Public Engagement and Education Can Support the Transition Towards Sustainable Bioeconomy

Marco M. Grande
University of Bologna, Department of Agricultural and Food Sciences, Bologna, Italy
https://doi.org/10.38126/JSPG200104
Corresponding author: marcomaria.grande@unibo.it
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Executive Summary: In August 2021, the Intergovernmental Panel on Climate Change approved a new contribution to its latest report emphasizing the urgency of addressing human-made climate change. One mechanism for this is through the transition towards a fair and sustainable bioeconomy. This transition can build resilience to climate change and other environmental, social and economic challenges of our time but requires the support of public engagement and education activities. The transition must consider communication and educational needs in the implementation and design of current and future European public policies for the development of a sustainable bioeconomy. Stakeholders need to better understand what the bioeconomy is and what benefits it can bring, while also acquiring newly required skills. Therefore, it is necessary to exchange information clearly and transparently, involving key stakeholders at each level. To bridge the skills gap in the European bioeconomy, it is pivotal to offer transdisciplinary education to new generations, while promoting school projects, vocational training, life-long learning programs and informal STEM education. Adequate levels of public funding and commitment will be required to implement such policies. Furthermore, meeting the needs of stakeholders both as audiences and as learners will ensure that no one is left behind. Relevant EU and local policies should support public engagement and education for a sustainable bioeconomy, exploiting the results of EU-funded projects.

I. Introduction

The Intergovernmental Panel on Climate Change (IPCC), the international scientific body which provides policymakers with regular scientific assessments on climate change (IPCC s.d.), recently published a new contribution to its Sixth Assessment Report (IPCC 2021). The IPCC stressed that climate change, which has been shown to be induced by human activities, has led to irreversible changes in the climate of all regions of the planet, affecting the weather and causing climate extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones. Changes have occurred in the atmosphere, oceans, ices and the biosphere as global temperatures have increased. To limit this human-induced global warming, it is necessary to reduce greenhouse gas emissions, such as CO_2 and methane, aiming for at least net zero CO_2 emissions. To reduce these emissions and then limit the consequences of climate change, we must act rapidly, working at the socio-economic, climate change mitigation, and air pollution control levels (IPCC 2021).

In recent years, new international agreements and policies have been enacted to face environmental and socio-economic issues, such as the Paris Agreement (UNFCCC 2016), the United Nations' 2030 Agenda for Sustainable Development (UN 2015), as well as national initiatives leading to changes in laws and constitutions (e.g., the Italian parliament added the protection of the environment,

biodiversity and ecosystems for the future generations in the Italian Constitution (Italian Senate of the Republic 2021, Italian Chamber of Deputies s.d.)).

However these are not enough, and if the European Union hopes to contribute to climate change mitigation, it would need "fundamental changes in lifestyles, production and consumption, knowledge and education", as recently declared by the European Environment Agency (EEA 2019).

One mechanism for this would be the development of a bioeconomy. This would provide us with a way to address the major environmental challenges and meet the needs of society related to production and consumption. However, the bioeconomy must be fair and sustainable for the environment, society, and the economy (GBS2020 2020, Kircher 2022), contributing to all Sustainable Development Goals (SDGs) (FAO 2021).

The word bioeconomy encompasses the economic sectors related to biotechnology, bio-resources (such as agriculture, marine, forestry, and bioenergy sectors), and ecological processes (Bugge, et al. 2016). Transitioning from a *linear*, fossil fuel dependent economy in which by-products are treated as waste towards a *circular* bioeconomy would make it possible to re-use the by-products of food, forestry and other sectors as raw materials, limiting waste and pollution (Ellen MacArthur Foundation s.d.).

Sustainable and bio-based production and consumption will help us cope with many environmental challenges (Ronzon and M'Barek 2018, GBS2020 2020), and the use of bio-based renewable resources for energy production could reduce greenhouse gas emissions even more than other renewable energy sources (Baležentis, et al. 2019). Moreover, through the bioeconomy we could protect the biosphere with more sustainable use of natural resources and improve our knowledge on biodiversity (Bastos Lima & Palme 2022), while also ensuring safer and more sustainable food thanks to biotechnology and innovative approaches in agriculture (Henry 2020, Farcas, et al. 2021).

