



Promises of Bioeconomic Change as a Strategy for Avoiding Socio-ecological Transformation

Where limits to growth are tangible: the olive sector in Jaén and its bioeconomic future

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Received: 25 November 2021 / Accepted: 9 September 2022 / Published online: 3 November 2022
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Abstract

The olive sector in Jaén in the South of Spain serves as an example of what happens when a centuries-old bio-based economy reaches its biophysical limits. The Andalusian Bioeconomy Strategy seeks to reform the sector by modernizing it, i.e. investing in technological innovation and increasing the efficiency of mechanization. This paper first considers recent data on the olive sector in Jaén before comparing its historical evolution with the demands of the 2018 Andalusian Bioeconomy Strategy. The comparison yields several results: first, the history of olive cultivation in the province is characterized by a strong peasantry that continuously grew on a large scale and consisted of thousands of small farmers; thus, it is not a typical story of land concentration and technological modernization. Second, there is potential for conflict between what the paper depicts as a historical, “old” bioeconomy and the bioeconomy envisioned by the Andalusian strategy.

Keywords Olives · Jaén · Andalusia · Peasantry · Bioeconomy · Degrowth

Introduction

The bioeconomy has been a frequent focal point of interest among politicians, scholars and actors from civic society since its introduction into the European political sphere with the strategy “Innovating for sustainable growth: a bioeconomy for Europe” in 2012. It promised to guarantee sustainable economic growth while decreasing the importance of fossil fuels and creating new jobs in the growing biotechnology sector (EC 2012). Since its release, the European bioeconomy strategy has not only been further translated into many national strategies and updated by a new Europe-wide strategy in 2018, but has also been critically analysed by social science scholars (see, among others, Giampietro 2020; Vivien et al. 2019; Lüthmann 2020).

In comparison to the US-American context, the European Union (EU) and its member states do not focus on the development of new biotechnology as much, although this is mentioned as a key aspect of the bioeconomy in most official publications, but seek to strengthen the production and utilization of biomass within Europe to replace fossil fuels with bio-based alternatives (Meyer 2017). While this transformation of the resource basis is a necessary step towards a sustainable productive system, the EU’s specific strategy for achieving this commonly agreed upon goal has come under criticism, with Vivien et al. (2019) arguing that the term bioeconomy itself is being “hijacked” as Georgescu-Roegen’s original vision in the 1970s included notions of sufficiency and degrowth, rather than allowing for a continued increase in resource usage and consumption on a different material basis. Hausknost et al. (2017) note that they do not consider the biophysical requirements for the EU’s bioeconomy vision as given. It therefore becomes a “policy legend” (Giampietro 2020) rather than an actual plan for a more sustainable economic system that would need to include necessary, far-reaching transformations.

Even with its 2018 update, the European bioeconomy strategy, despite its shortcomings in terms of sustainability, is shaped by the same powerful actors who prioritize

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economic growth over actual transformative measures (Lühmann 2020). However, despite growth-oriented policies on the European level, it is precisely the EU that partly allows exceptions to the rule: the olive sector in province of Jaén in Andalucía (southern Spain), which provides more than 40% of the region's biomass, is characterized by thousands of smallholder farmers, mostly on land unsuitable for the use of machinery (Parras Rosa et al. 2020). The fragmented ownership structure inhibits large scale investments in efficiency improvements, while being kept largely intact by EU Common Agricultural Policy (CAP) subsidies. This runs counter to the general thrust of European policy, which is to compete in international markets by increasing efficiency and production volumes. This situation gives rise to a central question: how does the historical development of the olive sector fit into the new, growth-oriented narrative of the Andalusian Bioeconomy Strategy, while simultaneously being confronted with numerous limitations? This paper aims to answer this question by first analysing the history of the sector and then, in a second step, inferring from its historical evolution its possible future within a new bioeconomy.

This paper presents and discusses the contradictions between a historical bio-based economy in the province of Jaén, which has used olive cultivation as subsistence measure, and a bioeconomy strategy based on international competition, technological innovation and economic growth. It is shown how the modernization and reframing of an already existing 'old bioeconomy' without acknowledging its specific local development can prove difficult for several reasons. While other authors (see La Cal Herrera 2014; Sánchez Martínez et al. 2011; Sanchez Martínez and Gallego Simón 2011) have previously discussed conversions in the olive sector, this contribution aims to frame these developments as a socioeconomic transition from an "old" to a "new" bioeconomy that may lead to social conflicts.

The following section introduces recent data on the case of Jaén. This introduction entails general information about the region, as well as data on the specific productive regime of the olive sector in the region and a critical summary of the different visions of bioeconomy associated with the respective program in Andalucía. Section "[The historical olive sector as subsistence agriculture](#)" then further elaborates on the importance of taking into account the historical evolution of the olive sector by highlighting again the differences between the "old" and the "new" bioeconomy. Section "[Discussion](#)" analyses the implications of the comparison between the historical and potential future bioeconomy of the olive sector on the region and its inhabitants, using data from numerous interviews with stakeholders in the region.

This work is based on a comparison between historical accounts of olive cultivation in the province of Jaén, current data on the sector such as statistics on the development of

cultivated areas and the changes in productive capacity, as well as on political and scientific papers on various bioeconomic visions and strategies. The synthesis of this information makes it possible to outline various lines of potential conflicts that could arise from the lack of recognition of the historical development of the olive sector. These claims are backed by data acquired in qualitative, semi-structured interviews with 43 stakeholders in the region from 2021 to 2022. While these interviews are not representative of all farmers or the generality of stakeholders in the olive sector, they can help provide insights into olive farmers' opinions on current developments within the sector, especially concerning the bioeconomy. However, it has to be noted that the bioeconomy as it is framed in the Andalusian strategy is still new, therefore knowledge among farmers and the body of existing literature on the topic are both limited. The interviews can indicate general attitudes towards developments that will unfold in the coming years, but they cannot give a comprehensive account of the relationship between the "old" and "new" bioeconomy.

Case study: the olive oil sector in Jaén

With approximately 640,000 inhabitants and population density of 44 people per square kilometre in 2018, the province of Jaén, located in the southern interior of Spain, is one of the most sparsely populated regions in the country (Infoloso 2021).

As visible in Fig. 1, it is located on the northern edge of the autonomous region of Andalusia. According to data from the *Servicio Público de Empleo Estatal* (SEPE), the region suffers from an ageing population and emigration. The share of individuals younger than 20 is 20%, while the population older than 65 accounts for about 19% of the province's inhabitants. The largest age group is between 50 and 54 years old, significantly older than the median age in Spain, which is 44 years, as shown in Fig. 2 below (European Commission 2022).

