Toward a European Bioeconomic Transition: Is a Soft Shift Enough to Challenge Hard Socio-ecological Issues?

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INTRODUCTION

Humankind has initiated major changes to fully take advantage of Earth's resources. However, the resulting industrial economic system on which anthropocene societies are now based is responsible for unprecedented and irreversible biosphere's damage (Crutzen & Stoermer, 2000; Ceballos *et al.*, 2015). As illustrated by Steffen *et al.* (2015), the total consumption of ecological resources and services currently exceeds the Earth regenerating capacity and was equivalent to 1.6 consumed planets within a year according to the last estimations (WWF, 2016). Unlike before the Industrial Revolution, humans can now extract huge amounts of resources for a fraction of the cost, which 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, because otherwise it will mean jeopardizing our societies (Diamond, 2005; Ehrlich & Ehrlich, 2013).

In order to avoid an unacceptable situation for humanity, it is globally understood that our economic system has to radically change and to go hand in hand with sustainable human development. By contrast, 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 extractivist logic inherited from the oil era, which means : (i) exploitation of resources until exhaustion without concern for its reproduction and (ii) large delocalization of resource consumption relative to its 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 hard to globally launch the industrial process change; but there is a huge need for a local and sustainable production of raw materials, because renewable resources can be limited too if it is extracted regardless its cycle of reproduction. These objectives involve a combination of multi-scalar and interdisciplinary solutions, implemented simultaneously, and in a way that ensures intergenerational fairness, which together challenge inherited knowledge and skills. The complexity of the transition does not just involve multi scalar stakes, which means 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 are the 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. For the last ten years, this concept has evolved a great deal and in the perspective of "horizon 2020" the European commission aims to give a new breath to the global bioeconomy strategy by identifying new guidelines. In this context, a European workshop on bioeconomy was organized on the 28th and 29th of June 2017 by INRA and IRSTEA. During this workshop, the speakers were invited to answer three questions to stimulate the reflexion: (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 are necessary for the development of bioeconomy and which new stakeholders. At the same time, a young scientists panel was composed to attend to this workshop and to give the point of view of the young generation. The aim of this paper is to (i) present the position of this panel as young scientists but also as citizens, about the actual bioeconomy concept and what it could be and (ii) raise the main points to focus on to go forward a European bio-economic transition.

1. From Bioeconomy: much Discussion, little Agreement

At a first glance, it would appear that the "bioeconomy" is a new kind of economy, focused on use of biomass as the main feedstock but 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 instead of fossil feedstocks.

However, the concept of bioeconomy does not provide a shift in the ongoing economic paradigm as it only changes the feedstock . We argue that the term of "biologicalisation" of the economy is more appropriate. Moreover, this vision of bioeconomy is therefore more related to 'greenwashing' rather than a true economic conception. 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 economic crisis of 2008, but (iii) mostly because of its ambiguity. Ambiguity in its historical origin, on its signification, on its construction and on the political or industrial objectives related to it (Theys, 2014). The oxymoronic ambiguity has not entirely disappeared from these different semantic fields and persist in the emergence of the concept of bioeconomy which may lead to a similar confusion or failure.

1.1. Plurality of Bioeconomy Definitions

Today more and more people recognise themselves as stakeholders of "bioeconomy" and active contributors to an ecological shift. As such, the European workshop was rather a recognition event than a substantial debate one. While there was no debate on the definition of bioeconomy during the workshop, it is really clear that there are no fewer than three different conceptions of the bioeconomy. The first conception of bioeconomy 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, this plurality of definitions allows the integration of a lot of sectors into the bioeconomy (each sector defining its own bioeconomy) and a kind of pluridisciplinary approach but, on the other hand, it leads to unclear global objectives and policies without any figured targets. Moreover, the perception of bioeconomy by citizens is most of the time not integrated to the definitions proposed. Consequently, it is obvious that several serious debates must be oriented to social choices regarding expected functionalities of bioeconomy. Indeed, three hypotheses on the evolution of a bioeconomy can be envisaged. First, the bioeconomy might not draw a whole new paradigm like the oil era did but it might rather organize the chemicals-energy-material production mix. Secondly, 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 double intensification, ecological and economic, in the use of renewable resources.

1.2. 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, narrated as a wide range of opportunities and tools in order to reshape our economic system and to diminish its dependency on fossil feedstocks. For instance, it was observed that industrial biomanufacturing implementation is not following the model of current chemical industry, based on mega-facilities (Clomburg *et al.,* 2017). Interesting potentialities 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 bioeconomy (Biome Bioplastics, 2015).