A sustainable bioeconomy can also offer new business and job opportunities (GBS2020 2020), modernize production, and renew industries (Ronzon & M'Barek 2018). The European bioeconomy employs 18 million people, and its added value represents 4.2% of the EU's GDP (EC 2018). By 2030 it is estimated that the bioeconomy could create one million new jobs (EuropaBio 2016, EC 2018), thanks in part to jobs created due to greater environmental awareness (EuropaBio 2016). As pointed out in the Updated Bioeconomy Strategy of the European Commission: "The systemic and cross-cutting nature of new and emerging bioeconomy approaches and new value chains will need new education and skills" (EC 2018), something that must be provided to current and new workforce in bioeconomy sectors.

The bioeconomy encompasses many concepts that could be difficult to understand or be easily misunderstood. One example is confusion of the term "bio", which is usually used as a label for organic foods, but also indicates the products made from biological raw materials (bio-based products) (BIOWAYS 2017). Another case is the difference between "biodegradable" (the capability to be decomposed by bacteria in specific conditions) and "bio-based" (made from materials derived from living organisms), and that being bio-based does not imply being biodegradable (BIOBRIDGES 2020b). It is also difficult to find useful information on the bioeconomy and its products (BIOWAYS 2017).

Public engagement and education can support this transition by raising the awareness of key stakeholders and equipping them with the necessary skills (EC 2018), particularly the skills for change towards sustainability. In 1998, the European Union and forty-six additional countries ratified the Aarhus Convention (UNECE s.d.), committing to promoting environmental education and awareness among the public (UNECE 1998). This should be taken to heart, and communication and educational needs should be considered by the European Commission and the governments of the Member States in the implementation and definition of current and future European public policies for the development of a sustainable bioeconomy.

II. Public engagement and education can support the transition

In 2018, the European Commission updated its bioeconomy strategy for the deployment of a sustainable European bioeconomy (Figure 1). This strategy requires the European Commission and the EU Member States to promote education, training, and skills across the bioeconomy, adjusting and developing education and training programs (EC 2018). Furthermore, the European Green Deal aims to provide knowledge and skills on climate change and sustainable development (EC 2019).

However, according to the European Bioeconomy University – an alliance of six European universities involved in bioeconomy education, research, and innovation – "a strong reference in the Green Deal workstreams to the EU Bioeconomy Strategy is missing", as well as to the sustainability of raw materials and their production processes (EBU 2020). This shortcoming must not be present also in public engagement and education.

Many EU-funded projects have provided policymakers and other stakeholders with useful information and recommendations on how to properly communicate, raise awareness and educate in the European bioeconomy (LIFT s.d.). One of these projects is Transition2BIO ("Support the TRANSITION towards the BIOeconomy for a more sustainable future through communication, education and public engagement"), a *coordination and support action* project funded by the EU Horizon 2020 research and innovation program. Among its activities, Transition2BIO is exploiting and maximizing previous outputs and insights, searching for what has been already done to identify the interests and needs of key stakeholders for awareness-raising, communication and education activities, and suggest the proper messages, contents and tools (Transition2BIO 2021).

The project also aims to identify the future skills and related educational needs in the European bioeconomy sectors, as well as to support Member States and Regions with tools and methodologies to raise awareness and communicate the opportunities offered by the bioeconomy. By the end of 2022, the project will deliver an online library of existing materials for awareness-raising, communication, and education activities in the European bioeconomy, and toolkits aimed at key stakeholders to raise their awareness on what the bioeconomy is and why and how they can support it. So far Transition2BIO has identified several key insights across both public engagement and education.

