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The sustainability
of agricultural
intensification
in the early
21st century:
insights from the
olive oil production
in Alentejo
(Southern Portugal)

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INTRODUCTION

Widespread consensus has emerged around the importance of further agricultural intensification, if the nutritional requirements of the ever-expanding global population are to be met (FAO 2017). Mainstream models of agricultural intensification, closely linked to specialization, have proved to have a strong impact on the environment while also disconnecting agriculture from rural communities (Woods 2011; Primdahl and Swaffield 2010). Climate change and increasing urbanization pressures add urgency to the challenge of ensuring global food security without compromising the sustainability of social-ecological systems.

Calls for sustainable forms of agricultural intensification are frequent in policy and scientific circles (Garnett et al. 2013; Lima Santos 2017). Yet, what constitutes sustainable intensification remains contested, with a range of weak to strong sustainability concepts depending on, for example, uses of technology, synthetic inputs, and local ecological knowledge (Horlings and Marsden 2011; Rockstrom et al. 2017).

In the Portuguese context the Alentejo region seems to be undergoing a process of rapid agricultural intensification, despite its dry Mediterranean climate and a tradition of extensive, multi-functional agricultural systems. This has been fuelled by local, national, European, and global factors and processes, in close alignment with the dynamics of urban-financial capitalism. Specific drivers include a long-standing public investment in the Alqueva irrigation system, national and EU agricultural policies, and recent strategies of financial investment in agriculture-related assets, especially since the 2008 global financial crisis. Although the two modes of production continue to coexist in the region, the transition from a long lived model of extensive agricultural production toward a predominantly intensive mode of agriculture has been extremely fast.

The chapter addresses the sustainability of the ongoing agricultural intensification and financialization processes. We explore how this is taking place in the area of influence of the Alqueva irrigation system since 2002, when the system's main dam was completed. We focus on olive oil production, which in 2017 occupied 57% of the newly irrigated land (EDIA 2017). The process of agricultural intensification in southern Portugal is relatively new, and there is an urge to better understand its contours, mechanisms, and potential implications.

On this basis, we focus on the emerging actor-networks and explore their implications for the making of sustainable rural places, particularly place-specific interdependencies between economy, community, and ecology (Marsden 2013; Ferrão 2016). To operationalize the notion of network and adjust it to the study of agri-food systems, we adopt the broader notion of actor-network proposed by Latour, previously employed in studies of food governance and its political economy (Stuart 2010) as well as in research on land degradation in Southern Europe, including Portugal (Wilson and Juntti 2005). As emerges from our case study, we are witnessing the constitution of new heterogeneous networks composed of both social (individuals, organizations, rules in use) and material elements (e.g. technologies, infrastructures, genes, olive tree varieties, fungi, fauna). This notion of actor-network acts, in our case, as entry point to understand rapid change in economy-community-ecology linkages in rural places undergoing agricultural intensification.

Our vision of sustainability is premised not only on the original social, economic, environmental, and institutional requirements of the concept (WCED, 1987), but also on the requirements of social-ecological resilience (Folke et al. 2016), often reaffirmed in the face of the challenges posed by both climate change and “planetary urbanization” processes (Merrifield 2013). In addition, our analysis is informed by a geo-historical approach that considers the economic, social, and environmental legacies of past agricultural modernization processes, and their implications for the present and the future. Our guiding questions are:

- What new actor-networks have emerged in the process of agricultural intensification associated with the Alqueva irrigation system, particularly in relation to olive oil production?
- How are new actor-networks relating to local communities? How are new actor-networks dealing with key public environmental goods such as soil fertility, water quality, and biodiversity? Are new actor-networks helping to link economy, community, and ecology in the region?
- What risks can emerging actor-networks present for sustainability in the region under the influence of the Alqueva dam?

The findings presented here combine research results from three different projects: (i) an individual post-doctoral project (2016-2019) on non-point source pollution, spatial politics, and adaptive governance in the Guadiana

river basin, financed by the Portuguese Foundation for Science and Technology (GuadianAdaptativo)¹, (ii) an EU-wide project (2015-2019) on Sustainable Finance for Sustainable Agriculture and Fisheries (SUFISA)², and (iii) an inter-university research project (2015-16) on Municipal Adaptation Strategies for Climate Change in Portugal.³

Research methods employed are of qualitative nature, primarily semi-structured interviews (20 considering all projects), focus groups (3), participatory workshops (2), media content analysis and analysis of primary sources such as legislation, plans, statistics, and policy documentation. Further detail is provided in Table 10.1. These provide a rich set of primary information, allowing more opportunities for triangulation of information from different sources. We have overcome the absence of a single line of enquiry planned *ex-ante* by focusing on the knowledge emerging from consistent overlaps, and mutually beneficial insights, revealed in a structured *ex-post* analysis.

The remainder of the chapter is organized as follows. The first section reviews literature on key approaches to the challenge of sustainability in agriculture, including that of sustainable intensification, and connects those approaches to enabling financial and scientific processes. In part II we introduce key conceptual and analytical tools for a geo-historical analysis of sustainability in rural places. This is followed by an overview of the trends of intensification of olive oil production in the Alqueva irrigation system and some of its drivers. Part IV describes the novel actor-networks emerging from the intensification of olive oil production in the Alqueva irrigation system, while part V discusses some of the social and ecological implications of this recent phenomenon. In the conclusion we review and discuss key findings, and share recommendations for both public policy and further research.

1 <http://www.ics.ul.pt/instituto/?ln=eandpid=255andmm=5andctmid=2andmnid=1anddoc=31809901190>.

2 <http://www.sufisa.eu> (H2020-Project Number: 635577).

3 <http://climadapt-local.pt/en>.