The latest survey on Jaén's demographic and labour market states that the most notable demographic change in the region is the increase of people aged 55–79 years and those over 84 years, while the proportion of the population under 50 is decreasing. In the coming years, significantly more people are leaving the labour force (aged 55–64 years) than entering it (aged 15–24 years), a trend that will intensify in the coming decades, as can be seen in Fig. 2 (SEPE 2021). The overall age of the region's population in combination with the current trend is also relevant for the future of the region's olive sector, since a shrinking working population/labour force could accelerate a restructuring of land ownership structures when fewer and fewer people who own small

Fig. 1 Location of the province of Jaén in Spain (Wikimedia Commons 2010)

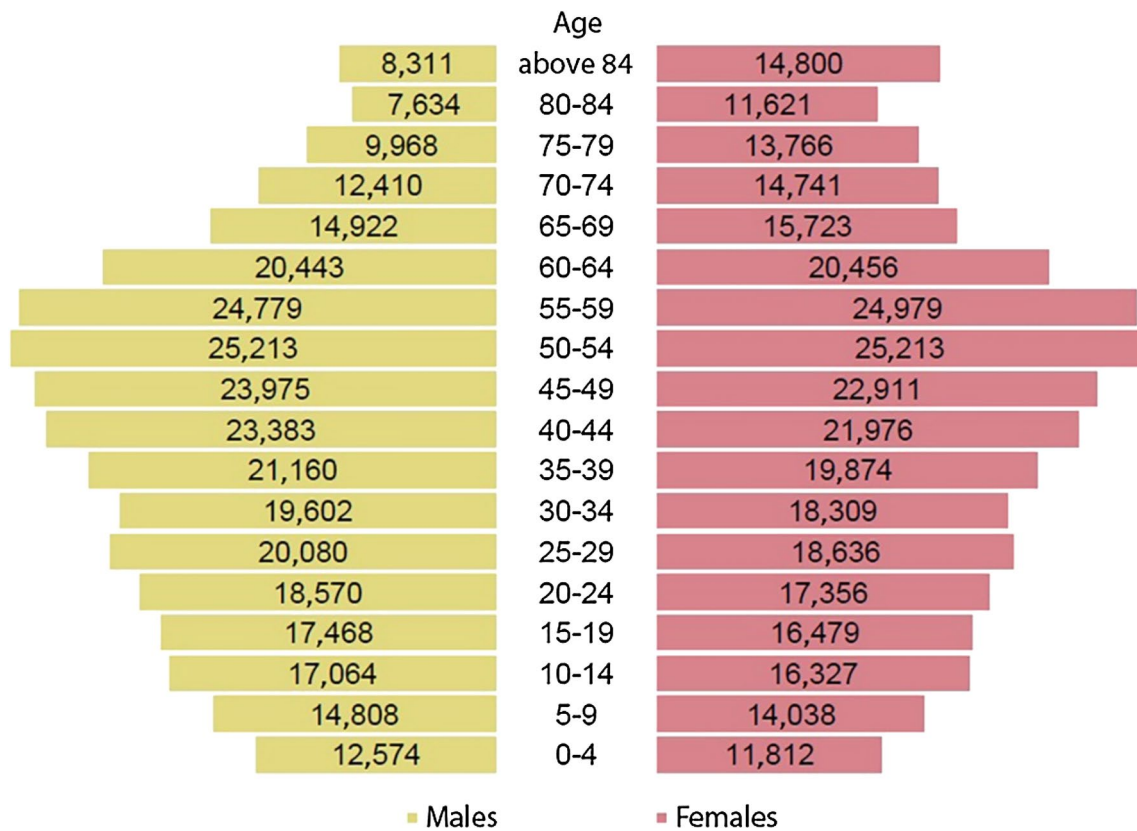


Fig. 2 Distribution of age groups in Jaén divided by gender (Own translation, Spanish original from SEPE 2021)

plots of land will no longer cultivate them for reasons of age or lack of heirs to continue their economic activities.

In 2019, Jaén's net migration was $-2,379$, with most of the emigrants moving to other parts of Spain, while 50% went abroad (SEPE 2021). Unemployment has been a problem for the province since the last financial crisis in 2007: although the rate has steadily decreased since 2013, Jaén's unemployment rate is still 22%, well above the national average of 15% (SEPE 2021). Of the working population, over 10% are employed in the primary sector, a share far higher than the rest of Spain, where the average share amounts to roughly 4% (SEPE). The largest share of employment opportunities in the primary sector is in the olive sector.

The current monoculture of olives

In the province of Jaén, there are currently around 60 million olive trees on over 580,000 ha of land. More than 90% of the province's agricultural land is used to grow olives, which are primarily processed into olive oil. During a harvest season, an estimated 4 million day wages are paid to 30,000 and 40,000 labourers (Abolafia 2019). The SEPE also denounces this dependence on one crop, combined with the lack of industry in the region, as a major problem. While the cited report highlights the positive economic developments in olive cultivation, such as quality improvements and stronger connections to international markets, the dependence on what is essentially a monoculture is identified as a weakness of the region's economic structure. The solution advocated is much in line with Andalusia's bioeconomy strategy, presented later in this paper, in that it proposes an increase in efficiency and therefore production, greater connection to international markets and a stronger focus on the international promotion of Jaén products (SEPE 2019).

During the 2018/2019 season, 7.5 million tonnes of olives were pressed across Andalusia. Of these, 3.2 million tonnes (43%) came from Jaén. Of this amount, an average of 20% becomes olive oil, which in the case of Jaén is around 660,000 L of oil (Junta de Andalucía 2020). There are three different forms of olive cultivation: *Tradicional* (80–120 trees per hectare, non-irrigated, usually older than 25 years), *intensivo* (200–600 trees per hectare, irrigated, on an area with a slope of less than 15%) and *superintensivo* (1000–2000 trees per hectare, irrigated, highly mechanized). Intensive and super-intensive cultivation play practically no role in Jaén (Sánchez Martínez and Ortega Ruiz 2016). More than a third of the province's agricultural land has a gradient of more than 20%, which makes the use of machinery impossible, and depending on the data, between 20 and 40% of the olive groves are irrigated. Furthermore, a distinction is also made according to the degree of mechanization possible: there are OTDM (*olivares tradicionales difíciles a mecanizar*, i.e. traditional groves that are difficult

to mechanize, consisting mainly of small and tiny areas in the mountains of the province) and OTMS / OTMR (*olivares tradicionales mecanizables secanos/irregados*, i.e. mechanizable traditional groves, either dry or irrigated, with a slope of less than 15%) (Parras Rosa et al. 2020).