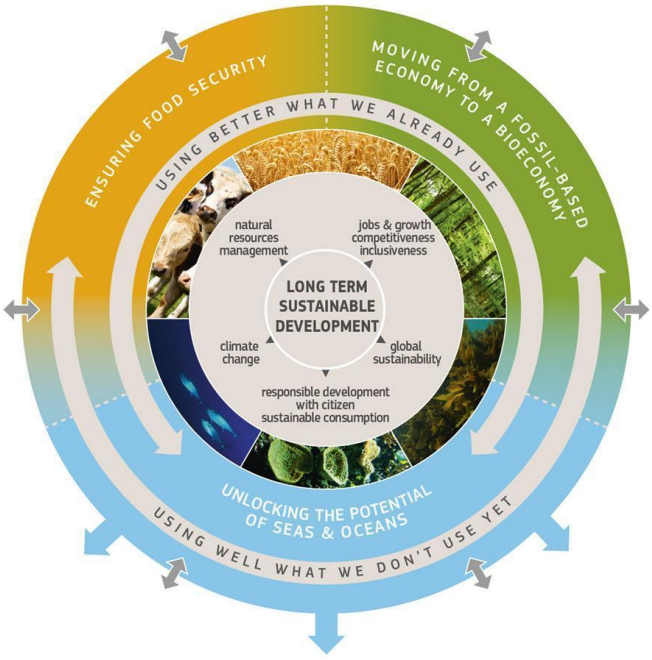

Figure 1. Goals of the European Bioeconomy Strategy. Public engagement and education can support the achievement of these goals, mainly affecting citizen sustainable consumption, and jobs & growth competitiveness and inclusiveness. (©European Commission)

i. Public engagement

The research on public engagement supporting a sustainable bioeconomy highlights the role of information exchange between key stakeholders (producers, consumers) and other relevant actors able to amplify the messages (multipliers such as policymakers, teachers, NGOs, etc.) plays in changing in the perception and acceptance of stakeholders (Wreford, et al. 2019, BioCannDo 2020, LIFT 2020a). This is especially important when discussing the socio-economic and environmental impacts and benefits of a sustainable bioeconomy.

The public must be engaged in a clear and transparent way (Wreford, et al. 2019, BioCannDo 2020, LIFT 2020a). It is necessary to tackle duplicitous messaging strategies such as "greenwashing", when something is depicted as

sustainable and environmentally friendly when it is not (Bang, et al. 2009, Lewandowski 2018). This deceives consumers and potentially orients them towards unsustainable choices. To promote transparency in sustainability communication, false claims should be avoided and banned in advertising and in policy communication. Further, the biodegradability and disposability of bio-based products must be properly communicated to consumers consistently with the relevant local policies (BioCannDo 2020).

Providing a glossary in public authorities' and other multipliers' communication materials can also be helpful when addressing the misunderstanding of complex concepts. This provides definitions in lay and understandable language (BIOBRIDGES 2020a). Using a lay lexicon without jargon can also affect the doubts people may have about the bioeconomy, while still ensuring the message is based on strong scientific evidence (LIFT 2020a). It is also important to set up communication in different languages (ISSCS 2021), making the information accessible.

Other points about how to frame information come from Transition2BIO's interviews with bioeconomy experts (Transition2BIO 2021). For example, it was suggested to involve women in public events and communication materials to inspire girls to pursue a career in the bioeconomy.

The importance of supporting stakeholders in order to achieve a fair transition was also emphasized. In this transformation of the economy, the demand for labor could increase in some sectors and decrease in others, leading to an imbalance in the labor market. In addition, bio-based products tend to have higher prices for consumers, due to the higher costs of production. This could be perceived as a loss of purchasing power (Kircher 2022), leading some stakeholders to perceive a presumed change of wellbeing. It will be necessary to identify compensatory mechanisms.

A way to actively involve people in this transition is the implementation of co-creation activities, such as bottom-up co-design of shared solutions (LIFT 2020c), testing new technologies with the involvement of the end-users (living labs), and the direct participation of citizens in scientific research (citizen science) (GBS2020 2020). Indeed, these activities can ensure the empowerment of stakeholders, also including their points of view in agenda-setting (BLOOM 2018, LIFT 2020c).

ii. Education

Gaps in existing bioeconomy education programs present another important challenge that must be addressed (GBS2020 2021). One major educational need is to pursue transdisciplinary education, associating social subjects (such as ethics, law and economics) with STEM disciplines (i.e., Science, Technology, Engineering and Mathematics) (Raupelienė 2017, Masiero, et al. 2020, GBS2020 2021). The newly required skills will depend on the different sectors, but also include cross-sector skills and soft skills such as communication, education, policy, decision-making (LIFT 2020b, Pubule, et al. 2020, Urmetzer, et al. 2020, GBS2020 2021).