Table 10.1 *An overview of the research methods employed*

METHOD/ TECHNIQUE	NUMBER OF PARTICIPANTS	TIME OF DATA GATHERING	DATA ANALYSIS	DATA SOURCE
Media Analysis	none apart from SUFISA researchers	Data collected between September 2015 and May 2017, covering the period between 2002 and 2017	Content analy- sis using NVivo software, using the keywords (in Por- tuguese): Intensive, Super-Intensive, Olive Oil, Sustain- ability, Resilience, Intensification, Production, Export, Invest- ment, Irrigation, Environmental Impact.	9 internet portals, 5 specialized journals, 4 daily newspapers, and 3 professional newsletters
Semi- -structured interviews	20 participants from government organizations; farmer Associations; Agri-business managers; Academic institutions; and Non-Governmen- tal Organizations	Interviews conducted between 2015 and 2017	Transcriptions of recordings; notes of the rapporteur and thematic coding of common issues	ClimAdapt.Local interviews (N=2) in 2015, SUFISA interviews (N=10) in 2016, and Gua- dianAdaptativo (n=8) in 2016 and 2017
Focus Groups	3 focus group discussion with 3 to 5 participants following Intensive, traditional or mixed production methods	September 2016, March and June 2017		Focus groups conducted under the SUFISA project
Workshops	Workshop 1 - 36 participants from Governmental institutions at the National, Regional, Municipal, and Parish levels (26%); Civil Society Organizations (22.2%); Public universities and Regional Research Centres (22.2%); Private companies (11.1%); Other local experts and leaders (18.5%) Workshop 2 - 15 participants from Independent Farming businesses (20%), Regional governmental organizations (33%); farmer Associations, and Professional and Technical Lobbies (33 %); and Non-Governmental Organizations (24%)	Workshop 1 - November 2015 Workshop 2 - September 2017		Workshop 1 conducted under the project ClimAdapt.Local Workshop 2 conducted under the SUFISA project

GETTING MORE OUT OF OUR LAND: THE DEBATE ON THE INTENSIFICATION – FINANCIALIZATION – TECHNOSCIENCE “VIRTUOUS CYCLE”

There is a lively debate in both policy and scientific circles about new pathways for sustainability in agriculture (see Levidow and Papaioannou 2012). We follow and complement Marsden's (2012) conceptualization of two polarized visions: on one side the bio-economy, which is the dominant paradigm of agricultural modernization and arguably espouses a weaker conception of sustainability; on the other the eco-economy, which embraces a holistic, stronger view of sustainability that is firmly embedded in agroecological knowledge.

In general terms, bio-economy refers to all economic activities that produce, manage, or exploit biological resources. Its objective is to transform production through bio-economic processes such as genetic engineering, while mobilizing scientific knowledge from a diverse set of disciplines such as veterinary medicine, food sciences, engineering, and industrial biotechnology (Marsden 2013, 217–218). Allowing living things to become appropriated and patented through genetics and genomics fits well with the current urban-financial form of capitalism (Busch 2010, 339).

In contrast, the eco-economy paradigm incorporates a stronger, more ambitious interpretation of sustainability in agriculture. Rather than intensifying the use of technological inputs, eco-economy strategies and practices seek to intensify the ecological processes that underpin long-term agricultural productivity, promote soil fertility, and conserve water and organic matter. Under the eco-economy paradigm knowledge about local agro-ecologies is integrated in processes of scientific knowledge co-production to provide local and regional food security solutions.

Table 10.2 provides a summary of distinctive features of bio-economy in opposition to eco-economy. This provides an idealized typology that is best interpreted as a heuristic model, presenting the two extremes of a continuum in which more or fewer hybrid realities may be identified across regions and agricultural systems.

In terms of economic gain and control, the bio-economy paradigm both fuels and benefits from the financialization of agriculture, providing urban-financial capitalism with a new opportunity to expand its sphere of intervention from the global to the local, the individual and, more recently, to the gene. In the context of world agriculture, Busch (2010) describes financialization as “the

tendency of financial markets to dominate and for financial organisations to dictate conditions to those organisations involved in production” (Busch 2010, 337). In the context of agribusiness and trade in agricultural commodities, financialization has given way to the rise of commodity trading companies and a stark increase in the use of commodity derivatives (financial products that enable risk to be transferred, effectively allowing speculators to gamble on the future behaviour of key variables in agro-food systems). This makes the performance of the financial markets more important than real trade in agricultural goods.

Table 10.2

A comparative characterization of two competing paradigms for sustainability in agriculture

DIMENSIONS	THE BIO-ECONOMY PARADIGM	THE ECO-ECONOMY PARADIGM
Economy	Long-distance control, short-term decisions	Place-based agri-food networks
	Productivity increase through technology-oriented science	Productivity increase through “intensification of ecological processes”
	Mono-culture	Multi-functional agriculture
	Typical actors – large corporate and financial actors	Typical actors – farmer cooperatives, small to medium size family firms
Technology	Technology development driven by corporate actors/ high-tech suppliers	Technology development as a demand driven process
	Reduced role of the state in setting research agendas	Local and traditional knowledge contributing to set research agendas
Socio-cultural	Sense of dependency	Sense of autonomy
	Loss of agricultural employment	Labour and skills intensive
	Instrumental relationship between humans and nature	Multiple synergies between society and nature
Ecological	Ecological and genetic engineering	Agro-ecological principles emerging from specific socio-ecological contexts
	Lab based experimentation and field trials	Knowledge co-production and dissemination
Spatial	Globalized/export-oriented/use of external factors of production/“space of flows”	Locally embedded/use and conservation of local resources/primarily a “space of places”

Own elaboration, adapted from Marsden (2012), and complemented by the authors based on Busch (2010), Levidow (2012), and Primdahl and Swaffield (2010).

The financialization of agriculture has been facilitating the phenomenon of farmland concentration in the European context. Following the 2008 global financial crisis, farmland gained renewed importance as a commercial asset and a new category of investors emerged. Adopting a strategy of “portfolio diversification”, a number of European banking groups, pension funds and insurance funds have created specialized agricultural investment funds, with a view to invest in farmland, spread risk, and profit from a boom in agricultural commodity prices (Van der Ploeg, Franco and Borrás 2015). As Ferrão (2016) notes, there should be particular concern with farmland concentration; the expansion of the bio-economy paradigm; and the extent to which the first is paving the way for the second.

TOOLS FOR A GEO-HISTORICAL ANALYSIS OF SUSTAINABILITY IN RURAL TERRITORIES

The “social” constructs the “spatial” in multiple ways (Jessop et al. 2008). Notions of place, for example, emerge out of a common sense of attachment, proximity, identity, strong social relations, and local differentiation. They constitute a specific set of socio-spatial relations and result in spatial identities that, in the case of Alentejo, often link local and regional identities to multi-functional agricultural landscapes with high ecological value, such as traditional olive groves (Gómez-Limon and Riesgo 2012). Naturally, notions of place are highly dynamic, particularly under urban-financial capitalism and agricultural intensification.