Most producers in Jaén own very small areas and are dependent on subsidies. In 2019, about 86,400 olive farmers applied for subsidies under the European Common Agricultural Policy (CAP) (Parras Rosa et al. 2020). The CAP is the EU's main instrument for distributing subsidies in the European agricultural sector. Many people depend not only on the income from these groves, but also on European subsidies. However, a precise characterization of olive farmers in Jaén is difficult to achieve. This is mainly due to the fact that there is no exact census of all the owners of an olive grove. While there is no specific study of the farmers and their socioeconomic positions, the best way to approximate their number is through the amount of applications for subsidies under the CAP. It is estimated that 10 ha suffices to farm for a living (Parras Rosa et al. 2020). The total cultivated area divided by more than 440,000 plots results in an average size of around 1.24 ha per plot, with more than 70% smaller than 5 ha. Thus, it can be concluded that a significant number of aforementioned farmers do not pursue olive cultivation as their sole economic activity. Apart from the extensive research already available on the olive market, the production, geographic expansion and the historic development of the sector, more specific research on the socioeconomic characteristics of olive farmers is needed in order to understand their stance on certain developments within the sector and the broader economy. A first step in this direction could be the qualitative interviews in combination with the questionnaires on socioeconomic data, carried out by the author of this paper between 2020 and 2022. A total of 43 people were interviewed, including 21 producers, 8 people from academia, 5 public administration staff and 9 people from different backgrounds.¹ The interviews were carried out to research stakeholders' perceptions of the various developments in the olive sector. Although the number of interviews and the survey methodology do not allow for general conclusions to be drawn about the socioeconomic situation of olive farmers in Jaén, the initial, preliminary findings obtained through the structured content analysis can provide an idea of possible differences of opinion and future lines of conflicts, all of which will be discussed in greater detail in a later section of this paper.

According to Parras Rosa et al. (2020), the production costs per kilogram of olive oil determine its profitability.

¹ "Diverse backgrounds" is a category used to describe people who are indirectly related to the olive sector, such as restaurant owners, shop keepers, etc.

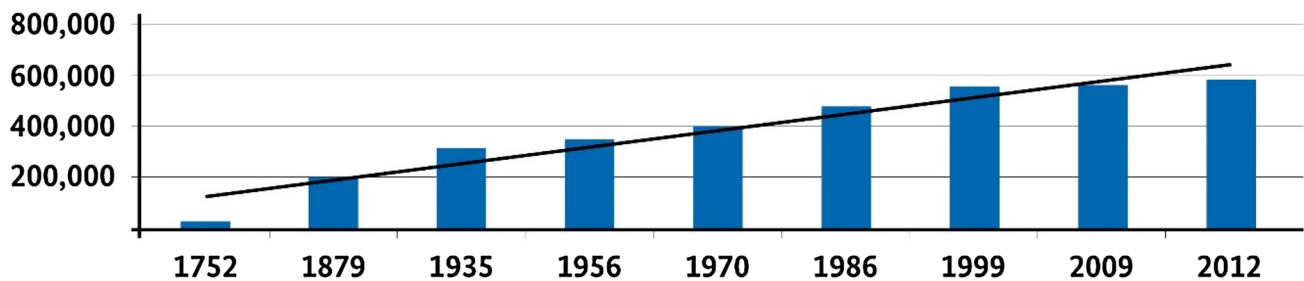


Fig. 3 Evolution of area cultivated with olives in Jaén from 1752 to 2012 (own English numerical translation, Spanish original from Sánchez Martínez and Ortega Ruiz 2016)

Although they argue for a continuation of the EU’s previous policy, they see the sector’s unprofitability as a major problem. The removal of subsidies would lead to an entire region losing part of its income, as olive cultivation still represents a permanent reservoir of jobs for many families (Delgado Cabeza 2014).

Figure 3 shows the historical evolution of olive area from 1752 to 2012: there are several sudden increases in olive cultivation and a stagnation after 1999, but the growth of the total area is significant. Paired with the aforementioned small average size of cultivated areas and the considerable share of non-mechanizable olive groves (around 30–50% of the currently cultivated area), it can be concluded that the expansion of olive cultivation in the province of Jaén is less a story of exponential growth, but rather a story of continuous, extensive expansion until certain biophysical limits were reached (Sánchez Martínez and Ortega Ruiz 2016). In the case of Jaén, olives already cover almost all arable land, as can be seen in Fig. 4 (Sánchez Martínez and Ortega Ruiz 2016).

In Fig. 4, the geographical expansion of olives is shown in olive-green, while forests are shown in dark green, meadows are light green, other crops are in yellow and urban areas are in red. The northern, southern and eastern parts of the province, which are dominated by meadows and forests, are either part of national parks or mountainous areas, where no agriculture is possible. The land available for agriculture is therefore characterized either by olive cultivation or by small patches of different crops within the vast area of groves (Sánchez Martínez and Almonacid 2021).

Table 1 summarizes the empirical data for the current production regime, the olive sector of Jaén.

While it is evident that the geographical expansion has reached its limits, the small plot size and low degree of mechanization promise opportunities for modernization and innovation. Concerning the share of irrigated plots, there is also potential for improvement. However, as the president of the hydrographic confederation of the Guadalquivir, the region’s largest river, notes, Jaén is among the region’s most affected by droughts due to climate change. It is highly

uncertain, whether there is any possibility to increase the share of irrigated plots (Mudarra 2021). In the following sections, I will discuss the Andalusian Bioeconomy Strategy’s stance on these issues and critically examine the potentials mentioned.

The Andalusian Bioeconomy Strategy in the context of different visions

There are several different visions of bioeconomies currently being propagated by various political and societal actors. According to Meyer (2017), two general “directions” of bioeconomic policy can be identified: one focusing on biotechnology and one focusing on the production and usage of biomass. This paper argues that a characterization of the olive sector can be made using the latter vision, which is in line with the European and Andalusian Bioeconomy Strategy. Although the historical olive sector does not aim to replace fossil fuels with new biomass-derived products, as is currently planned, it can be considered a biomass-based economy: the different products that an olive grove produced and that were made possible by the provision of by-products are very much in line with the contemporary bioeconomic practice of integrated production. Therefore, further literature is needed to better distinguish between the past and present bioeconomy in the case of the olive oil sector case study presented in this paper. Hausknost et al. (2017) present a compelling analysis of different bioeconomy visions in terms of their biophysical feasibility and different aims.

