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Toward a European bioeconomic transition: is a soft shift enough to challenge hard socio-ecological issues?

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Abstract – The bioeconomy is under tension regarding its function: a transition lever based on an in-depth transformation of its production modes regarding the use of renewable resources, or a possibly green growth lever in maintained modes of production. This contribution to the debate identifies three leads to develop bioeconomy as means of organizing the sustainable transition to sustainable production modes through a renewed approach to territories, new relations regarding the exploitation of nature, and the development of new knowledge bases under sustainability constraints.

Keywords: bioeconomy / transition / sustainability / territories / agriculture

Résumé – Vers une transition bioéconomique en Europe : une transition douce est-elle suffisante pour relever les difficiles défis socio-écologiques ? La bioéconomie est traversée par une tension quant à sa fonction : être soit un levier de transition par la transformation profonde des modes de production grâce à l'utilisation de ressources renouvelables, soit un vecteur de croissance, éventuellement verte, dans des modes de production inchangés. Cette contribution au débat propose de considérer la bioéconomie comme un moyen d'organiser la transition vers des modes de production plus soutenables grâce à un rapport renouvelé aux territoires, de nouveaux rapports à l'exploitation de la nature et la formation de nouvelles bases de connaissances sous contrainte de soutenabilité.

Mots-clés : bioéconomie / transition / soutenabilité / territoires / agriculture

Humankind has initiated major changes to take full advantage of Earth's resources. However, the resulting industrial economic system on which anthropocene societies are now based is responsible for unprecedented and irreversible damage to the biosphere (Crutzen and Stoermer, 2000; Ceballos *et al.*, 2015). As illustrated by Steffen *et al.* (2015), the total consumption of ecological resources and services currently exceeds Earth's regenerating capacity and was equivalent to 1.6 consumed planets within a year according to the latest estimations (WWF, 2016). Unlike before the Industrial Revolution, humans can now extract huge amounts of resources for a fraction of the cost. This has led to over-consumption and is now causing major negative environmental consequences on a global scale. We now have to face these new ecological responsibilities, since otherwise this will mean jeopardizing our societies (Diamond, 2005; Ehrlich and Ehrlich, 2013).

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In order to avoid an untenable situation for humanity, it is globally understood that our economic system needs to radically change and proceed hand in hand with sustainable human development. However, opinions differ on how to resolve this problem. Among desirable changes, it seems clear that the production of raw materials can no longer rely on the extractive logic inherited from the oil era, i.e., (i) exploitation of resources to the point of exhaustion without concern for their regeneration and (ii) extensive delocalization of resource consumption relative to their place of extraction, with economic and geopolitical consequences. Beyond ecological considerations, fossil resources are limited production factors (unlike renewable resources). Therefore, extractive companies are facing expensive and growing difficulties in accessing fossil fuel reserves. Consequently, it is not very difficult to launch the industrial process change on a global scale. But there is a huge need for the local and sustainable production of raw materials, as renewable resources can be limited too if extracted regardless of their regeneration cycle. These objectives involve a combination of multi-scale and interdisciplinary solutions implemented simultaneously and in a way that ensures intergenerational fairness, which together challenges inherited knowledge and skills. The complexity of the transition does not just involve multi-scale stakes, meaning a co-development of individual and collective work, but also a stronger dialogue between generations, as the populations most impacted by the ecological and societal crises will be future generations.

The concept of bioeconomy is based on biomass instead of fossil fuels. Thus this concept seems to be a promising way to achieve this ecological and societal transition. Over the past ten years, this concept has evolved a great deal, and in the perspective of "Horizon 2020" the European Commission aims to give a fresh impetus to the global bioeconomy strategy by identifying new guidelines. In this context, a European workshop on bioeconomy[1] was organized on the 28th and 29th of June 2017 by Inra (Institut national de la recherche agronomique) and Irstea (Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture). During this workshop, the speakers were invited to answer three questions to stimulate reflection: (i) what are the priority research needs for the next 10 years, (ii) which tools for research and development are lacking today and, (iii) which types of partnerships and which new stakeholders are needed for the development of bioeconomy. At the same time, a panel of young scientists was formed to attend this workshop and express the viewpoint of the young generation. The aim of this paper[2] is (i) to present the position of this panel speaking as young scientists and also as citizens regarding the current bioeconomy concept and what it could be and, (ii) raise the main points that need focusing on to push forward a European bioeconomic transition.