Our analysis is empirically grounded on the observation of emerging actors in the sphere of agricultural production, which, by enrolling new market institutions, technologies, plant varieties, specific types of scientific knowledge, and labour, often of foreign origin, are decoupling agricultural production from its underpinning social and ecological systems. Our departure point is therefore the change in the nature of actor-networks, while our final target is the changing notions of place, particularly via processes of de- or re-territorialization (Ferrão 2016). The notion of territorialization refers to the spatial embeddedness of an economic activity in a given place, within local knowledges, place identities, and regional ecologies. It occurs therefore in the presence of strong and mutually reinforcing linkages across the economy-community-ecology triangle. The concept relates to an interpretation of

sustainable rural places such as those that are territorialized, i.e. well-rooted both socially and ecologically (Baptista 2011; Marsden 2013; Ferrão 2016).

The recent Portuguese geo-history holds key information about the dynamism of economy-community-ecology linkages in the Alentejo. The region witnessed a state-led process of re-territorialization between the 1880s and the 1950s, when vast portions of bushland were cleared for agriculture, and the multifunctional agricultural landscape gained prominence. Its core drivers were the construction of new transportation links (roads and railways) to national and international markets; the availability of chemical fertilizers, allowing sufficient productivity in poor soils; and, most importantly, a large scale campaign (1929-1935) to promote wheat production (Roxo 2000). In effect, the Alentejo was assigned the role of the nation's breadbasket.

Unfortunately, the soils of the region were (and remain) too poor to fulfill this political assignment. The ecological consequences of this re-territorialization trend were serious and were visible in the depletion of organic matter in soils (Roxo 2000). This less visible process of environmental degradation must be seriously considered when assessing the sustainability of current policy and market incentives for agricultural production in this region.

Following this first period, the expansion of urban-industrial capitalism in the period from the 1950s-1980s introduced, according to Ferrão (2016), new trends that destabilized previous links between economy, community, and ecology, namely:

- ecological decoupling, as new technical and scientific knowledge made baseline environmental conditions considerably less relevant;
- sociocultural decoupling, through which progressive urbanization stimulated the dissemination of urban values and discouraged those associated with rural ways of life;
- institutional decoupling, in which a command-and-control administration system devalued or dismantled proximity-based decision-making mechanisms such as neighbourhood councils;
- functional integration of the rural into the sphere of the urban, as a result of a decrease in agricultural employment, urban-industrial expansion, and greater rural-urban mobility.

In the late 1980s a second round of urban-industrial capitalism expansion started in Portugal, triggered by the country's entry into the European Union

(then European Economic Community). New visions and narratives sought to bring about a post-agricultural rural in which socio-cultural and ecological identities are adequately valued (Ferrão 2016). These are having a limited impact, however (Figueiredo 2011).

The trend of agricultural modernization continues, particularly in rural areas with: (i) predominantly medium and large properties; (ii) adequate climatic conditions and access to natural resources (e.g. water), especially those with irrigation infrastructure; (iii) better connections to larger consumption centres. The first two conditions are particularly obvious in the Alqueva region. In general, current agricultural modernization in Portugal is leading to further de-territorialization (Baptista 2011; Ferrão 2016), driven mainly by the intensification of agricultural production and mechanization and by a continued process of depopulation, ageing, and migration.

Ferrão (2016) notes that a bio-economic approach to agricultural modernization tends to aggravate de-territorialization. While well-resourced economic agents use highly sophisticated scientific knowledge to construct an artificial “nature” on an industrial scale, links with local communities are also very weak or non-existent (Marsden 2012).

Throughout the chapter, the analysis of the geo-historical process of de- or re-territorialization is aided by an investigation of the assembling and reassembling of actor-networks, inspired by Latour’s Actor Network Theory (1999), and its application in agri-food systems research (Stuart 2010). We therefore define actor networks as heterogeneous networks comprising social and institutional elements and enabling material/technological elements. Nevertheless, we add emphasis to the role of social power and asymmetries in social power, which we see as constitutive of social constructions of space.

INTENSIFICATION OF OLIVE OIL PRODUCTION IN THE ALQUEVA IRRIGATION SYSTEM: TRENDS AND DRIVERS

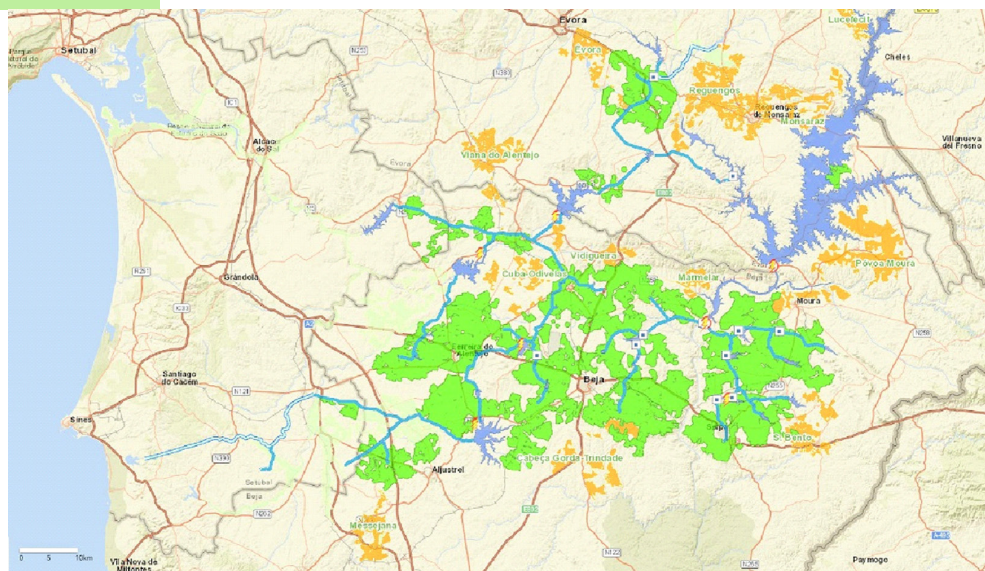
The Alqueva dam and irrigation system is located in Alentejo, southern Portugal. In administrative terms, the Alentejo comprises 47 municipalities covering an area of 31,551 km² representing a third of the total area of the country. The region is well known for its characteristic rolling plains and flat landscapes. It is characterized by a Mediterranean mesothermic climate with

hot summers (Aug 31–32°C Tmax) and mild winters (Jan 6–7°C Tmin) and total mean rainfall value of approximately 600–750 mm per year, with the rain falling mainly during autumn/winter and early spring (IMP 2008). The population density of the region has been continuously falling over recent decades, and in 2014, it stood at 23.2 inhabitants per km², while the national population density was 111.8 inhabitants per km² (INE 2018).