In this techno-political option space for visions of a bioeconomy, shown in Fig. 5, the authors classify bioeconomy policies according to their orientation towards capitalist growth or sufficiency and industrial biotechnology or agro-ecology. In the case of Jaén’s olive sector, it could be argued that the historical olive sector as presented in this paper was characterized by sufficiency practices on the one hand and continuous, but not exponential growth on the other, and could therefore be plotted on the left side of the “Eco-Growth” quadrant, while the current bioeconomy strategy for Andalucía is clearly situated in the quadrant of

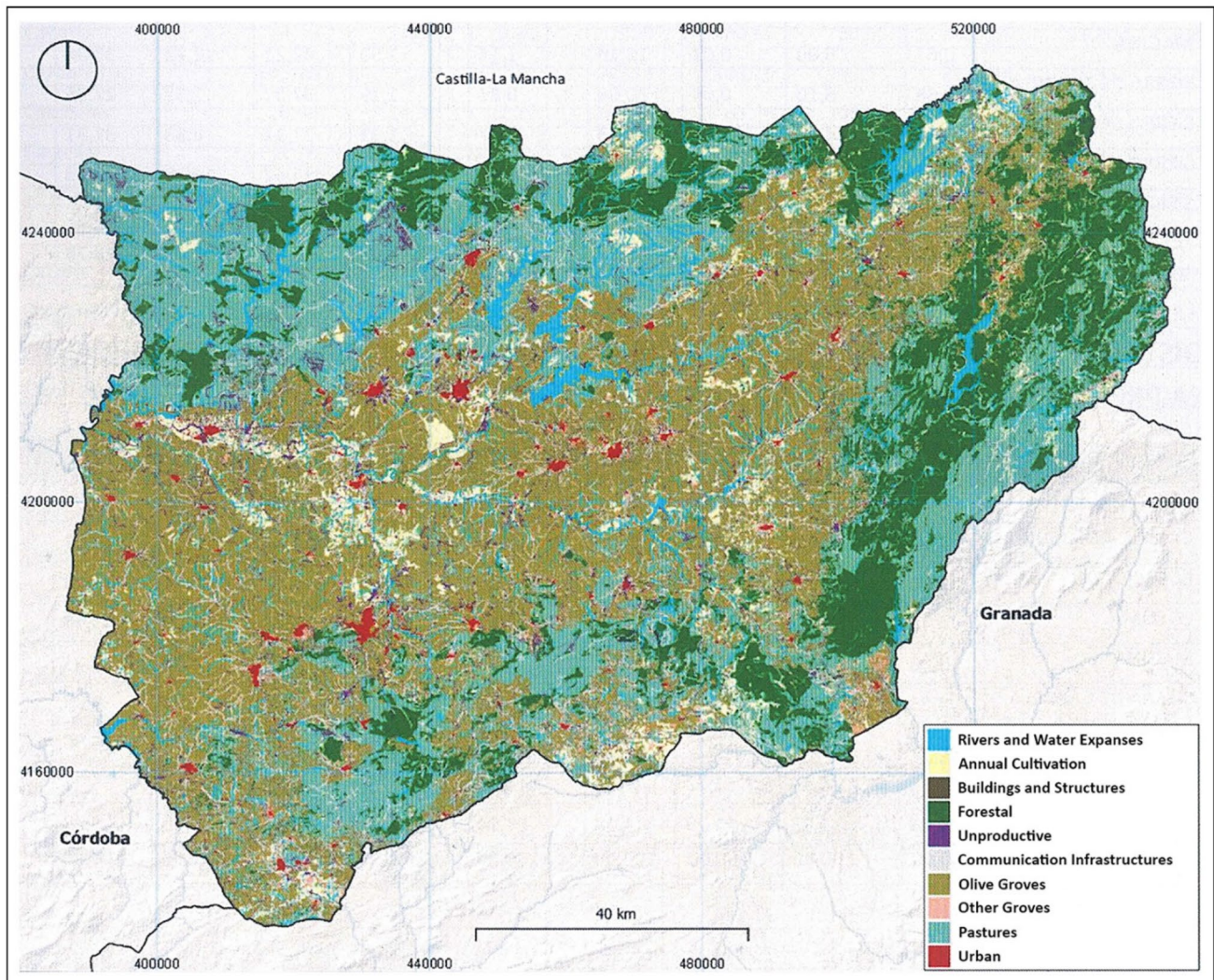


Fig. 4 Map of the primary soil usages in the province of Jaén in 2020 (own English translation, original from Sánchez Martínez and Almonacid 2021)

“Sustainable Capital”, as will be further elaborated below. The different positions of the historical development of the olive sector and the Andalusian Bioeconomy Strategy indicate a possible divide in the practices and attitudes of their defendants as well as potentially mark lines of future conflict.

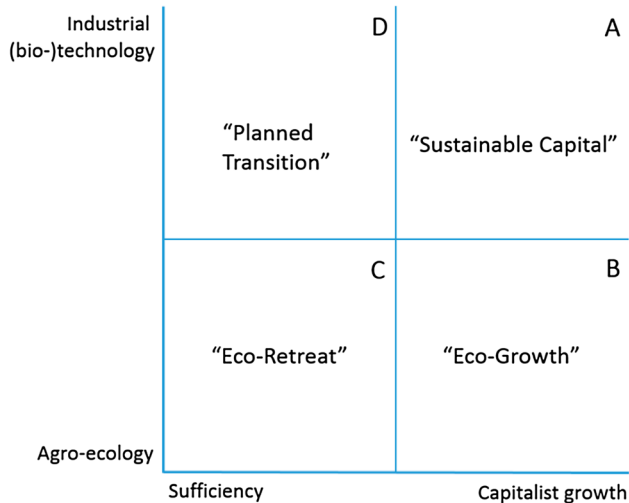
The Andalusian strategy for the circular bioeconomy was adopted in September 2018 (Junta de Andalucía 2018). It covers the sectors of agriculture, forestry, fisheries, food production, paper production, biotechnology and energy industries (Junta de Andalucía 2018). The strategy, which aims to allocate 1.3 billion euros to bioeconomy projects between 2018 and 2030, sees the need for a “transformation” of the economic system, but does not refer to a socio-ecological transformation that diverges from the idea of economic growth, but rather to an economy based on biological

resources that boosts the regional economy by (1) increasing the amount of biomass produced and (2) refining these resources and adding value to biotechnological, innovative products by promoting research and development.