Towards a bioeconomy: much discussion, little agreement

At first glance, it would appear that "bioeconomy" is a new kind of economy, focused on the use of biomass as the main feedstock, although in a more sustainable manner. However, it would rather seem that most of the time, the word "bioeconomy" consists in using living organisms and biomass as raw material for feed, food, fuel, energy and chemicals for the conventional economy in the place of fossil feedstocks.

However, the concept of bioeconomy does not provide a shift in the current economic paradigm as it only changes the feedstock. We argue that the term "biologicalisation" of the economy is more appropriate. Moreover, this vision of bioeconomy has therefore more to do with "greenwashing" than with a true economic concept. In reality, it seems that "bioeconomy" is the new "buzz word" to substitute the phrase "sustainable development" which also suffered from its lack of concrete content (Brand, 2012). The collapse of the concept of "sustainable development" was due to: (i) the successive failures of the major international conventions such as the Kyoto Protocol, Copenhagen, Rio and Doha, (ii) its role in the globalization of the 2000s and the 2008 economic crisis, and (iii) mostly, however, to its ambiguity. Ambiguity in its historical origin, about its meaning, about its construction and about the political or industrial objectives related to it (Theys, 2014). The oxymoronic ambiguity has not entirely disappeared from these different semantic fields and persists in the emergence of the bioeconomy concept, which may lead to similar confusion or failure.

Plurality of bioeconomy definitions

Today an increasing number of people identify themselves as stakeholders of "bioeconomy" and active contributors to an ecological shift. As such, the European workshop was rather a recognition event than an occasion for substantial debate. While there was no debate on the definition of bioeconomy during the workshop, it is quite clear that there are no fewer than

[1] https://colloque.inrae.fr/bioeconomy2017_fre/Position-Papers.

[2] The first version of this text was published on the conference website (https://colloque.inrae.fr/bioeconomy2017_fre/Position-Papers). See also, in the same issue, the article by Colonna *et al.* "Nouvelles questions de recherche en bioéconomie" (first version also published on the conference website).

three different conceptions of the bioeconomy. The first is historically based on a search for balance between ecological constraints and human activities (Georgescu-Roegen, 1977; Passet, 2012) leading to circular economy. Another is based on the development of biotechnologies. The third type of bioeconomy refers to biorefineries in terms of valorisation of biomass into energy, value added chemicals or materials.

On the one hand, the plurality of definitions allows for the integration of a wide range of sectors into the bioeconomy (each sector defining its own bioeconomy) and a kind of multidisciplinary approach, but on the other hand, it leads to unclear global objectives and policies without any clear targets. Moreover, the perception of bioeconomy by citizens is most of the time not integrated in the definitions proposed. Consequently, it is obvious that several serious debates must focus on social choices regarding expected functionalities of bioeconomy. Indeed, three hypotheses on the evolution of a bioeconomy can be envisaged. First the bioeconomy may not draw a whole new paradigm as did the oil era, but rather organize the chemicals-energy-material production mix. Second, the relevant scale of development of industrial projects remains largely to be defined in relation to the identity of the territory in which each project has to be articulated. Thirdly, the bioeconomy does not seem to reduce the pressure on the environment and, on the contrary, it seems necessary to explore a double intensification, ecological and economic, in the use of renewable resources.

The promise of biotechnologies

Among the various approaches developed by bioeconomy roadmaps, many rely on environmental innovations and new technological developments. Thus, a great number of new research questions are generated in order to address both technical and social challenges raised by these innovations. Most of these technologies are biotechnologies and can be simplistically divided into two categories: (i) those aiming at replacing current petrochemical-based technologies (for example bioprocesses for biofuels, biomaterials, bulk chemicals, etc.), and (ii) those aiming at improving or enhancing already existing biological phenomena, such as crop improvement or genome editing.

The current dominant trajectory is the development of biotechnologies, presented as a wide range of opportunities and tools in order to reshape our economic system and diminish its dependency on fossil feedstocks. For instance, it was observed that the implementation of industrial biomanufacturing does not follow the model of current chemical industry based on mega-facilities (Clomburg *et al.*, 2017). Interesting perspectives are notably offered by environmental biotechnologies, such as anaerobic digestion regarding waste management for further circularization of our economic system. Biome Technologies plc provides a good example by investing in the utilisation of waste material feedstock (lignin) in order to produce compounds, which in turn contribute to the replacement of fossil derived chemicals in order to produce biodegradable bioplastics. The benefits of this are threefold. First, the waste feedstock is utilized. Second, a fossil-based feedstock is replaced with a sustainable one. Third, biodegradable plastics are produced at the end of the process. This illustrates how biotechnological processes can be used to integrate circular economy as well as the bioeconomy (Biome Bioplastics, 2015).

