Towards a typology of bioclusters

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A bioeconomy can be defined as an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources and as such, the bioeconomy has the potential to contribute to sustainable development by stimulating a shift away from fossil fuels, combatting climate change and at the same time fostering innovations and regional and agricultural development (McCormick and Kautto, 2013, Brunori, 2013).

However, the shift away from fossil-based sources of carbon is likely to require more than just the development of new technological alternatives (hardware). Nowadays it is increasingly acknowledged that innovations should be viewed as successful combinations of hardware with software (new knowledge and new modes of thinking) and orgware (reordering institutions and organizations) (Smits, 2002). In an increasingly interconnected society, the success of an innovation depends on changes up and down the value chain and on numerous social processes in which multiple actors from society, government, science, agriculture, and industry interact. This means that a single actor is unlikely to possess all the knowledge and resources to push through a particular innovation and that collaboration and learning processes between multiple stakeholders is necessary (Hermans et al., 2015).

Cluster initiatives have become an important tool for governments to establish, promote, and strengthen economic collaboration, learning, innovation, and employment within particular regions (Porter, 1990). In our contribution to the SFER 2019 Symposium, we will investigate clusters that specialise in the field of the bioeconomy: so-called bioclusters. These bioclusters are expected to play a key role in the development of the bioeconomy (Zechendorf, 2011, Hermans, 2018) and as a result, the promotion of bioclusters often features prominently in the bioeconomy policies of many countries (Dietz et al., 2018).

However, the concept of what a bioeconomy cluster is and what roles it can play in the transition towards sustainability has so far remained unclear (Vivien et al., 2019). A literature review done by Bugge et al. (2016) identified three visions of the bioeconomy: a biotech vision, a bio-resource vision and a bio-ecology vision. For some authors, bioclusters are thus shorthand for biotechnology clusters (Cooke, 2002), but others take a broader definition and also include also agglomerations of primary production units for instance in the form of agro-holdings (Wandel, 2009, Hermans et al., 2017).

In our contribution to the SFER 2019 Symposium we will present a new typology of bioclusters from a theoretical perspective. We will present a review of the cluster literature and together with a characterisation of different sectors that form the bioeconomy. Combining these two strands of literature, we will come to a characterisation of four different types of bioclusters and develop some thoughts about their implications for their potential contributions to different types of sustainable development at different scales and levels.

Towards a typology of bioclusters

To come to a definition of a biocluster, we first turn our attention to the definition of a cluster. The most popular definition of a cluster comes from Porter (1990) who defined a cluster as "a geographically proximate group of interconnected companies and associated organisations (for example, universities, standards agencies, and trade associations) in a particular field, linked by commonalities and complementarities."(Porter, 1990). In the case of a biocluster the 'particular field' is formed by one or more sectors of the bioeconomy and in this paper we will thus take a broad definition of a biocluster that includes primary production of agriculture and forestry.

For our cluster typology we use the classic typology of industrial districts from Markusen (1996) and combine it with the knowledge based taxonomy of clusters by Iammarino and McCann (2006) and the multi-scalar conceptualisation of innovation systems of Binz and Truffer (2017). Based on three sources, we identify four types of bioclusters that differ on two important axes. The first axis is represents the different types of knowledge applied and transferred within a biocluster. Codified knowledge is more easily shared than tacit knowledge that depends on personal experiences. In this regard, Jensen et al. (2007) make a useful distinction between sectors that rely on STI (science-technology and innovation) and sectors that rely on DUI (doing, using and interacting) types of knowledge. The second axis is formed by the type of product valuation, where we can identify standardisation and versus customisation. Is the sector organised on cost cutting, standardised production methods, or is the value added created in specialisation and customisation? This element is especially important in the different bioeconomy sectors, and is often depicted in the so called 'value pyramid of biomass' (Bosman and Rotmans, 2016, Asveld et al., 2011). The idea is that at the bottom of the pyramid firms compete on standardised bulk products and higher up in the pyramid activities and products become more and more specialised and customised, thereby increasing their value added.