Accordingly, the core objectives include increasing biomass production in the community, expanding the processing industry (biorefineries) and promoting markets for the products produced (Junta de Andalucía 2018). Production is to be sustainable as defined by the Brundtland Report, the necessary infrastructure should be built and awareness of the bioeconomy should be raised among the population (WCED 1987; Junta de Andalucía 2018). Therefore, economic growth must be combined with environmental protection through the bioeconomy to create a balance that enables both simultaneously. It is a vision of limitless green growth that is very clearly formulated here (Junta de Andalucía 2018).

Table 1 Empirical data on the productive system of the olive sector in Jaén in the harvest season 2019/2020 (data from Sánchez Martínez and Garrido Almonacid 2021; Parras Rosa et al. 2020; Caja Rural de Jaén 2020)

	Season 2019/2020
Total arable land (ha)	625,493
Cultivated area (ha)	581,403
Share of arable land (% of ha)	92%
Number of plots	440,000
Average plot size (ha)	<2
Number of farmers	86,400
Production (t)	1,700,000
Yield (kg/ha)	3000
Dry (% of plots)	61%
Irrigated (% of plots)	39%
Intensivo/superintensivo	<20%
Mechanizable	63%
Not mechanizable	37%

**Fig. 5** The techno-political option space for visions of a bioeconomy (Hausknost et al. 2017)

The olive sector in Jaén can be seen as a prime example of bioeconomic production following the criteria formulated by the Andalusian Bioeconomy Strategy: vast amounts of biomass are already being produced, whose waste is reused and recycled (Junta de Andalucía 2018). This so-called *producción integrada*, or integrated production, is already in effect in large parts of the community, according to the Andalusian Bioeconomy Strategy. Of the 550,000 ha that produce in this way, almost 100,000 ha are in the province of Jaén, the majority of which is attributed to the olive sector (Junta de Andalucía 2017). The olive sector in Andalucía produces on average around 5 million tonnes of olives per season, of which over 500,000 tonnes are leaves, 4.3 million

tonnes of moist olives, 500,000 tonnes are stones and just over 900,000 tonnes are dry residues (Callejo López and Parra Heras 2015). 80% of these residues are converted into either electricity or thermal energy, i.e. incinerated. 14% of the residues are used as fertilizer, around 5% of the mass is fed to animals.

The existing olive sector is therefore a stroke of luck for the Andalusian bioeconomy: most of Jaén's groves fall under the category of "traditional" olive cultivation, which means they are often not mechanized or irrigated. A policy programme aimed at increasing biomass production, rural development and technological innovation sees the olive sector as a field with great potential for efficiency gains and investment. La Cal Herrera (2014) argues that collecting cuttings from olive groves, which also can be used for biomass refinement, is most cost-effective when done in super intensive groves, as it minimizes the need for manual labour. The dependence on subsidies from the EU and the recent increase in olive oil exports argue for a "renewal" of the olive sector in the context of an emerging growth-oriented bioeconomy. Climate change will also affect the yields and might lead to greater fluctuations in olive production in the future. Combined with international competition and fluctuating world market prices, many producers may be inclined to follow the promises of the bioeconomy. With its aim to decouple growth from its material basis, the bioeconomy seems to fit the problems of the olive sector exactly.

The focus on biomass production and economic growth in conjunction with technological innovation clearly places the Andalusian bioeconomy on the side of biomass-focused visions, according to the classification of Meyer (2017). In the techno-political option space of Hausknost et al. (2017), the focus on growth allows for the strategy's placement in the quadrant of sustainable capital: economic growth is the primary goal of the strategy, which entails not only increasing biomass production, but further increasing value creation by refining this biomass into new, biotechnological products. These promises, paired with expectations of employment opportunities, are common in bioeconomic strategy papers. In a study, Eversberg and Holz (2020) examined the promises of the bioeconomy and found that many of them are not warranted. The material reality shows that the strongly promoted biotech sector remains largely insignificant and the primary sector (agriculture for the production of biomass) is largely stagnant, at least in the German context. Material reality also plays a key role in the work of Hausknost et al. (2017) and Giampietro (2019). Both analyse bioeconomic projects in relation to their biophysical basis and conclude that the scope of the promises exceeds the biophysical capacities of the respective arable land in question.

The information presented serves to situate the current olive sector within its recent development in terms of geographical expansion as well as production capacity and its

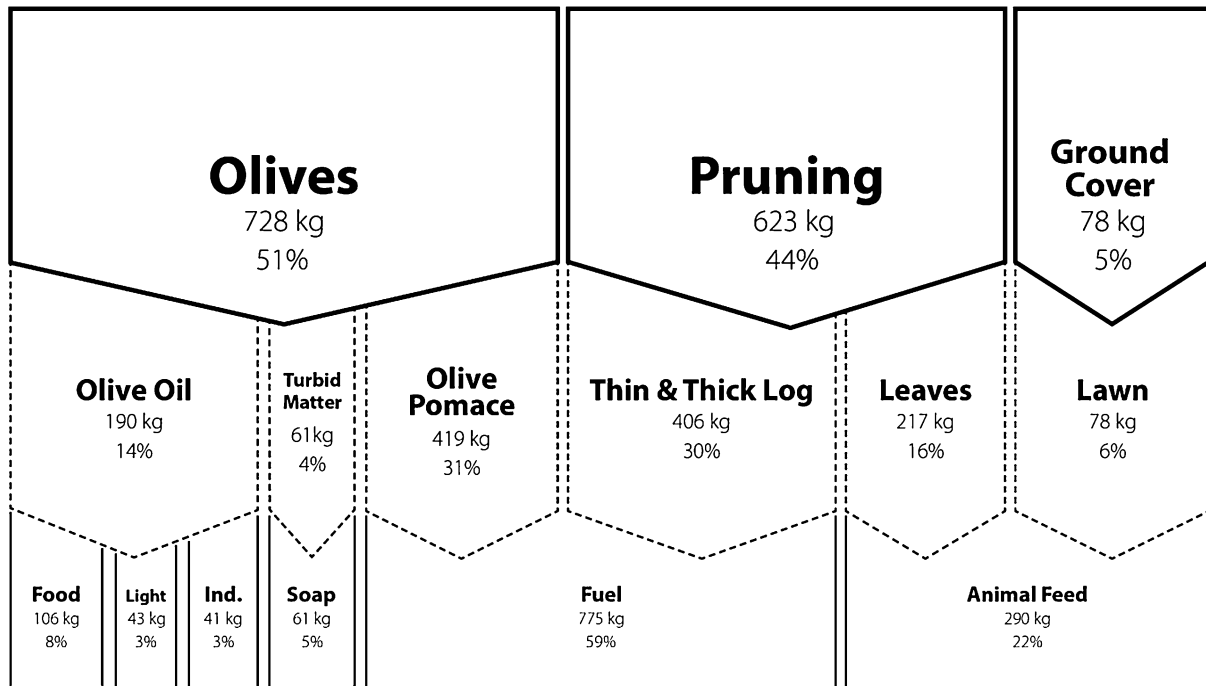


Fig. 6 Production and use of 1 ha of olives in kg/ha in Baena, 1899 (own English translation, Spanish from Infante Amate 2011)

relation to the Andalusian Bioeconomy Strategy. The latter will prove important in the discussion section below when compared with the data introduced in the following section: the historical evolution of the olive sector as subsistence agriculture.