The construction of the Alqueva dam was concluded in 2002, when the infrastructure was effectively established and the reservoir began to fill. It currently represents the largest artificial lake in Europe, with 4,150,000,000 m³ of water storage capacity. Despite recent historic drought records it was at 70% of its capacity in November 2017. The first irrigation blocks became operational in 2004 and in 2015, 117,666 hectares were covered by the infrastructure (EDIA 2016). Figure 10.1 shows the Alqueva irrigation system, including both the first stage of the project concluded in 2016, covering up to 120,000 hectares, and the second stage that will add 49,427 hectares to the system in the period between 2018 and 2022 (Agência Lusa 2017).

Figure 10.2 shows how olive groves expanded and areas benefiting from the water provided by the Alqueva irrigation system. In 2017, the percentage of

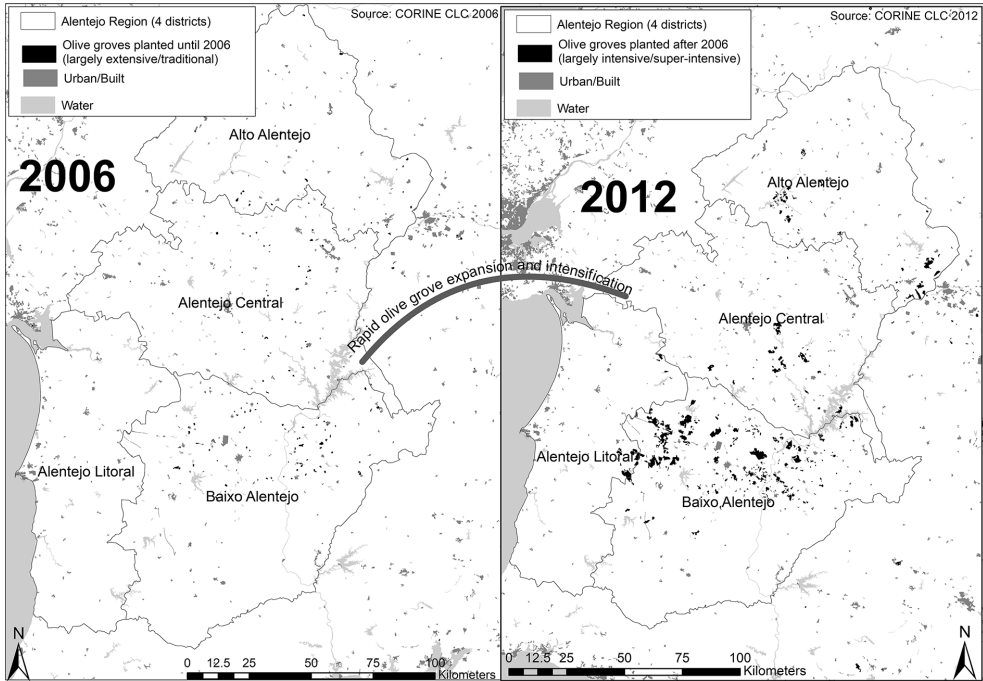
Figure 10.1 *Map of the Alqueva irrigation system*



Source: www.edia.pt.

Figure 10.2

Map of the olive grove expansion and intensification in Alentejo between 2006 and 2012.



land used for irrigated olive groves (intensive and super-intensive plantations) was 57% in the Alqueva area of influence, with the second most popular crop (almond groves) covering less than 10% of irrigated land (EDIA 2017).

Marques (2015) has shown a 20-year trend toward intensification, specialization on commodity production, and professionalization of workforce, noting that the turning point was the start of the operation of the first Alqueva irrigation blocks in 2004. Figure 10.3 illustrates the contrast between traditional and 21st century olive grove landscapes

Information from media analysis, semi-structured interviews, and focus groups identifies a general shift in the system, involving the emergence of new investors and a wider variety of crops, which is also visible in the olive oil sector. We handpick some signs of this trend: (i) PepsiCo investment in peanut production; (ii) multi-nationals with foreign HQ contract local farmers for vegetable provision (e.g. onion), determining which seeds or production inputs (i.e. fertilizers and pesticides) to use; (iii) English companies make

Figure 10.3*10.3a — A traditional olive grove.**10.3b — A super-intensive olive grove.*

contracts for the production of poppy in similar manner; and (iv) the largest retailer and distributor company in Brazil buys olive oil from new super-intensive olive tree plantations.

Regional statistics for Alentejo show an increase in both olive grove area and olive oil production. In 1998 olive groves occupied an area of 144,759 hectares (22,238 of which were irrigated). In 2015 olive groves occupied 169,869 hectares in the region. Among these, 49,026 hectares were irrigated and 31,128 were located in the Alqueva irrigation system (INE, 2015; DRAPAL, 2015; EDIA 2016). Naturally, this radical change was translated into litres of olive oil produced: from 118,000 hectolitres in 1998 to 866,204 hectolitres in 2015, with an exponential shift after 2008. As a result, national statistics from 2015 show that the country is now able to satisfy internal demand and has become net exporter of olive oil (INE 2015).

In general terms, between 1999 and 2009 the number of farms with over 100 hectares of agricultural land in the Alentejo has increased, while all other categories of smaller size farms have declined (INE 1999 and 2009, in Marques and Carvalho 2017, 28). In the case of olive oil production, and the evolution of the number and size of farms dedicated to this production between 1999 and 2013, statistical data show that the number of farms with more than 100 hectares has increased significantly (from 136 to 250), with a decrease in the number of all other smaller size farms (INE 2015; DRAPAL 2015). The traditional farm structure in olive oil production, with a majority of smaller size farms and few properties with more than 100 hectares, is therefore undergoing rapid change, particularly in areas with access to irrigation.

