances (plants, animals, bacteria, viruses, enzymes) to meet the individualized needs of human consumers, according to their characteristics and circumstances (Brambila Paz, 2011).

Finally, it is relevant to mention the concept of biomimicry, which refers to the replication of biological processes and principles in production processes (e.g., biomanufacturing) or in the design of sociotechnological systems (e.g., temperature control, waste disposal, traffic control). Janine Benyus, the driving force behind the concept and co-founder of the Biomimicry Institute, has defined biomimicry as sustainable innovation inspired by nature (M., 1997).

Historical background

The bioeconomy is a relatively recent term. In its current formulation, it first appeared in U.S. policy documents in the early 21st century. However, the basic ideas that are part of the bioeconomy concept date back to the 1970s. At that time, the U.S. economy was in a phase of decline, and the international situation had been complicated by the end of the Bretton Woods agreements and the 1973 oil shocks. The loss of competitiveness of the US economy vis-à-vis Japan, Europe and other emerging countries gave rise to a debate on the future of the world economy and on what could be the most effective strategy to recover growth and competitiveness (Cooper, 2008).

In this context, the report entitled "Limits to Growth" showed how economic growth based on the unlimited exploitation of non-renewable natural resources, such as oil and gas, was not sustainable in the long term and endangered the delicate balances of the planet and its varied ecosystems. Therefore, the genealogy of the bioeconomy concept cannot ignore these fundamental changes in the way science, technology, economy and society are understood, since it was as a result of these changes that the concept itself emerged.

However, the first document to link the prefix "bio" to the word "economy" was a 2001 report by the US Biomass Research and Development Board, which presented the bioeconomy as a revolution, a technological return to a sustainable past through the implementation of an economic model based on renewable energy and natural resources. On the other hand, the first and nowadays most widely used definition of bioeconomy was elaborated by the OECD in 2006, which defined bioeconomy as "the set of economic operations of a society that uses the latent value in biological products and processes to achieve new growth and benefits for citizens and nations" (OECD, 2006).

The concept of bioeconomy was put forward by Nicholas Georgescu-Roegen (1975, 1977), who stressed that the economic process could not be understood in isolation from the laws of nature. In terms of obtaining goods and services, the human species transforms natural resources with low entropy and converts them into products and waste with high entropy. This highlights the problems faced by humanity in depending on a limited number of usable resources (e.g., availability of land suitable for agriculture) and their unequal distribution (Quiroga Canaviri & Menéndez Gámiz, 1983).

In the same manner, when speaking of bioeconomy and growth, Georgescu-Roegen (1971), in his book "Entropy and the economic process", sets out the first reflections by comparing the economic models that govern countries with the laws of thermodynamics. The author takes up the concept of entropy: "Energy is conserved, but it degrades as the entropy of the system increases". His work reflects a profound analysis of the environment, pollution and the depletion of non-renewable resources. He was a pioneer in analyzing, from a critical point of view, traditional economies. He proposes how nature can be included in economic analyses and its finite nature in terms of resources should be considered. His text reads as follows:

> "Production and consumption are irreversible and unidirectional transformation processes that qualitatively alter the energy and inputs involved in them, thus nullifying the possibility of returning to the initial state or point of equilibrium" (Georgescu-Roegen, 1971) In a seminal article, published in January 1975, in the Southern Economic Journal Georgescu-Roegen (pp. 377-378) proposes what he calls a minimum bioeconomic program, which includes 8 actions:
>
> • First, the production of all instruments of war, not just war itself, should be banned altogether.
>
> • Second, through the use of the resources associated with the war that are released, as well as additional well-planned and well-intentioned measures, the underdeveloped countries should be helped to reach a good (not luxury) life as quickly as possible.
>
> • Third, humanity must gradually reduce its population to a level that could be adequately fed by organic agriculture alone.
>
> • Fourth, until the direct use of solar energy becomes a general convenience or controlled fusion is achieved, energy wastage - by overheating, overcooling, over speeding, over lighting, etc., must be carefully avoided, and if necessary, strictly regulated.
>
> • Fifth, we must cure ourselves of the morbid desire for extravagant gadgets.
>
> • Sixth, we also have to get rid of fashion.
>
> • Seventh, durable goods need to be made even more durable by being designed to be repairable.