The historical olive sector as subsistence agriculture

The production regime in the nineteenth century

Olive cultivation grew steadily in the region from the eighteenth century onwards and was initially used as part of a different productive system, namely that of subsistence agriculture in the nineteenth century. Then, olive groves were not only used for the production of oil, but were integrated into a living agriculture system providing various products for daily life and the market: olive trees were planted between grain fields to provide shade, falling branches were used as firewood and herds of animals often grazed between the loosely planted trees at that time (Infante Amate 2011).

As can be seen from Fig. 6, olives accounted for only about half of the products of an olive grove. Almost as much mass was produced by pruning, i.e. waste, and another 5% of the biomass consisted of the vegetation under the trees, which was also used. Of the olives, only a part (14%) was processed into olive oil, and only a part was used as food.

Today, some producers refer to the use of the cores for heat generation as an innovative, bioeconomic practice (Berbel and Delgado-Serrano 2018).

All the biomass produced by the groves beyond olive oil contradicts the story of the olive as *cultivo capitalizado* (so a cash crop), because these substances often served the subsistence of the farmers who cultivated the groves just as much as the actual olive trees. It is therefore assumed that the farmers in Jaén increasingly planted olives because they allowed them to produce a variety of goods. According to Infante Amate (2013), olive cultivation was also popular because it was less labour intensive than livestock or other crops. At that time, there were thousands of smallholders in Jaén. Partly outside the capitalist market, the olive spread very widely in the twentieth century (Infante Amate 2013). The history of the region's olive sector provides some evidence that the development of livelihoods related to the olive groves may have brought forth alternatives to the dominant capitalist, which is discussed in more detail in the following section.

Extensive growth and subsistence agriculture

The section essentially follows the argumentation presented by the Spanish historian Juan Infante Amate made in his 2013 publication *¿Quién levantó los olivos? La expansión olivarera decimonónica como estrategia de producción campesina (1750–1930)* (Who grew the olives? The

nineteenth century olive expansion as productive strategy of farmers (1750–1930)), in which he describes in great detail that the two systems of property, the one based on latifundia and the one based on an intact peasantry, always coexisted, while in some places the peasantry developed more and in others the number of large land owners grew.

While in parts of Southern Spain, such as in the Baena region, latifundia existed and were probably the main (but not the only) driving force behind the large expansion of olive groves at the end of the eighteenth century, an intact peasantry still existed in Jaén and other regions in the nineteenth century. There, it not only survived, but also became stronger over time (Ellis 1998). Recent trends in historical studies of the region therefore no longer seek to fathom how the peasantry was replaced in the transition to capitalist modernity, but what made this group so adaptive and resilient (Jonsson and Pettersson 1989).

Two coexisting interpretations of the role of the olive sector in different parts of Southern Spain form the basis of contemporary analysis and policy: one sees society between the eighteenth and nineteenth centuries as divided into large landowners and (landless) day labourers, with the large landowners being the driving force behind the expansion of olive cultivation (Infante Amate 2013). The other interpretation sees small farmers, who have long been able to “hide” from capitalist modernity, as the main protagonists of change in the sector (Infante Amate 2013). The story line that ‘great men’ modernised Andalusia fits well with the currently dominant narrative of the victory of capitalist modernity over backward feudalism (Infante Amate 2013). Following this line of argument, alternative modes of production that could exist outside the emerging *capitalist market* are excluded.

In the case of Jaén, the expansion of olive cultivation was closely related to the growing number of small farmers (Infante Amate 2013). In the mid-eighteenth century there were 42,000 ha of olive trees, which had grown to 200,000 ha by the end of the nineteenth century (Garrido González 2005). Between 1750 and 1850, the individual areas under cultivation increased on average throughout Andalusia. This enlargement can be explained on the one hand by the expansion of already existing groves, on the other hand by land concentration, which was, however, less pronounced in Jaén than in other parts of Andalusia. As a result, the cultivated area in Jaén was still significantly smaller compared to other provinces. This indicates that there was an intact peasantry and that the large landowners played a rather subordinate role in the spread of olive cultivation (Infante Amate 2013). By 1930, 320,000 ha of olive trees had been planted (Infante Amate 2013). During the same period, the number of landowners in the province had increased by more than 85,000.

The expansion before the beginning of the twentieth century is of great importance, because the development of new land and the larger number of landowners laid the foundation

for the sector as it exists today. During this period, the share of olives in the cultivable land also grew. At the end of the nineteenth century, a third of the total cultivated area was used to produce olives (Sánchez Martínez and Ortega Ruiz 2016).

Especially in the first three decades of the twentieth century, the area under olive cultivation increased throughout Andalusia: it grew by 46% and the production of olive oil increased by 70%. It was above all the increase in olive oil production and exports that led to this period going down in history as the *Edad de Oro*, i.e. the golden age of the olive sector (Cicuendez Cadahia and Ortega Nieto 1957).

In view of this data, it can be assumed that the designation of the olive as a *cultivo capitalizado* was only actually justified as of the beginning of the twentieth century. However, the narrative probably existed before then, possibly to emphasize the myth of modernity displacing the antiquated (‘peasant’) way of life (Infante Amate 2013).

The twentieth century

As early as the 1930s, 320,000 ha of the 550,000 ha of cultivated land in the province of Jaén were occupied by olive trees (Sánchez Martínez and Ortega Ruiz 2016). Despite numerous efforts to intensify production of the olive sector, as will be shown in this section, the degree of mechanization and irrigation remained is still low until today.

Efforts to ‘free’ the region from its dependence on olive oil after the civil war (1936–1939) with the so-called *Plan Jaén* and thereby make it less prone to crises, were futile, and the share of groves in the total cultivated area remained large. At the latest when the plan failed, it became clear that the olive had come to stay.