PUBLIC REGULATORY FRAMEWORK, POLICY, AND INVESTMENT

The most cited national legislation concerning land use for olive oil production is *Decreto Normativo 1/2002*, approved by the Ministry of Agriculture, Rural Development and Fisheries, forbidding, in principle, the destruction of existing olive groves without public permission. A recurring reference in focus group discussions was the often granted permission to replace old groves with imported fast growth/high yield olive tree varieties such as Arbequina.

The public company – EDIA – manages the Alqueva Multi-Purpose Project, charging irrigation water and irrigation conservation fees according to national legislation. Payment of conservation fees is compulsory for all landowners in the system, regardless of whether they choose to irrigate or not. The irrigation conservation costs make intensification capacity more dependent on access to capital or credit (EC, 2014; Fragoso and Marques, 2009). The cost of Irrigation Conservation Fees (55 Euros/hectare for water provided with higher pressure and 20 Euros/hectare for water provided on low pressure in November 2017) is a significant driver for smaller farmers to sell to private investors/companies interested in large-scale intensive farming. According to discussions during focus groups, Alqueva is driving a “true agrarian reform”, giving the land to those who want to farm it, i.e. those who want to farm it intensively.

At the same time, low water prices are granted to all to promote competitiveness of the agro-business in the region. In April 2017, a cross-ministerial decision (Despacho 3025/2017) was taken to lower the prices of irrigation water by 20% for farmers using water in high pressure and 33% for farmers using water in low pressure. This represents a *de facto* increase in the public subsidy awarded to all farmers in the irrigation system. A state-led policy of irrigation expansion oriented to agricultural exports is therefore an important driver of intensification and financialization of agriculture in the newly irrigated lands of Alqueva.

In addition, a food sovereignty argument seems to be a complementary driver. Both media and policy-makers emphasize the fact that Portugal is now self-sufficient in olive oil, and that a national surplus is enabling exports. This analysis was contested by some focus group participants, who argued that most olive oil produced in Portugal is exported (that with the best quality) and most of the olive oil consumed in Portugal is imported (that with lower quality). This is confirmed by Freire (2017).

While subsidies from the European Union Common Agricultural Policy (CAP) are decisive for extensive olive oil production businesses, intensive producers consulted argue that CAP subsidies are simply a welcome bonus. The latter rely on large scale exports of olive oil, sold in bulk and treated as a commodity rather than a differentiated high-quality product. Nevertheless, interviewees and focus group discussants highlight that CAP support to large-scale intensive producers is still larger in absolute terms. These producers have greater capacity to prepare applications and meet complex subsidy requirements than smaller or traditional producers.

PRIVATE INVESTMENT

A clear indicator of the influence of corporate agricultural businesses in the Alqueva system is the fact that between 2009 and 2013 corporate farm ownership in Alentejo increased by 33% and fell 10.6% in the case of individual producers (Marques and Carvalho 2017). Interviewees and focus group participants confirmed that the large majority of new investments in olive oil production are being carried out in the Alqueva irrigation system.

Both media and academic literature indicate that the development of intensive olive groves is expensive and strongly associated with foreign capital investment (Pires 2012; Pires and Neves 2013). Our media analysis revealed that the majority of actors in the intensive and super-intensive olive oil business aim for maximum agro-industrial competitiveness; highest possible levels of production (intensification and upscaling); technological innovation (irrigation, crop and soil protection, harvesting and transformation); large-scale marketing with limited information on product specification; and financialization through, for example, alliances with risk investment funds. A paradigmatic example is Sovena and its joint venture with the venture capital company Atitlan Alpha, seeking to buy farmland and olive orchards. The company owns approximately 10,000 hectares of intensive and super-intensive olive groves spread across 57 properties (Crespo 2010) and two large olive oil processing mills. Overall, our media analysis revealed that the benefits and advantages of intensive olive oil production for rural development permeate the media with little discussion about alternatives, disadvantages, or unintended consequences.

THE ACTOR-NETWORKS EMERGING FROM THE INTENSIFICATION OF OLIVE OIL PRODUCTION IN THE ALQUEVA IRRIGATION SYSTEM

This section identifies and characterizes the core elements and dynamics of actor-networks associated with intensive production of olive oil in the Alqueva system. Figure 10.4 provides an abbreviated illustration of these elements. Regarding the social elements of these networks, related agri-businesses tend to be managed by young highly specialized managers and technicians, many of whom are foreign to the region. In order to cover demand for cheap workforce, unskilled staff are sourced by employment agencies in Eastern Europe, Nepal, and Thailand for short periods of time.

To allow mobilization of financial resources, some of these new producers have created partnerships with venture capital funds (e.g. the Spanish firm Atitlan Alpha) (Crespo 2010), and/or received support from investment funds (Caixa de Crédito Agrícola; Santander). Intensive olive oil production requires a high level of initial investment and is feasible only for those with access to sufficient financial capital. As to state-led organizations, EDIA plays the main role in implementing and charging water and irrigation conservation fees, mediating access to fundamental factors of production – water and the set of technologies and infrastructures that distribute it to each of the farms serviced. This irrigation infrastructure is operated and monitored in real-time.

In close association with the Alqueva project, the Operational Centre for Irrigation Technologies (with the Portuguese acronym COTR) was created in 1999 with the aim of promoting regional development through irrigated agriculture. It constituted the only instrument of the Portuguese state to promote collaboration and knowledge dissemination amongst farmers and agri-businesses adopting irrigated agriculture. COTR is a non-profit association, fully funded by the Portuguese Ministry of Agriculture and Regional Development until 2015, involving EDIA, a range of farmers' associations, regional municipalities, and universities. It operates on a project basis according to the priorities of its associates, and currently focuses on water use efficiency and related technological solutions.