• Eighth, we must come to realize that an important prerequisite for a good life is a substantial amount of leisure that can be employed intelligently.

In the last two decades, both at international and national levels, the bioeconomy has been clearly identified as a desirable development strategy. Regardless of the approach, the use of biomass or the role of knowledge, the common thread is the role of innovation (technological, logistical, business and markets), which aims to improve the capture of solar energy and its transformation into other energy sources, products and services, in order to influence the environmental impact of production, distribution and consumption activities, and to promote a more efficient and sustainable use of natural resources in general.

Theoretical development

The bioeconomy has a certain relationship with the theory of degrowth, as a foundation for a balanced production in a world where resources are finite and economic processes are entropic. That is, where materials or energy are neither created nor consumed, but where low entropy (e.g. firewood) is transformed into high entropy (e.g. ashes from combustion) (Georgesco-Roegen, 1971). This means that, due to the Law of Entropy, it is impossible for there to be an infinite use of natural resources, since they do not return to their original state. The ashes produced by combustion cannot return to being a piece of wood.

The bioeconomy is defined as an economy that uses renewable biological resources and biotechnologies to produce food, energy, products and services in a sustainable manner. This approach integrates concepts of biotechnology, ecology and economics to promote sustainability and reduce dependence on fossil resources.

Fundamental principles of the bioeconomy

The bioeconomy is based on several fundamental principles:

1. Sustainable use of biological resources: Use of biomass in a way that does not compromise the ability of ecosystems to regenerate. This includes sustainable agriculture, forest management and responsible fisheries (OECD, 2006).
2. Biotechnological innovation: Application of advanced technologies to develop new products and processes, improving efficiency and reducing environmental impact. Industrial biotechnology plays a crucial role in the conversion of biomass into value-added products.
3. Closed resource cycle: Promotion of a circular economy in which waste is minimized and reused. By-products from one industry can serve as feedstock for another, closing nutrient and material cycles (Ellen MacArthur Foundation , 2013).
4. Energy diversification: Production of biofuels and bioenergy from biological resources, reducing dependence on fossil fuels and contributing to the reduction of greenhouse gas emissions.

Bioeconomy and education

Education plays an essential role in the implementation of the bioeconomy. It is crucial to train new generations in sustainable practices and innovative technologies to ensure the transition to a greener economy. ICTs (Information and Communication Technologies) facilitate this process in several ways:

1. Access to information and knowledge: online platforms and digital resources allow access to a vast amount of information on sustainable practices and biological technologies, facilitating continuous and up-to-date learning (UNESCO , 2019).
2. Distance education: ICTs enable remote learning, making bioeconomy education accessible to people from diverse regions and socioeconomic backgrounds (World Bank, 2020).
3. Simulations and virtual models: Digital tools such as simulations and virtual models help students better understand biological processes and biotechnology applications in the bioeconomy.
4. Collaborative networks: ICTs facilitate the creation of collaborative networks between educational institutions, researchers and industry, promoting knowledge sharing and joint development of sustainable solutions (European Commission, 2012).

Economic and social impact

The bioeconomy has significant potential to drive economic growth and green job creation. According to a European Commission report, the EU bioeconomy represents more than 18 million jobs and a turnover of around €2.3 trillion (Commission, 2018) In addition, the bioeconomy can contribute to food security, poverty reduction and climate change mitigation, improving the quality of life of rural and urban communities.

Neoclassical theory is an essential part of capitalist ideology with numerous flaws such as asymmetric distribution of wealth, environmental problems, biological disruptions and ethical uncertainty. The neoclassical theory of economics, with its assumptions of independence of economic agents and factors of production, is inadequate for an interdependent and interactive global economy, where small events acting in synergy will produce large and uncontrollable effects. Neoclassical economics is inadequate because it does not deal with the real problems of a real world but works on the basis of assumptions in an autistic world.

Biological economics with its theoretical basis in the science of biology and the undeniable realities, not conjectures, offers an alternative to social-social theory. This theory is the social-biological theory, which maintains that social events can also have biological causes, as has often been observed in cases of civil violence due to environmental problems (Mohammadian, 1996).