In the 1980s, the *plan de reestructuración del olivar mejorable y reconversión de comarcas olivareras deprimidas* (roughly: restructuring plan for olive cultivation that could be improved and the conversion of neglected olive cultivation regions) was passed, which provided subsidies for around 25,000 ha of groves in Jaén and, although it was overall about 25% smaller than its predecessor, it did not fail to have an impact: With the help of these funds and the new CAP on the European level, olive cultivation was intensified on the areas concerned, which on the one hand served as an example for other producers and on the other established the cultivation methods *intensivo* and *superintensivo* (Sánchez Martínez et al. 2011).

During this time, more and more arable land was developed, but above all, the productivity of the land was increased and the degree of irrigation steadily increased to its current size (Sánchez Martínez and Ortega Ruiz 2016). In the late 1990s, however, the available land seemed to be becoming so scarce that subsidies for the development of new groves were abolished. During this “post-productivist”

Table 2 Comparison between the historic olive sector and the goals of the current Bioeconomy Strategy (own elaboration)

	Historic bio-based economy	“New” bioeconomy
Goals	Economic subsistence, employment reservoir	International competitiveness, resource base for bioindustry
Growth model	Extensive, slow	Accelerated due to international competition, focus on R&D
Usage of products	Reusing on site, heat generation	Gasification, bioplastics, heat and energy generation
Ownership structure	Fragmented	Centralized to increase efficiency
Irrigation	Low share	Increase, increasing pressure on aquifer
Density of plantation	Very low	Increase to boost efficiency and usage of machinery

(Sánchez Martínez and Ortega Ruiz 2016) decade, no more aid was provided for groves developed after 1998. However, price guarantees remained in place. Fewer new areas were opened, but cultivation itself continued to be intensified.

In the twentieth century, numerous attempts were made to modernize the olive sector or break its dominance in the region, but overall most of those efforts failed. The olive sector, with its high number of smallholders and extensive forms of cultivation, remained in place. In the second half of the century, reforms were aimed at improving the cultivation methods of individual farmers rather than centralizing ownership and thus reducing the population's dependence on olive cultivation. In summary, the sector's development is not a classic story of capitalist accumulation, because over the last 100 years smallholder farmers have constantly resisted giving up their groves, and despite a certain degree of intensification, mostly necessary due to the increasing scarcity of land, many families have stuck to extensive forms of cultivation.

Discussion

The following section discusses the possible implications of the discrepancies between the ‘old’ and ‘new’ bioeconomy in Andalusia in the light of the various limits to growth presented in this section.

As can be seen from the data presented in Table 1 in section “[Case study: the olive oil sector in Jaén](#)”, there is not much land left for further geographical expansion, while significant areas are either not suitable for mechanization or cannot be irrigated due to the already existing shortage of water (Estévez Alcalde 2018; Contreras 2019). These aspects, combined with the declared goals of the Andalusian Bioeconomy Strategy in section “[Case study: the olive oil sector in Jaén](#)” and the previously presented data on the historical growth of the olive sector in Jaén, allow for the comparison of the two productive regimes based on their functions:

Table 2 shows that although the central function of an extensive form of production and expansion has become more and more integrated into the capitalist economy over

the last two centuries, it has remained largely the same: the reuse of various by-products of olive cultivation to fertilise the soil or generate energy, while providing a steady income and employment opportunities. Exponential growth through geographical expansion and intensification of production were either not possible or not prioritized. Ownership was divided by inheritance, leading to a fragmented landscape of small farms that serve as reservoir of employment and income opportunity. This form of cultivation could therefore be titled “economic subsistence”. The Andalusian Bioeconomy Strategy, on the other hand, recognizes the importance of the olive sector for the production of biomass: residues from olive oil production alone account for more than a quarter of Andalucía's biomass potential alone (Junta de Andalucía 2018). In order to combat climate change, the efficiency of mills needs to be improved, by-products could be gasified to produce green energy and the olive sector as such needs to undergo a process of industrialization to secure the livelihood of producers in the face of international competition and fluctuating world market prices (La Cal Herrera 2020). With the majority of the autonomous community's olive cultivation situated in Jaén, the province becomes a vital part of the bioeconomy's plans to re-industrialize the province (Junta de Andalucía 2018). The strategy does not specify exact measures for the development of its bioeconomic sector, but formulates goals that focus on economic growth, technological innovation and more efficient use of biological resources. The latter is of central importance to the olive sector, since the strategy explicitly demands an increase in biomass production to assure a steady supply of resources for its future bio-industry (Junta de Andalucía). It must be pointed out that concrete empirical data on the future bioeconomy and the future of the olive sector in general is, for self-evident reasons, difficult to obtain. The argument to be made in this paper is that there are already differences at the conceptual level between the functions of the olive sector as a historically developed economic sector and the future goals of the Andalusian Bioeconomy Strategy, and that these differences are not only rooted in a different perspective on how the well-being of Jaen's population can be maintained in the face of international competition, climate change, demographic trends and other issues, but also

in concrete, biophysical limits like the available arable land, the topography of the region and its water resources:

1. Between 37 and 50% of current olive groves cannot be mechanized due to geomorphological reasons. The remaining half is suitable for further intensification; however, due to the already existing water shortage in the region, the potential for transforming traditional olive groves, which currently account for over 90% of Jaén's groves, into *intensivo* or even *super intensivo* is limited (Estévez Alcalde 2018; Canal Sur 2022; Mudarra 2021).
2. The fragmented ownership structure of the sector, combined with a high variation of different qualities among farms impedes mechanization. As Sanchez Martínez and Gallego Simón (2011) note, land concentration or a concentration of management is central to an intensification of olive production, also because around 80% of farmers do not engage in full-time olive cultivation.
3. As previously mentioned, olive cultivation was performed under a different premise than economic growth and technological innovation. Changing this function to compete with an innovative, growing economy might clash with its historical (and current) function as employment reservoir and additional income in times of crisis.
4. Moreover, the bioeconomy's focus on biotechnology, research and development (R&D) and growth further fails to recognize the high degree of "integral use" of all products of a grove that has been practiced for centuries, as exemplified in Fig. 6. Making use of sufficient and sustainable practices today under a different name is not wrong per se—if it can accomplish what it sets out to do.