However, enthusiasm for new technologies should not make one lose sight of two important facts. First, biotechnologies are coined with the idea of sustainable growth in which technological progress should play major role, even if non-technological issues may be considered. Second, biotechnologies deal with living organisms and ecosystems and are therefore subjected to major ethical issues. To be sustainable, biotechnologies also need to be ethical. Issues like intellectual property, transparency, traceability, or natural resources appropriation and trade need to be addressed.

Lastly, numerous unwanted, yet damaging, consequences could occur with the implementation of these technologies: less agricultural diversity, biodiversity loss, intellectual property rights on living organisms, control of food production by a small number of actors, and possibly other issues that have not yet been identified or are less predictable. As for now, it seems that these consequences remain poorly discussed or studied; this should therefore become a priority for government policy.

Yet, these issues entail several substantive debates, including on externalities and ecosystem services, the purpose being to attribute a monetary value to these services. Some natural assets are not appropriable, divisible or exchangeable and trying to set a price on the priceless may lead to perverse effects, including zoning for environmental deterioration, and the massive extinction of biodiversity, which produces territorial and environmental inequalities. However, adding financial penalization for excessive or unsustainable use of natural resources (through a tax on carbon emission, energy consumption or biodiversity impoverishment) could encourage companies to take sustainability into account in their decision making and could be a simple way to regulate these damages. This would give more "sustainable" companies a competitive advantage as a result.

With this in mind, the economic transition is both a wake-up call and an urgent invitation to rethink the place of Humans in Nature. During the European workshop, the idea of the place of Humans in the nature was alluded to. It seems that for the bioeconomy the underlying philos-

ophy is still to dominate nature and exploit it. We need to base our economic model on the availability and sustainable utilisation of resources, rather than to focus on maintaining a linear economic growth.

Toward a socio-ecological transition? Inducing change in the short term to target long term objectives

Change must occur as soon as possible. The issue of climate change and the overstepping of several of Earth's limits highlights the critical need for action (Steffen *et al.*, 2015). But before these considerations, our reflections were based on the fact that much of the discussion seemed to be technologically driven. It appeared that the hope for a viable technology that is transferable to a variety of territories and situations still remains even though this is in contradiction with bioeconomy aims. One of the major issues should be to focus more on bottom-up innovations and on various scales of territory issues. This paradigm shift should probably be based on a flexible bioeconomy and be adapted in accordance with socially driven issues and local problematics.

Develop bioeconomies closer to citizens: the importance of territories

To sustain and develop a bioeconomy, initiatives can be carried out on different scales. Whereas the guidelines are defined on a national scale, it seems really important to take greater account of bottom up initiatives and local issues to design various bioeconomies that are more closely linked to territories and to the expectation of citizens.

Industry was rebuilt from the end of the Second World War around a limited number of raw (mainly fossil) materials, imposing the standardization of production and consumption patterns. The necessary abandonment of fossil resources and, therefore, the management of a large variety of raw materials requires reconsidering the links between industry and its territories. The complex articulation between the regeneration and modes of extraction, processing and consumption of renewable raw materials is therefore at the heart of the transition to the bioeconomy. This industrial transition raises the question of defining the relevant scale to develop bioeconomies, avoiding overspecialization which can lead to dependence on a single economic activity and erase the territory's identity. Indeed productive territories or industrial basins are built over time on the basis of close links and cooperation between industry, research and local elected representatives. But local productive territories also exist on a smaller scale, which implies considering the diversities that underlie their identities: socio-demographic specificities, local natural resources, individual and collective needs.

The transition to a decentralized use of renewable resources utilised as close as possible to their place of extraction and processing, seems to be a key point in the anchoring of industries in a territory. Thus, to be sustainable, a biorefinery should not convert huge volumes of a given renewable resource into energy and chemicals, but should adapt efficiently to low amounts of various raw materials and diverse output products to match needs. The challenge therefore lies in the development of strategies viewing the territory not as a simple stock of natural resources and skills, but as a driving force for the reconversion and emergence of ecological industries. In return, industry should be considered as a common good, and could become the support for the satisfaction of human needs through a higher valorization of local resources.