Multidisciplinary or transdisciplinary approach

The bioeconomy is born as a segment of the economy, built "on the basis of improved uses of biomass and opportunities arising from new biology and associated sciences" (Trigo, et al., 2014). That is, it is an "economy based on the consumption and production of goods and services derived from the direct use and sustainable transformation of biological resources [...] taking advantage of the knowledge of biological processes and principles [...]" (Rodríguez, Mondaini, & Hitschfeld, 2017).

One of the pillars for the development of the bioeconomy is agriculture and, therefore, this must be sustainable, ensuring an environmentally friendly process, capable of regulating itself and being resilient to the pressures caused by climate change, and involving sustainable activities to safeguard the resources of present and future generations.

The bioeconomy should aim to improve agricultural production, to optimize food supply for urban people with scarce resources and, at the same time, enhance food security from rural

areas (Trigo, et al., 2014). Agroecological practices meet that objective by providing healthy and ecologically balanced food with the environment. The concept of agroecology began to develop in the 1970s, but agroecological practices are as old as the origin of agriculture (Altieri, et al., 1999) since humans began to domesticate wild forest plants to provide food for their communities or tribes.

Bioeconomy and education

The educational system in almost all parts of the world has followed a bureaucratic, dissected and reductionist course. Educational institutions are dedicated to teaching facts and figures, they are dedicated to providing young people with information and not training. They should be places where the new generations are given the ability to find their place in society, the tools to establish a proper relationship and interdependence with other living beings and with the environment.

This educational revolution can be achieved through a holistic educational process, namely the Bioeconomic Educational Process resulting from the synthesis of Biology, Education and Cognition, which undoes the reductionist scientific rationality and promotes a new one based on holism and interdisciplinarity.

Bioeconomy education requires an approach that integrates multiple disciplines and fosters active collaboration among diverse stakeholders to prepare future generations to face global sustainability challenges. This approach includes both the multidisciplinary perspective, which brings together different areas of knowledge, and the transdisciplinary perspective, which promotes knowledge building between academia, industry and society.

The multidisciplinary approach to bioeconomy education involves incorporating content and methodologies from various disciplines to provide a comprehensive understanding of bioeconomy concepts and practices. The main disciplines involved are:

1. Biology and life sciences: They teach the fundamentals of biological resources, biodiversity and biotechnology.
2. Environmental sciences: Addresses ecological sustainability, natural resource management and environmental impact.
3. Economics and management: Analyze economic viability, sustainable business models and resource management in the bioeconomy.
4. Engineering: Develops technologies and processes for the production and transformation of biomass.
5. Social sciences: Explore the ethical, social and cultural aspects related to the bioeconomy, as well as the acceptance and participation of society.

The transdisciplinary approach goes beyond the integration of multiple disciplines by promoting deep collaboration between academia, industry, government and civil society. Key characteristics of the transdisciplinary approach in education are:

1. Knowledge Concretization: Engages students, teachers, researchers, businesses and communities in the co-creation of knowledge and practical solutions.
2. Problem-Based Learning Projects: Uses real and complex problems as a basis for learning, encouraging the practical application of theoretical knowledge.
3. Interaction with external stakeholders: Facilitates collaboration with companies, NGOs and government agencies to provide practical and relevant experiences.

4. Integration of practical and scientific knowledge: Combines scientific knowledge with practical knowledge and experience from the community and industry.
5. Sustainability education: Promotes a holistic understanding of sustainability, integrating environmental, economic and social aspects.

The education of the new society must be based on clear concepts of the meaning of life and how to achieve goals. It cannot be through reductionism and unidisciplinarity, but through holistic teaching based on concepts of ethics, cooperation with others, reciprocity and solidarity. This is the way to achieve true sustainable development. It is essential to emphasize that we all belong to the great human brotherhood and that in order to continue to exist we need to take care of our common home, planet Earth.

The bioeconomic educational process is based on the holistic philosophy of education about the environment; through the environment and all for the environment and in the unity of human life with its biological basis. The bio-economic educational process has the purpose to show, how we can create bio-economic value, as well as to teach learning how to learn. This holistic educational process has the potential to mobilize the people of developed countries to change their wasteful behavior and value system to achieve sustainable society through a Holistic Educational Process.

Possibilities and limitations

The bioeconomy provides a framework for the development of policies focused on addressing the major societal challenges and sustainable development concerns contemplated in the 2030 Development Agenda for Sustainable Development.