Rethinking bioeconomy-related education in this way should start early at the high school level, by promoting school projects to inform and inspire new generations, and using appealing tools like games and social media (LIFT 2020a, LIFT 2020b). Educators should therefore be properly trained and updated on the advancement of bioeconomy knowledge (GBS2020 2021, Transition2BIO 2021). This is essential for them to be able to teach and raise awareness on sustainability, circular economy, new sustainable biotechnology approaches, as well as digital skills for sustainability (Sá, et al. 2021).

Furthermore, university courses should be updated and rethought, building curricula with knowledge, skills, and perspectives from different disciplines relevant to sustainability and circular economy (LIFT 2020b). They should use a transdisciplinary approach instead of focusing on detached individual disciplines (GBS2020 2021). To do this, universities need flexibility in curriculum design.

Vocational training is considered important within the bioeconomy education context. Providing the professional skills specifically required for one's career path may help to bridge the skills gap in the workforce of the European bioeconomy (LIFT 2020b, Transition2BIO 2021). Furthermore, given

the rapid evolution of the bioeconomy, life-long learning programs will play a pivotal role in bioeconomy education (EEA 2019, LIFT 2020b, GBS2020 2021).

Education must also step outside the academic context. Informal stem education will transfer bioeconomy knowledge and skills to the new generations through hands-on and interactive activities in museums, libraries, nature centers, etc. with the involvement of academia, industry and government (Hakovirta & Lucia 2019).

To meet these needs, educational instruction, education materials and scientific findings should be available to the public and accessible all over the world (GBS2020 2021), removing the existing legal, technical and socio-economic limitations.

iii. Requirements for change support

These recommendations need adequate funding from the European Commission and the Member States to be implemented, the amount of which depends on the needs and strategies of the single Member States. The € 750 billion Next Generation EU fund for the recovery from the COVID-19 pandemic may be a starting point (EC 2020). The policy areas covered by the fund also include the green transition, sustainable and inclusive growth and jobs, and policies for the next generation, such as education and skills (European Council 2021).

The implementation of current and possible future policies in this direction could require European and local public funders to require that research, education, and innovation institutions make a certain level of commitment, possibly flanked with internal policies and strategies for science communication and public engagement in general (Mannino, et al. 2021). In addition, adequate funds and support are needed to hire properly trained professionals and encourage collaboration between academia and the government (ISSCS 2021).

To adequately address the educational and skills needs of a sustainable bioeconomy it should be noted that the different recommended course types may not have the same effectiveness and role. Despite the importance of vocational training and life-long learning programs, university courses play a fundamental role in the personal growth and education of young people, while also addressing the educational needs with a longer-term perspective and more effectively (Kuh 2019). Furthermore, it could be argued to consider universities as providers of knowledge to students with the aim to empower them, improve their lives and open their minds, while meeting the needs of the society and not only ones of the market (Tilak 2006). In this sense, universities should be able to design curricula focusing on the needs of students (ESU 2020).

Eventually, the transition towards a sustainable bioeconomy must be fair (FAO 2021), leaving no one behind from a social, economic, engagement or educational point of view.

III. Conclusion

The transition towards a sustainable bioeconomy is urgent to address many global environmental and social challenges (GBS2020 2020). For the transition to be fair and sustainable, it must improve the social, economic, and environmental conditions of Europe and other regions in the world, addressing all the SDGs (FAO 2021). Supporting this transition at the European and local levels will foster the development of the bioeconomy, which can furtherly contribute to a green recovery from Covid-19 (GBS2020 2020). Public engagement and education are required as fundamental support for the transition (EC 2018).

To achieve such a goal, research and projects such as Transition2BIO can provide useful insights and recommendations for raising awareness, communication, and education activities in the European bioeconomy (Transition2BIO 2021). The design and implementation of relevant EU and local policies can and should be evidence-based, taking advantage of research findings, and involving all the stakeholders in the solutions.

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Marco M. Grande is a research fellow at the University of Bologna, Department of Agricultural and Food Sciences. He has conducted research on public engagement and education in the European bioeconomy under the H2020 project Transition2BIO. He is also involved in the Bioeconomy Unit of the Research Services office at the University of Bologna, supporting the European Bioeconomy University alliance, of which the University of Bologna is a co-founding member. He graduated from the University of Padua with a master's degree in industrial biotechnology, and from the University of Ferrara with a postgraduate course in institutional science communication.

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