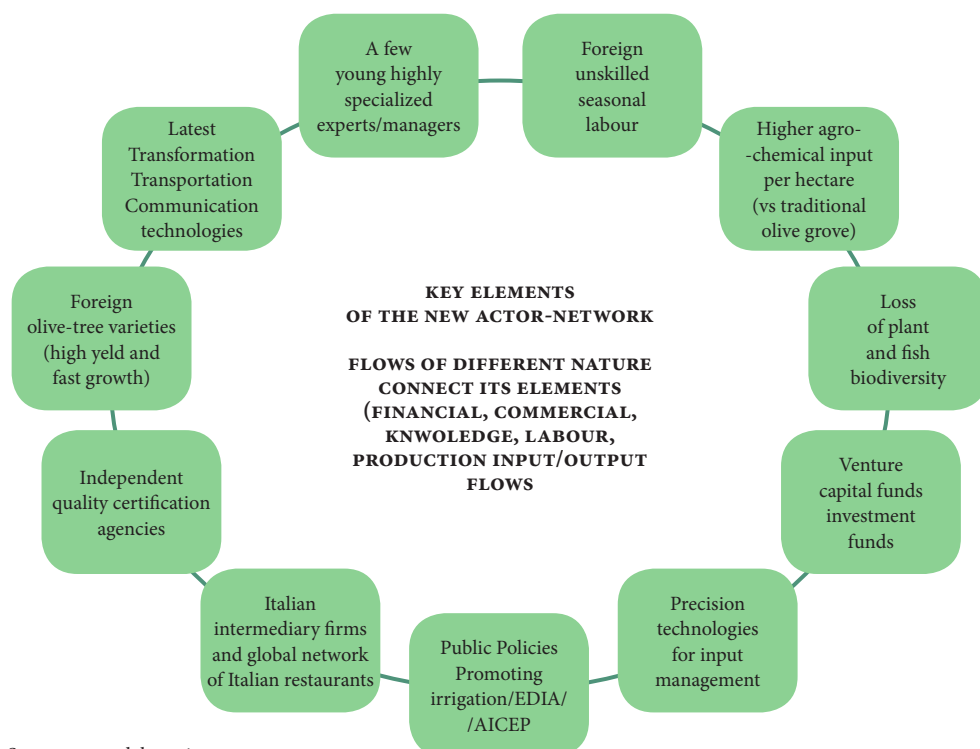
The Portuguese government agency aiming to promote trade and attract foreign investment (AICEP) also plays an important role in facilitating financial flows underpinning intensive olive production. Bottling of bulk olive oil and distribution to retailers and consumers worldwide are often done by Italian and Spanish intermediary firms selling to their network of Italian restaurants

and Spanish shops worldwide. Italian traders, for example, mix, bottle, and commercialize Portuguese olive oil using labels “Italian produce of EU origin”. Italian agents compete on the ground for access to Portuguese olive oil, which they generally consider of good quality. Before being able to sell to Italian intermediary firms, a certification of the product quality is required; this process is carried out by independent certification agencies (e.g. Agricert or Certis) set up in the Alentejo. Intensive producers are closely aligned with large-scale market operators and distributors (DRAPAL 2015).

The most striking material component of the new actor-network is the dominance of new varieties of olive trees that are fast growing/high yield/short lived, mainly Arbequina and Picual, which originated in Northeast Spain (SUFISA Focus Groups). These highly productive olive trees yield their first crop when only three years old, but have a very short life span (*circa* 14/15 years).

Figure 10.4

An abbreviated view of the actor-network associated with the intensive olive grove agribusiness



Source: own elaboration.

With the aim of maximizing production and saving resources, the latest technologies manage irrigation, inputs application, and harvesting in the case of super-intensive olive groves, with high levels of precision. There is also a perception of intense use of agro-chemicals (especially herbicides), which remains contested by intensive producers on the basis of their economic incentive to save on inputs whose application is minimized through the use of precision technology. The transformation into olive oil is done in high tech olive oil mills built by the largest investors. Rather than selling the olive oil by the bottle, many of these businesses sell the largest proportion of their production in bulk. The olive oil is then transported in tank trucks with purchase prices set by the tank-load to facilitate international trade.

Non-human elements of this actor-network include the fishing eagle (*Pandion Haliaetus*) and an endangered endemic plant *Linaria Ricardoii*. Their presence is invoked to help producers in intensive production modes legitimize the sustainability of irrigation and intensive agricultural practices (Campos 2017).

SOCIAL AND ECOLOGICAL IMPLICATIONS OF NEW ACTOR NETWORKS

In view of the rapid emergence of the new actor-networks, key implications for economy-community-ecology links need to be considered. Firstly, we can observe a de-coupling of land from the previously dominant social fabric, accompanied by an active effort by public entities to re-wire newly irrigated land with the new actor-networks. Participants in the projects underpinning this analysis perceive the linkages between the new agriculture and local communities to be weak.

The permanent staff needs of large firms associated with intensive forms of agricultural production are often covered by a few young and highly skilled individuals, most of whom are foreign to the region. As to the seasonal employment opportunities, these are often covered by employment agencies importing cheap labour from Eastern European and Asian countries (Guedes 2018). At the same time, there is a widespread perception of a lack of labour (skilled or not). This was mentioned by some focus group participants as a significant factor fuelling decisions to transform extensive production systems into super-intensive ones, which are fully mechanized.

From a farmer's perspective, the fact that EDIA's irrigation conservation fee per hectare is equal for all farms, on which the infrastructure is installed regardless of their consent or socio-economic situation, is seen as driving a detachment between agricultural land and farmers with traditional production practices. This, in association with the 2002 ministerial decree allowing the replacement of old olive groves by new ones of different varieties, is effectively dismantling the pre-existing actor-network of extensive olive oil production in the area covered by the Alqueva irrigation system.

Key elements of this extensive farming actor-network are long-lived, traditional, Portuguese olive tree varieties (e.g. Galega, Cordovil), older farmers with fewer technical skills, often as family businesses with occasional help from foreign unskilled labour. Pre-existing actor-networks are based on economies of scope (differentiated, traditional products, and associated ways of life), and are highly dependent on subsidies from CAP, including pillar II agri-environmental schemes. Commercially, they target the local and national market and benefit from labelling as produce of protected origin (with the Portuguese acronym DOP – *Denominação de Origem Protegida*). Some agro-tourism is also found in association with extensive olive groves. National and regional statistics of 2015 (INE) reveal that since 1999 an increasing number of small farmers in the olive production sector have declared bankruptcy. More traditional farmers linked to extensive agriculture are showing very limited capacity to adapt to new physical infrastructures and market demands (Pinto-Correia and Azeda 2017).