Potential

The current moment in the world economy is an opportune time to stimulate changes in production and consumption patterns and the bioeconomy provides a framework for this. The bioeconomy, linked to the technological revolution, can be placed at the service of the new style of development through policies that revive investment and orient it towards sustainability and equality (ECLAC, 2016).

Supported by enabling technology platforms such as biotechnology, nanotechnology, digital technologies, and the convergences between them, the bioeconomy is also a way to exploit new opportunities for increasing value addition to primary production and for diversification, especially in the manufacturing and energy sectors.

The bioeconomy approach in consistent with the development of knowledge-intensive innovation strategies for the agricultural and agroindustrial sector, enhancing capacities and fostering collaboration in biotechnology and other enabling technologies, favoring bioenergy developments (biomass bioenergy, solar bioenergy, biogas), diversifying the economic base of regional economies (not only food production, but also biomass in a broader sense) and increasing value addition (e. g. rural agroindustry, new bio-based value chains).g. rural agroindustry, new bio-based value chains).

The bioeconomy is also a pathway for structural change, from a sustainability perspective. The bioeconomy approach is consistent with the 2030 Development Agenda, with the goals of mitigation, emission reduction (decarbonization of the economy) and adaptation to climate change, and with the aspirations of economic and social inclusion. As one of its main objectives

is to eliminate the use of energy and fossil resources, the bioeconomy represents an effective strategy for structural change aimed at decarbonizing the economy (ECLAC, 2016).

How can rural development be promoted through the bioeconomy? Several authors argue that the bioeconomy can contribute significantly to the future development of rural and coastal areas by promoting both supply and demand for regional biomass actions. For example, the relatively high cost of biomass transportation (Brown, 2003) would mean that most of the production, processing and transportation would likely take place in rural areas (Johnson, 2014). Because of this the main actions would be related to the creation of continuous supply chains of feedstock for bio-based industries. Such feedstock could be based on agricultural residues and wastes, transformed through the establishment of a network of small-scale local bio-refineries or through the development of aquaculture infrastructures.

The extent to which new biomass and bioenergy processing plants will contribute to rural employment and income generation will depend on the policies designed to promote the bioeconomy. These could favor centralized, larger-scale enterprises or more decentralized systems with greater participation of the rural poor. (Schmidt, 2012). To benefit small farmers and rural communities, policies aimed at strengthening the bioeconomy could create additional opportunities for rural development, such as those cited by Schmidt et al. (2012):

- Promote the value of the landscape and quality of life in rural areas as a basis for other agricultural activities, such as agrotourism and ecotourism, including their economic value for rural development.
- Supporting "green" care therapy ventures: utilizing the rural environment, farm animals, plants, gardens, forests and landscape as a basis for promoting mental and physical health and quality of life for a variety of client groups.
- Linking agriculture to energy production by recycling biological residues from agricultural production and thereby reducing input costs and greenhouse gas emissions.
- Support the configuration of short food supply chains that remunerate farmers for the use of agroecological farming methods.
- Increasing the resilience of biodiverse agri-food systems by protecting against disease threats.
- Attractive job creation for professionals in the fields of agriculture, horticulture, food processing, nursing and services.

A review of strategies around the world shows the diversity of areas that a bioeconomy strategy can cover, which are generally determined by the existing biological resource base and capacities that exist or are to be strengthened. Among the most common areas are biomass industrialization, bioenergy, biotechnology, mainly in agriculture and industry, bioindustry, green economy, and ocean economy. The review also makes it evident that there is no single model, in terms of governance and institutional development. However, some elements common to most of the dedicated strategies are:

a) the creation of coordinating bodies, which generally include the participation of several ministries, the private sector and academia;
b) the creation of technical support entities of various types,
c) the development of specialized public-private entities; and
d) the development of support and information dissemination mechanisms.

Possibilities

Promoting sustainability and environmental awareness

- Education for sustainable development: integrating bioeconomy into educational curricula can promote greater awareness of sustainability and responsible use of biological resources, forming environmentally committed citizens (UNESCO, 2019).
- Practical and experiential projects: Educational programs can incorporate practical projects that allow students to apply bioeconomy principles in real-world settings, such as sustainable agriculture, biofuel production and waste management.