The above-mentioned interviews can shed further light on potential conflicts: While the interviewed producers were mostly full-time farmers, most do not cultivate land of more than 20 ha. Their opinions differed significantly from the positions of larger producers on modernization and what is considered an ecologically sound practice: hardly any of the small producers had heard of the term "bioeconomy" in conjunction with the olive sector and some expressed opposition to the idea of extracting biomass for the production of industrial goods, instead of leaving the by-products in the groves, thus achieving a truly circular economy. The central finding of the conducted interviews, at least regarding the relationship between the "old" and "new" bioeconomy is that until now, the Andalusian Bioeconomy Strategy is hardly recognized among farmers, especially smallholder farmers. It is important to note that those interviewed are supposedly still more involved in the development of the agricultural sector than the vast number of people who have less than 20 ha and

are not full-time farmers, but even they either do not know of the bioeconomy or are sceptical of it. Bioeconomy as a concept has been present in the discourse on the olive sector for several years, but mostly through the works of La Cal Herrera (2014, 2020) and in conjunction with related works on the future of the sector (Cárdenas García et al. 2018). However, the connection between a distinctive bioeconomic policy and the day-to-day reality of smallholder farmers, has yet to be established. It is important to recognize that the bioeconomy as political strategy is something new in the sector and that it will prove to become more important in the years to come. Farmers, regardless of the number of ha they cultivate, will have to familiarize themselves with this concept in order to be able to influence its overall direction, because a bioeconomy is, by no means, sustainable by definition. It has to be controversially discussed and actively shaped by all involved parties to achieve its supposed goal of economic and ecological sustainability, both of them necessary to secure the future of the olive sector.

Another finding of the interviews is that large land-owners were more often in favour of reforming the olive sector's fractured ownership structure in favour of land concentration and intensification, while smallholder farmers considered a higher valuation of their product as the most viable way to secure their livelihoods in the future. However, the sector will evolve, it is certain that it will have to adapt to a changing world (market) and society, where international markets put increasing pressure on local producers, ultimately causing youth to leave the region in search of better employment opportunities. Further, the future of the CAP is by no means certain, and while it has preserved the sector for over three decades, uncertainty about the EU's future policies may be contributing to the current emigration trend. In fact, another insight from the interviews is that low prices for olive oil and the future of European subsidies are central concerns for olive farmers, again with differences according to socio-economic background. While all groups are critical of some aspects of the CAP, the aspects criticized differ: Large land-owners are sceptical of subsidies that keep inefficient production methods alive, while smallholder farmers often mentioned that the CAP would disproportionately favour large land-owners.

All these factors lead to the conclusion that there must be changes in the olive sector if it, and thus the province of Jaén, is to have an economic future. Producers are aware of this as well: most of the stakeholders interviewed claimed that due to climate change, volatile world market prices for olive oil, the dominance of oil retailers and the dependence on European subsidies are concerns for producers. As indicated by the average size of exploitations, most groves are managed extensively and have been in family hands for decades or longer, according to the producers interviewed. Therefore, olive cultivation has a high sentimental value that goes beyond calculations

of economic viability. The Andalusian Bioeconomy Strategy promises to re-industrialize the region by not only increasing production of biomass, but by further refining agricultural products in the region in addition to increasing demand for these new, locally produced, biotechnological goods. It could therefore contribute to solving the issue of obsolescence and emigration by creating new jobs while maintaining a high demand for biomass that could guarantee better prices for products from olive groves. However, while the bioeconomy strategy might succeed in increasing productivity in some areas and retain the added value of locally produced goods from cascading usage of resources, all of which would contribute to the region's economic development, the above-mentioned biophysical limits and limits to intensification will be reached eventually. These limits are not identified by the bioeconomy strategy, so it falls in line with other European strategies that aim to decouple economic growth from its biophysical basis—a promise that is impossible to fulfil. Further, a policy focused on economic growth might jeopardize the social function olive cultivation has maintained during the last century: an olive grove is seen as a reservoir of employment and a small, yet secure income. Groves, according to the producers interviewed, often have a strong emotional value, which is why selling them or handing over management to bigger producers is not a viable option for a number of farmers. Sanchez Martínez and Gallego Simón (2011) already argued in favor of political support for farmers and cooperatives that do not solely focus on economic growth, but rather fulfil a socio-economic function by keeping traditional, small olive groves alive. They deem public support in form of subsidies and laws for the recognition of the social function of extensive olive cultivation, like the *Programa de Desarrollo Sostenible de Andalucía* (2010–2014) (Program for Sustainable Development in Andalucía), to be necessary (Sanchez Martínez and Gallego Simón 2011). Otherwise, the conversion of the productive system could aggravate tensions in the social fabric of the regions and spark conflicts between farmers that are economically able and willing to modernize and mechanize their exploitations, on the one hand, and small-holder farmers that want to preserve their groves in order to retain at least a small additional income and their family's property, on the other. For both parties, European subsidies will remain a crucial pillar for their continued economic existence in the foreseeable future and the promised bioeconomic industrialization that would end this dependence is yet to come, if it can be achieved at all.

Conclusion

The aim of this paper was to assess the relationship between the historically grown olive sector in the province of Jaén and the current regional bioeconomy strategy, and furthermore to analyse, what biophysical limits exist for the 'new'

bioeconomy and what effects these limits might have on the sector.

The extensive growth of the sector has reached its biophysical limits in several respects: the available land is limited since most areas are already occupied by olives and the terrain of the province limits efforts to continuously mechanize production. Despite comparatively low yields, the traditional way of cultivation is kept alive through subsidies from the EU's CAP. The Andalusian Bioeconomy Strategy, on the other hand, aims to reduce the sector's dependence on subsidies by increasing efficiency and diversifying production through technological innovations to then better compete on international markets. The 'old', subsistence-based bioeconomy is thus at odds with the new, growth-oriented bioeconomy. While something has to change to combat emigration and demographic change in the region, it remains questionable whether a fundamental change in the sector's productive regime in favour of increased biomass output will help combating issues such as emigration, demographic change and unemployment or rather trigger new and different conflicts.

At this stage, it is difficult to predict the olive sector's future, yet a look at its historic development in conjunction with current political strategies can reveal possible social conflicts between different forms of the bioeconomy. Ultimately, producers will decide whether adopting the proposed measures will improve their situation. For future research, it will prove fruitful to assess local producers' knowledge of the bioeconomy and their expectations for the development of the sector. Further, the role of the CAP proves to be of major importance to the region's economic stability. Closer monitoring of its development and producers' opinions on the subject are crucial for analysing developments in the sector in the coming years.

Acknowledgements The work for this paper was funded by the German Federal Ministry of Education and Research as part of the work of the junior research group 'Mentalities in Flux' (flumen) (2019–2024, Grant Number 031B0749).

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest The author (Philip Koch) reports no conflict of interest.

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