However, enthusiasm for new technologies shouldn't make one lose sight of two important facts. First, biotechnologies are coined with the idea of a sustainable growth, in which technological progress has a major role to play, 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 have to also be ethical. Questions 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, obscured intellectual property rights on living organisms, control of food production by a small number of actors, and maybe others that have not yet been identified or are less predictable. As for now, it seems that these consequences remain poorly discussed or studied and this should therefore become a priority for government policy.

Yet, these issues entail several substantive debates, including those of externalities and ecosystem services, which purpose is to fix a monetary value on these services. Some natural assets are not appropriable, divisible or exchangeable and trying to put 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 penalizations for excessive or unsustainable use of natural resources (with a tax on carbon emission, energy consumption, biodiversity impoverishment) could help companies to take sustainability into account in their decision making and could be a simple way to regulate these damages and which will therefore 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 human's place in the nature/ecosystem was not alluded to. It seems the idea for bioeconomy is still to dominate the 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.

2. Toward a Socio-ecological Transition ? Inducing Change in the Short Term to Aim Long Term Objectives

Change must occur as soon as possible. The issue of climate change and the exceeding of several of the planetary boundaries, highlights the critical need to take action (Steffen 2015). But before that, our reflections were based on the fact that a lot of discussion seemed to be technologically driven. It seems that the hope on a viable technology that is transferable to many territories and situations still remains, even though it is in contradiction with bioeconomy aims. One of the big issues is to focus more on bottom-up innovations and various scales of territory issues. This paradigm shift probably should be based on a flexible bioeconomy and be adapted in accordance with social driven issues and local problematics.

2.1 Develop Bioeconomies Closer to its Citizens : the Importance of Territories

To sustain and develop a bioeconomy, initiatives can be led at different scales. Whereas the guidelines are defined on a national scale, it seems really important to take more into account bottom up initiatives and local issues to design various bioeconomies, closer to its territories and to citizens' expectations.

Industry was rebuilt from the end of the Second World War around a limited number of raw materials (mainly fossil) 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 renewable raw materials reproduction and modes of extraction, transformation and consumption is therefore at the heart of the transition to the bioeconomy. This industrial transition raises the question of the choice of the relevant scale to develop bioeconomies, avoiding overspecialization which can lead to the dependence of a single economic activity and vanish the identity of the territory. 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. This implies considering the diversities that underlie their identities: socio-demographic specificities, local natural resources, individual and collective needs.

The transition to decentralized use of renewable resources, utilised as close as possible to its place of extraction and processing, seems to be a key point in the anchoring of industries into territories. Thus, to be sustainable, a biorefinery should not convert huge volumes of defined renewable resource into energy and chemicals, but have to adapt efficiently to various raw materials in low amounts and diverse output products to match the needs. The challenge therefore lies in the construction of strategies viewing the territory not as a simple stock of natural resources and skills, but as a driving force of reconversion and the 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 by higher valorization of local resources.

In France, some local structures are still working to take up these challenges. For example, in the region "Haut-de-France", 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; Institut Pivert, 2017). If these types of initiatives seem to be successful locally, the question now is how to use these to build political measures to support the transition at the national, European and then at the global scale. This kind of bottom-up strategy could be a solution to support a more efficient transition of bioeconomy than a top-down strategy; thus, bioeconomy can used to revitalize the local and rural economy.

However even though local territories are important, it is still critical to consider bioeconomy on a global scale as well as a local one. Not doing so will lead to unnecessary inefficiencies and it is incredibly important 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. An example of a globalized biomass value chain is Drax Power Station in the UK, which 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) (Drax Group plc, 2017). This illustrates how global biomass networks can be established in order to take advantage of each country's biomass feedstock mix, which may lead to greater efficiency as suggested by the theory of comparative advantage. However, it may also interfere or hinder the management of the respective country's natural resources and lead to a more conflictual use of these resources or even 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' on all the value chain, even if it is 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).

2.2 Encourage the "Knowledge-mix" Within and Between All the Sectors

It was frequently mentioned throughout the workshop that in order to build a bioeconomy, more data and more knowledge is required, especially related to the availability of the biomass feedstock, its transformation efficiency or the feasibility of a national-scale bioeconomy for instance. Beyond the need of collecting and gathering 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, actual 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 of an asset more than a constraint. For example, in a circular economy, 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, and 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 has to be designed with a particular focus on the boundaries of such 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 fairer repartition costs related to R&D, data collecting, and access on 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, for exploring 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 the transformation of 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 the 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 to all citizens,

which in turn limits ingenious 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 this citizens' initiatives as "hot knowledge" in addition to "cold knowledge" which specifies academic knowledge. The encounter of these two types of knowledge, popularization, 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 precautionary principle, and leading us to gamble away the future of mankind. However, there is a debate about a bioeconomy as a job provider and as a contributor to national Gross Domestic Product (GDP), so it seems strange to decouple economic growth and bioeconomy. It can be argued 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.,* 2010). 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 and therefore the question has 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 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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