Development of transversal competencies and skills

- Interdisciplinarity and collaboration: Bioeconomics, due to its interdisciplinary nature, fosters collaboration between different areas of knowledge, developing skills such as critical thinking, problem solving and teamwork
- Innovation and creativity: Teaching the bioeconomy encourages innovation and creativity by addressing complex problems and seeking sustainable solutions, preparing students to face the challenges of the future.

Preparation for new job opportunities

- Training for Green Jobs: Bioeconomy education prepares students for careers in emerging and sustainable sectors, such as biotechnology, agribusiness, environmental management and renewable energy production (European Commission, 2012).
- Connection with Industry and Research: Educational programs can establish links with industry and research centers, providing opportunities for internships, collaborative projects and employment for graduates.

Use of Information and Communication Technologies (ICTs)

- Online Education and Digital Resources: ICTs facilitate access to bioeconomy educational resources, enabling distance education and lifelong learning (World Bank, 2020).
- Interactive Tools and Simulations: The use of simulations and digital tools in the classroom can enhance the understanding of biological and technological processes related to the bioeconomy (Bower, 2015)

Limitations

Harnessing the potential offered by the bioeconomy requires adequate knowledge of the available biological resource base, the scientific and technological capabilities that exist for its use, and the market potential and consumer acceptance of new bioeconomy products.

In the area of biodiversity, a prerequisite for realizing this potential is its protection. Therefore, bioeconomy strategies based on biodiversity require institutional schemes that link policies aimed at its protection with innovation and productive development policies. In the region there are two centers of origin of agriculture and agricultural systems were developed to adapt their expansion to the climatic conditions of the environment (Rodríguez, Mondaini, and Hitschfeld, 2017).

They include the need to: promote a better understanding of the bioeconomy concept; promote policy dialogue with public and private bioeconomy stakeholders; strengthen

understanding of the potential of the bioeconomy and bioeconomic growth for inclusive, competitive and sustainable development; systematize successful bioeconomy experiences, especially in market and business development, public-private collaboration, and university-industry collaboration; promote the exchange of successful bioeconomy experiences from the region at local, national, and regional levels; explore avenues for bioeconomy development that could be of interest at the national level; and elevate the bioeconomy to a higher policy level, reinforcing its potential contributions to pave the way towards a decarbonized economy, a better environment, and more inclusive societies (ECLAC, 2016).

Limitations in education

Curricular and pedagogical challenges

- Curricular integration: The inclusion of bioeconomy in educational programs can be a challenge due to the need to update curricula and train teachers in new contents and methodologies.
- Insufficient educational resources: The lack of specific educational materials and resources on bioeconomics can limit the ability of teachers to teach this subject effectively.

Teacher training and education

- Lack of specific training: Many teachers may lack the training and knowledge to teach bioeconomy concepts and practices, requiring specific professional development programs.
- Resistance to change: The implementation of new educational approaches may encounter resistance from teachers and school administrators accustomed to traditional teaching methods.

Technological and infrastructure challenges

- Access to technologies and equipment: Teaching bioeconomics often requires access to laboratories, specific technologies and digital tools, which can be challenging at institutions with limited resources.
- Digital divide: Unequal access to ICTs can limit educational opportunities in less developed regions, affecting equity in education.

Political and financial support

- Lack of educational policies: The absence of clear educational policies that promote the bioeconomy may limit its integration into educational systems.
- Insufficient funding: Implementation of bioeconomy education programs may require additional funding for infrastructure, educational resources and teacher training, which can be an obstacle in limited budget contexts.

Conclusion

The term bioeconomy is extremely important today, because it provides a framework for the development of policies focused on addressing the major challenges to achieve sustainable development, it is contemplated in the 2030 Development Agenda, and where its principles are based on the sustainable use of biological resources, innovation in biotechnology, promotion of a circular economy and energy diversification, Similarly, education plays an essential role in the implementation of the bioeconomy, being crucial to train new generations in sustainable practices and innovative technologies to ensure the transition to a greener economy and where ICT (Information and Communication Technologies) facilitate this process in various ways. Therefore, the possibilities of the bioeconomy must overcome its limitations and to take advantage of the potential it offers, it is necessary to have an adequate knowledge of the biological resource base available, the scientific and technological capabilities that exist for its use, and the market potential and consumer acceptance of the new bioeconomy products.

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