All of the factors and elements discussed above reveal a set of flows that help characterize the dynamism of economy-community-ecology linkages, namely financial and commercial flows, knowledge/information/data flows, labour flows, and production input and output flows connecting farms to wider ecological systems.

For a preliminary assessment of the environmental implications of new dominant actor networks, we focus on public environmental goods defined by Portuguese authorities as being particularly vulnerable to degradation in the context of intensive olive tree plantations – soil fertility, water quality, and biodiversity (DRAPAL 2009).

We should start by noting that the severity of environmental impacts often associated with the intensification of olive oil production is highly debated in the media. While there is a lack of scientific evidence regarding its effects over time in Portugal, signs of concern are often dismissed by

super-intensive producers on the basis of benefits for carbon sequestration, presence of certain species (e.g. rabbits), the lower water requirements, and use of agro-chemical inputs in comparison with crops such as maize (SUFISA Workshop 09/2017).

Portuguese government entities have identified a significant risk associated with intensive olive tree groves, particularly for soil fertility, water quality, and biological diversity in soils. The fast increase in the area of intensive olive groves in Alentejo led the Portuguese Ministry of Agriculture, Regional Development and Fisheries to set up an Olive Grove Working Group (Portuguese acronym GTO) in 2008 (DRAPAL 2009). The GTO was led by INIAV (the Portuguese acronym for the national institute for agronomic research), and comprised DGADR (the national Directorate-General for Agriculture and Regional Development), DRAPAL (Alentejo's regional directorate for agriculture and fisheries), and GPP (the national office for planning and public policy of the Ministry of Agriculture).

Due to a lack of financial and human resources, the GTO investigated the situation adopting a case study approach, instead of a statistically significant sample definition. For the same reason GTO members found it impossible to accompany soil erosion in newly irrigated olive groves over a significant time period. The case studies were chosen according to their distribution across municipalities and different soil types. On this basis, GTO experts selected 29 farms with intensive olive tree plantations (with over 200 trees/ha), 7 farms with super-intensive olive tree plantations (with over 1000 trees/ha), and a further 11 farms that are actively engaged in extensive olive oil production (under 200 trees/ha), for comparative purposes. The average production of olives per hectare in 2008 for super-intensive, intensive, and traditional plantations was found to be 9.1 tons/ha, 5.6 tons/ha, and 1.2 tons/ha, respectively. Key findings from this study are included in the analysis below.

Marques and Carvalho (2017) warn that the sustainability of irrigation agriculture is insufficiently researched, especially with respect to soil contamination and salinization. In his turn, Serralheiro (2017) emphasizes that a high risk of erosion and salinity exists for vertisols and luvisols, which constitute the most predominant soil types in the irrigation blocks served by the Alqueva dam.

An interviewee from a small farmers association (Guadiana Adaptativo 21/10/2016) emphasized that the longevity of intensive olive orchards is short (*circa* 15 years), and that, on the basis of information about Spanish intensive

olive groves, soils in the region are unable to hold more than two cycles of olive tree growth on account of serious soil degradation.

Among the main findings, GTO experts note that the amount of nitrogen-based fertilizer in intensive olive groves was twice that of traditional groves. Information collected for super-intensive groves conflicted with other previously available and thus remained inconclusive. As to the amount of phosphorous-based fertilizer, in super-intensive and intensive groves it was similar in both cases, but it was *circa* 32% higher than in traditional groves. Glyphosate was the most used herbicide in all types of olive tree groves, and was the only herbicide used in super-intensive groves. In 15% of the traditional and intensive groves, quantities applied surpassed those authorized. The consequences of this excessive herbicide use on water quality through seepage processes were not assessed in any of the case study farms.

One scientific expert interviewed (GuadianAdaptativo 10/11/2017) considered the presence of a monoculture to be a factor of high risk; and more so when one considers the lingering “myth” that soil erosion is only significant in fields with a slope. This disregards soil erosion processes in plain fields, including those areas previously used for wheat production throughout the 20th century in areas now occupied by intensive olive groves. Soil erosion is cited in the scientific literature as one of the principal environmental problems associated with olive farming in Mediterranean regions (Vanwalleghem et al. 2011). The Alentejo is no exception (Neves, Pires and Roxo 2013).

From the perspective of production input flows, good water quality is needed for irrigated land to be washed of excess salts and retain productivity (Serralheiro 2017). However, the GTO (DRAPAL 2009) found that in 94% of the cases analysed, the levels of bicarbonates exceeded the maximum thresholds advised for irrigation water; and in 39% of cases the levels of nitrates in the water were also excessive. This represents a considerable risk for already fragile soils. In relation to production output flows, deterioration of groundwater quality by excessive input of nitrates in intensive agriculture was reported in Ferreira do Alentejo (ClimAdapt interview 02/07/2015), where drinking water is supplied by the “Gabros de Beja” aquifer system. Although the aquifer system has been classified as a vulnerable zone under the European Union’s Nitrates Directive, its quality has continued to decline.

Regarding the ecological indicators of the impact of land use change and production output flows on water quality, Matono, Sousa, and Ilhéu (2013) examined a set of olive groves with different levels of intensification in the

Alentejo region, while comparing these with reference sites with little human disturbance. The authors' findings reveal that as intensification increases, water quality indicators show a deteriorating trend, particularly nutrient and sediment loads. They indicate that soil erosion and water runoff into nearby streams are a major source of suspended sediments, nutrients, and pesticides in watersheds. In addition, ammonium nitrite, total phosphorous, and phosphate concentrations showed increasing trends. As far as these indicators are concerned, these authors found that traditional olive groves are not significantly better, especially those with grazing animals, which are a significant source of organic matter and nutrient pollution in nearby waterways.

According to findings shared by Matono, Sousa, and Ilhéu (2013), a decrease in fish variety, habitat diversity, and continuity exists in streams close to the most intensive olive groves. There are also signs that the removal/deterioration of riparian vegetation is taking place in all types of olive groves, and is destroying the habitat of fish populations, especially of endemic and highly sensitive populations. Experts of the GTO (DRAPAL 2009) noted a significant decrease in the richness and diversity of vascular plants in the most intensive olive groves. The number of species present in these olive groves was 49% of those found in traditional groves. Dias (2018) also mirrors local stakeholder findings that are important to consider, including the coverings of streams and the absence of pollinators.