Preliminary Results

In Table 1 the four types of bioclusters are presented together with some typical examples of clusters that can be found in the literature. This is still work in progress, so the labels as well as some of the typical examples mentioned, might still change in the future.

Table 1: Types of bioclusters

		Type of knowledge	
		DUI	***STI***
Valuation	**Standardised**	*Agricultural agglomerations* • Examples: glass house /horticultural clusters, wine clusters, intensive animal husbandry areas • Traditional agricultural innovation model with strong role of AKS in innovation development Transition pathway: "Boosting primary production"	*Hub and spoke biocluster* • Examples: biorefineries, green chemistry but also paper and pulp clusters • Centralised processing facility, often dominated by large incumbents (MNC) • Innovations sources are R&D and university knowledge Transition pathway: Boosting primary production and Conversion
	Customised	*Marshallian district* • Examples: fashion, leather, wood construction and building • Innovation results from customer demands Transition pathway: Conversion & Low bulk, high value	*Life science clusters* • Examples: pharmaceuticals and medicine (red biotech), cosmetics • Innovations sources from university knowledge, R&D and spin-offs/ Transition pathway: "Low bulk, high value"

The role of different types of bioclusters in different types of transition pathways

The main four types of bioclusters can each have a different transition pathway to a bioeconomy. In this regard, Dietz et al. (2018) identify four transition pathways that a transformation process may follow. Although their pathways are defined from the supply side and neglect the demand side of a sustainability transition (as Dietz and all also note). As such the logic of these pathways follows from the scale increases of the activities within the cluster.

For instance, one of the pathways they define is that of boosting primary production. The idea is that technological innovation leads to increases of productivity in agriculture and forestry that can open up new production methods or locations. This transformation pathway follows the logic of the green revolution with its focus on the agro-industrial model of scale increases. As such it fits the agricultural agglomeration biocluster.

The second pathway is called the conversion pathway. In this pathway process innovations and conversion of new and (more) efficient uses of biomass comes to the foreground. This pathway looks at the processing of biomass and the most efficient use of it in downstream sectors. Biotechnology (enzymatic synthesis) can play an important role in this pathway. The clusters formed around a biorefinery, some paper mills and green chemistry clusters could potentially follow this transition pathway.

The third pathway can be linked to both the high-tech bioclusters of the pharmaceutical and life science clusters, but also to some of the Mashallian districts focussing on fashion, leather and design. This pathway is labelled ‘low bulk, high value applications’. The difference here is that in the high-tech bioclusters, the biological principles and processes are used more or less independently of biomass streams’ industrial applications. The corresponding transformative processes potentially result in cheaper and more environmentally friendly production methods or completely new products. In the Marshallian biocluster the link to the primary product is more pronounced. Especially in fashion districts, parts of the production process (the design) can be done in Europe, while actual production is done somewhere in Asia.

However, the environmental and social implications of some of these transformation pathways is contested. The classic example here are the biofuel policies in the EU and US that have led to increased demand for bioenergy, with direct and indirect effects on land use worldwide depending on land availability. The negative environmental consequences of the first generation biofuels made this policy controversial and combined with lower prices of fossil fuels due to the increasing supply of shale gas from fracking has led to calls away from biofuels and more towards policies aimed at the manufacturing of bioplastics (Carus et al., 2011). Therefore, issues like the rebound effect, geographical and temporal negative trade-offs in the forms of (in)direct land use and climate change and social and economic dependencies on regional primary production need to be monitored for their potential negative repercussions for the sustainable development at regional, national and international levels.

Discussion, (preliminary) conclusions and future work

The here presented typology of bioclusters is a work in progress and depends on a review of some existing cluster typologies combined with an analysis of some of the characteristics of different sectors of the bioeconomy. As such, the here presented typology contains a number of ‘archetypes’ of bioclusters. In reality bioclusters probably contain a broad mix of sectors, some of which are not connected to the bioeconomy at all (for instance ICT). The question remains whether these different types of bioclusters can be found in reality. A more detailed and refined view on these effects, not only inside but also outside of the clusters and the different effects across different levels is necessary and this is something we will work on in the future.

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