In France, some local structures are still working to take up these challenges. For example, in the "Hauts-de-France" region, ITE (Institute for the Energetic Transition) PIVERT is developing an oilseed biorefinery using only raw materials produced in the area in order to provide food, feed, fuels, energy and chemicals for local industries (Rous, 2012). If these types of initiatives seem to be successful locally, the question now is how to use them to develop political measures to support the transition at the national, European and ultimately the wider global scale. This kind of bottom-up strategy could provide a solution to support a more efficient transition of bioeconomy than a top-down strategy; thus, bioeconomy could be used to revitalize local and rural economies.

However even though local territories are important, it is still critical to consider bioeconomy on a global as well as a local scale. Not doing so would lead to unnecessary inefficiencies. It is therefore crucial to consider and develop potential biomass sources from non-EU countries in Europe, such as Ukraine and countries outside the continent, such as the US and Canada. As an example of a globalized biomass value chain, Drax Power Station in the UK imports biomass from North America and currently supplies 7% of the total electricity generated in the UK (70% being from compressed wood pellets instead of coal). This illustrates how global biomass networks can be established in order to take advantage of each country's biomass feedstock mix, which may generate greater efficiency as suggested by the theory of comparative advantage. However, this may also interfere with or hinder the management of the respective country's natural resources and lead to a more conflictual use of these resources or even to local market disruption. It is therefore important to import sustainably produced biomass, with properly tightened label and certifications, to fully take into account any potential

"butterfly effects" all along the value chain, even if it lies outside the importing country's jurisdiction. An example of unintended "butterfly effects" due to bioeconomy, is the EU targets for biofuels leading to higher production of palm oil in South East Asia (Fitzherbert *et al.*, 2008).

Encourage the "Knowledge-mix" within and between all the sectors

It was frequently mentioned throughout the workshop that in order to develop a bioeconomy, more data and more knowledge are required, especially concerning the availability of the biomass feedstock, its transformation efficiency or the feasibility of a national-scale bioeconomy for instance. Beyond the need to collect and gather more data, the use of this data is not clearly defined. Ideally, it should be shared in order to disseminate knowledge and methodologies for universal development and to allow equal access to data between the actors of the bioeconomy. In this perspective, current innovation processes and license systems seem inadequate: data collection should not be owned by a small group of companies for competitive advantage and it is hoped that the sharing of knowledge could become more an asset than a constraint. For example, in a circular economy, the sharing of data is essential to optimize flows of competences and materials. In doing so, industries are caught up in networks of symbiotic relationships whose benefits spread beyond the different industries involved, which also enriches the rest of the local socio-economic fabric by the indirect positive economic impacts that this symbiosis generates.

Consequently, a collective data sharing system needs to be designed with a particular focus on the boundaries of such a system related to the scales of the data-sharing: but should the data be shared within industrial communities or rather through the creation of regional and sectoral open access databases? Moreover this kind of data-sharing system could allow for a fairer repartition of costs related to R&D, data collecting, and access to associated markets. In order to initiate a sustainable ecological transition, natural-resource-based industries can be constructed as a collective mechanism through material and data sharing, to explore opportunities for economic activity creation, as illustrated by the Italian chemical company Novamont which uses invasive plants to produce oils. This business model is therefore based on transforming a local constraint into an economic opportunity, in a dynamic of collective territorial development.

The lack of knowledge sharing is not confined to the industrial sphere. For example, within the scientific sphere, the problem of non-open access academic publications still remains. A relevant illustration of this point is the segmentation of topics during the workshop: speakers talked about energy, public policies and cropping systems but, unfortunately, no presentations were proposed about interdisciplinary initiatives. As a matter of fact, industrial, scientific and social spheres still seem very impermeable. The transfer of knowledge from one sphere to another appears to be still infrequent. This lack of knowledge transfer also concerns the sharing of data and scientific results with all citizens, which in turn limits creative initiatives that could emerge such as the recent advances in agroecology. This is why knowledge mix with citizen experiences and its dissemination requires additional state funds. The Belgian philosopher Luc Carton described these citizen initiatives as "hot knowledge" in addition to "cold knowledge" which defines academic knowledge. The encounter of these two types of knowledge, their popularization and living labs are devices that need to be developed in order to enrich collective knowledge.