The predominance of alien olive tree varieties in intensive olive tree plantations, specifically the Spanish varieties Arbequina and Picual, was perceived by SUFISA focus group participants as a significant risk for genetic diversity. Traditional varieties (Galega and Cordovil) cannot produce similar yields under irrigation, and are being gradually less used. Yet, it was also noted that olive oil that is produced exclusively on the basis of Arbequina and Picual does not last once bottled. Olive oil durability is enhanced through the combination of varieties, particularly olive oil produced with traditional varieties, necessarily in an extensive production regime.

One finding of the DRAPAL (2009) cuts across the three types of public environmental goods highlighted here. In most farms surveyed there was no systematic record of the quantities of inputs used (phytopharmaceutical products, fertilizer, water volume) or of quantities of water in soils; and in none of the cases was there any monitoring of soil erosion processes.

CONCLUSIONS

This chapter addresses some of the new actor-networks emerging from the process of agricultural intensification in the context of the Alqueva irrigation system and olive oil production. The authors investigated the ways in which these actor-networks are rapidly changing previously existing links across economy, community, and ecology in the region, and we explored the consequences that this rapid transformation may hold for the sustainability of social-ecological systems.

This chapter shows that the actor-networks emerging from the intensification of olive oil production in the Alqueva region favour social and ecological elements that are foreign to the Alentejo, and represent a unique assemblage of human and non-human elements in the wider Portuguese context. From foreign skilled and unskilled labour, to fully mechanized harvesting and Arbequina olive trees in extremely dense and short-lived groves, new actor-networks are becoming the dominant socio-economic force, inevitably causing profound change in links across economy, community, and ecology in the case study area. This trend faces no opposition, as the previously dominant actor-network in the region has not been able to resist it or promote reflection on potential disadvantages of the on-going transition.

The new input/output flows associated with more intensive olive oil production, coupled with specific technological solutions and practices (ever higher tree densities, the cutting of riparian vegetation, more intensive use of agro-chemicals), are dissociating the agrarian economy from the ecological conditions underpinning it. Although there is currently no comprehensive assessment of the extent to which intensive and super-intensive olive production patterns are impacting ecological systems in Portugal, we found a significant amount of objective data from agronomic and life sciences research that indicate the high risk involved. On their side, the new dominant actors, very much in line with a bio-economic vision of agricultural modernization, associate themselves with the concept of sustainable intensification by stressing greater carbon storage capacity, and their use of precision technology for an efficient use of water, fertilizer, and pesticides, used only where and when needed.

In addition, a decoupling between economy and community is equally evident. The unavailability of local labour is playing a role and inducing two types of strategies: (i) the hiring of employment agencies to source cheap

foreign labour to work; and (ii) the conversion of extensive and intensive production into super-intensive and fully mechanized production, which results in further degradation or loss of the environmental public goods discussed. Unfortunately, we found that unskilled foreign labour tends to be tied up to a situation of poor working conditions, and no opportunity to create a connection with local communities or the ecological system. Although no representative survey has been conducted to allow a definite conclusion on the extent to which new trade, financial, and labour flows are disconnecting new actor-networks from local communities, our study gathers sufficient qualitative indicators to identify new high risk trends.

The findings suggest, therefore, that the new agrarian economy based on intensification is promoting a double decoupling process: a decoupling from the surrounding communities, in a context of local communities shrinking through emigration and aging, and a parallel decoupling from the underpinning ecological processes.

In a longer-term perspective, two types of de-territorialization seem to be succeeding one another. First, the departure through emigration of those with a greater sense of community belonging and attachment to the surrounding natural environment. As a consequence, the natural environment and ecological systems that previously supported local livelihoods are not conserved and valued in the same way, becoming more easily appropriated by external actors concerned with maximizing short-term agricultural production. This raises the expectation that once a territory suffers de-territorialization through “social emptying”, it is more vulnerable to de-territorialization through “resource extraction”, particularly concerning soil fertility, good quality water, and biodiversity, as shown in section v.

The double-decoupling process seems to have left a vacuum in which no actors feel responsible for the rural community or the environmental systems that underpin it. In the absence of other forms of intervention by public, private, and local community actors, de-territorialization can only increase in speed and intensity.

A few policy recommendations may be distilled. First, existing and novel governance processes need to be engaged in an expansion of problem framing to enable the identification of new solutions in line with climate change adaptation needs for the Alentejo. These consistently predict a decline in the environmental capacity to absorb human disturbance, such as less water in rivers and aquifers to dilute pollutant loads. This will require a

change of mind-set from supply management to demand management and risk avoidance. A second recommendation is to foster greater alignment of new actor-networks with sustainability goals, especially in view of the new sustainable development goals set for Portugal for the period up to 2030. This could mean, for example, that public irrigation systems include a new objective: to provide support water flows for those extensive traditional systems particularly disturbed by climate change and the significant change in the patterns of precipitation that it is bringing to the Alentejo region. Overall, climate change adaptation and sustainable development objectives demand us to re-imagine the role of irrigation in support of local social and ecological systems rather than promote water intensive crops or varieties in an increasingly arid region.

Moving forward toward a more sustainable form of agricultural intensification will require a greater investment in governance processes, particularly those at the biophysical scale, such as the landscape or the hydrological unit (i.e. the river basin). The complexity of the current and foreseeable challenges demands stronger collaboration amongst stakeholders with a view to facilitate information access, recognize risk, and build capacity to experiment, monitor, and learn practices that conserve and protect public environmental goods. This also requires a science policy that is better adjusted to the needs of knowledge co-production and greater involvement of social scientists as intermediaries across different forms of knowledge.

Future research should investigate the relationship between new and old actor-networks, and how they differ in their socio-spatial strategies, including those concerned with geographic scale. The politics of scale of the actors investigated in this chapter revealed links to specific notions of sustainability, food security, food sovereignty, and indeed territorial sovereignty, that remained unexplored. Future work could also usefully document the emergence of hybrid business models in the olive oil production sector, combining elements of the eco-economy and the bio-economy paradigms. Finally, further research should consider a comparative geo-historical analysis between Alentejo and Spanish regions where processes of intensification of olive oil production have been occurring for longer, and local stakeholders are already implementing measures to counteract the negative social and ecological consequences associated with this profound change in the agricultural landscape.

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