Conclusion

Instead of strengthening international cooperation and ecological policies, the focus on "green growth" is trapping the emerging bioeconomy as a tool for new "greenwashed" growth opportunities. It is promoting deeper individual and self-centered systems based on short-term norms of economic behaviour, moving societies away from the use of the precautionary principle, and leading us to gamble away the future of mankind. However, there is a debate about bioeconomy as a job provider and as a contributor to national Gross Domestic Product (GDP), so it seems strange to decouple economic growth from bioeconomy. One could argue that it makes sense to include economic growth as a deliverable of the bioeconomy, which would also provide an assessment criteria in order to measure the extent and success of the implementation of a bioeconomy. But the relevance of this indicator must be questioned, as some would say it is not a reliable method for measuring growth and welfare and is only part of the bigger picture (Kubiszewski *et al.*, 2013). On the contrary, there are a plethora of different measurable indicators and variables available that could be used in combination with GDP and are arguably better suited to measure the well-being and the good functioning of our societies.

During the workshop, it was noted that there was a significant lack of quantifiable deliverables listed, in order to measure bioeconomy implementation. Therefore, the question needs to be asked: how can we implement a bioeconomy effectively if we do not have well-defined targets and objectives such as these? Additionally if economic growth is a key deliverable of a bioeconomy then business is much more likely to "champion" the idea, which would therefore speed bioeconomy implementation. Humankind is facing

major ecological challenges and is looking for global policies. The bioeconomy is a complex system so it would be unwise to just include GDP as an indicator. However this does not excuse the lack of quantitative targets in national policy planning, especially as several measurable factors could be used in combination with GDP, such as carbon emissions. By converting high-carbon societies to low-carbon ones, bioeconomy should pave the way to a more sustainable model of development. But, it is probably only one part of the solution and more tough choices remain to be made. Indeed, our societies are facing a choice between: (i) a simple substitution of raw materials in our current modes of production and (ii) initiating a radical transformation of how our modes of production are organised supported by an ecological and energy transition.

The choice of "green growth" could simply reproduce an extensive growth-based society in which sustainability is nothing more than a marketing argument, or at the most, an opportunity to attract subsidies or generate new revenue streams. Alternatively coupling bioeconomy development and economic growth could lead to rapid technological developments, leading to a more effective and efficient implementation of a bioeconomy. On the contrary, transition toward a sustainable bioeconomy based on a general interest and common resources would open opportunities to build a new development model. To create new relationships between sectors, territories and technologies, there is a need for new productive conventions. Profit or financial rentability should not remain the single goal of economic activities and more focus should be applied on satisfying people's needs. In place of dominant market logic new non-profit modes of production should emerge, accompanied with new solidarities. Then the question of collective development of productive tools, brands and patents, as done by large agricultural cooperative or the Pomacle-Bazancourt biorefinery, should be addressed.

Planning policies still exist but they no longer deal with large research and development programs anymore: they promote greater liberalization instead, thus neglecting social and ecological objectives and expanding the rift between nature and society. There is a strong need to settle effective socio-ecological transition plans towards sustainable local productive systems. Defining these plans implies organizing and defining concrete steps to be achieved in this socio-ecological transition, using various hybrid forms of multiple actors forums in which collective decisions would be adopted between producers, consumers and state.

Finally, the current fossil fuel-based economy is very concerning in terms of the carrying capacity of the planet, but bioeconomy implementation cannot solve it once and for all. An economic system based on biomass has the advantage of being resilient, but it relies on the availability of appropriate biotopes and solar energy, and is temporally limited by biological ecosystems cycles in order to permit resource regeneration. Bioeconomy also raises major sustainability concerns given: (i) the growing food demand caused by the continuous population expansion and the rise of standards of living, (ii) the current competition for land use in a context of growing urbanization, (iii) the loss of biodiversity for which it is responsible, its own gas emissions and environmental impacts.

It is important to keep in mind that stepping out of high-carbon societies is far from being sufficient for meeting global challenges, because the biomass production and exploitation are also main components of our unsustainable model of development (Crist *et al.*, 2017). In the end, the sustainability of the bioeconomic model, is for the moment questionable but hopefully something that can be achieved in the future, if a strong paradigm shift is initiated from now on.

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