

Institutions, knowledge and water: the change of Maghrebi olive crops

Instituciones, conocimiento y agua: el cambio de los olivares magrebíes

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ABSTRACT

Olive growing is a millennia-old activity in the Maghreb countries, but recently is changing due to the spread of prosperity and the opening of new niches in internal markets. The aim of this paper is to understand how the development process affects agriculture. The methodology used combines the analysis of quantitative data available from international and national bodies, the information obtained from our field work, and the data extracted through the content analysis of 60 in-depth interviews conducted with farmers, entrepreneurs, academics, consultants and policy makers in 2019, 2020 and 2022 in the main regions devoted to olive growing. The results show that newcomer farmers adopt novel organizational and productive models. Knowledge, innovation and the use of water are the key elements for modern agriculture. New actors are entering the sector and displacing traditional forms of cultivation. However major economic, social and environmental challenges are looming on the horizon.

KEY WORDS: *Territorial development, Olive oil, Rainfed, Irrigation, Institutional change.*

RESUMEN

El olivar, actividad milenaria en los países del Magreb, está cambiando debido a la expansión de la prosperidad y la apertura de nuevos nichos internos de mercado. El artículo busca comprender cómo el proceso de desarrollo afecta a la agricultura. La metodología combina el análisis de los datos cuantitativos disponibles en los organismos nacionales e internacionales; la información obtenida de nuestro trabajo de campo y los datos extraídos de 60 entrevistas en profundidad realizadas a agricultores, empresarios, académicos, consultores y *policy makers* en 2019, 2020 y 2022 en las principales regiones productoras. Los resultados muestran que los nuevos agricultores adoptan novedosos modelos organizativos y productivos. El conocimiento, la innovación y el uso del agua son los elementos claves para la moderna agricultura. Los nuevos actores que están incorporándose a la actividad desplazan las formas tradicionales de cultivo. Sin embargo, grandes desafíos económicos, sociales y ambientales acechan en el horizonte.

PALABRAS CLAVE: Desarrollo territorial, Aceite de oliva, Regadío, Secano, Cambio institucional.

Instituições, conhecimento e água: a evolução dos olivais do Magrebe

RESUMO

A olivicultura é uma atividade antiga nos países do Magrebe, mas recentemente está a mudar devido à expansão da prosperidade e à abertura de novos nichos de mercado interno. O objetivo do artigo é compreender como o processo de desenvolvimento afecta a agricultura. A metodologia utilizada combina a análise de dados quantitativos disponíveis em agências nacionais e internacionais; informações obtidas no nosso trabalho de campo; e dados extraídos de 60 entrevistas em profundidade realizadas com agricultores, empresários, académicos, consultores e decisores políticos em 2019, 2020 e 2022 nas principais regiões produtoras. Os resultados mostram que os novos agricultores estão a adotar novos modelos de organização e produção. O conhecimento, a inovação e a utilização da água são os elementos-chave da agricultura moderna. Os novos operadores estão a substituir as formas tradicionais de agricultura. No entanto, grandes desafios económicos, sociais e ambientais espreitam no horizonte.

PALAVRAS-CHAVE: Desenvolvimento territorial, Azeite, Sequeiro, Irrigação, Mudança institucional.

Institutions, savoirs et eau: le visage changeant des oliveraies du Maghreb

RÉSUMÉ

L'oléiculture est une activité séculaire dans le Maghreb, mais elle est en train de changer en raison de l'expansion de la prospérité et de l'ouverture de nouvelles niches sur le marché intérieur. L'objectif de cet article est de comprendre comment le processus de développement affecte l'agriculture. La méthodologie combine l'analyse des données quantitatives disponibles auprès des agences nationales et internationales, les informations obtenues lors de notre travail sur le terrain et les données extraites de 60 entretiens approfondis menés avec des agriculteurs,

des entrepreneurs, des universitaires, des consultants et des décideurs politiques en 2019, 2020 et 2022 dans les principales régions productrices. Les résultats montrent que les nouveaux agriculteurs adoptent de nouveaux modèles d'organisation et de production. La connaissance, l'innovation et l'utilisation de l'eau sont les éléments clés de l'agriculture moderne. Les nouveaux arrivants supplantent les formes traditionnelles d'agriculture. Cependant, des défis économiques, sociaux et environnementaux se profilent à l'horizon.

MOTS-CLÉS: Développement territorial, Huile d'olive, Culture pluviale, Irrigation, Changement institutionnel.

Istituzioni, saperi e acqua: il volto mutevole degli oliveti del Maghreb

SOMMARIO

L'oléiculture è un'attività antica nei Paesi del Maghreb, ma recentemente sta cambiando a causa dell'espansione del benessere e dell'apertura di nuove nicchie di mercato interno. L'obiettivo dell'articolo è capire come il processo di sviluppo influisca sull'agricoltura. La metodologia utilizzata combina l'analisi dei dati quantitativi disponibili presso le agenzie nazionali e internazionali, le informazioni ottenute dal nostro lavoro sul campo e i dati estratti da 60 interviste in profondità condotte con agricoltori, imprenditori, accademici, consulenti e responsabili politici nel 2019, 2020 e 2022 nelle principali regioni produttrici. I risultati mostrano che i nuovi agricoltori stanno adottando nuovi modelli organizzativi e produttivi. Conoscenza, innovazione e uso dell'acqua sono gli elementi chiave dell'agricoltura moderna. I nuovi operatori stanno soppiantando le forme di agricoltura tradizionali. Tuttavia, all'orizzonte si profilano importanti sfide economiche, sociali e ambientali.

PAROLE CHIAVE: Sviluppo territoriale, Olio d'oliva, Piogge, Irrigazione, Cambiamento istituzionale.

Introduction

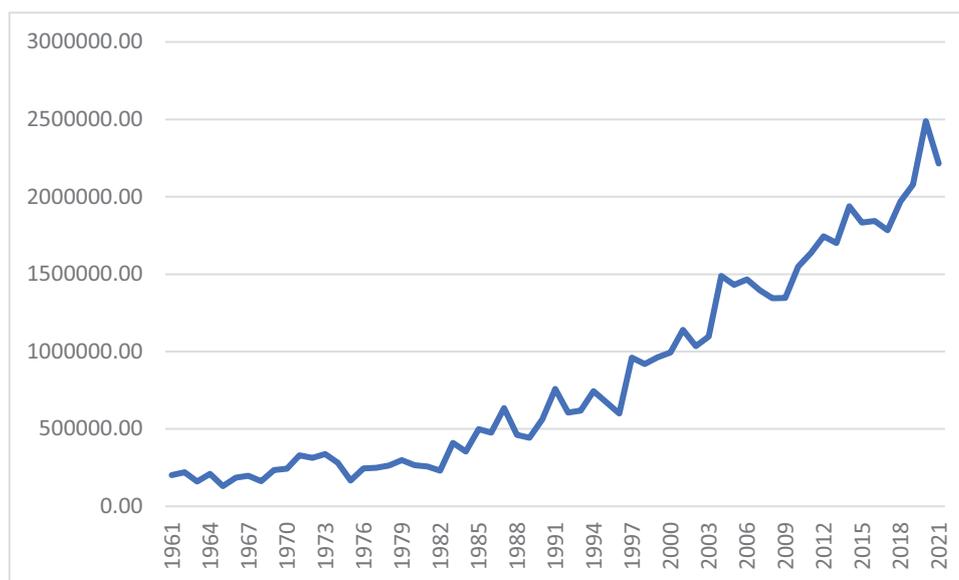
Olive-growing in the Maghreb is an age-old activity that, throughout history, has allowed the development and evolution of different varieties of the fruit, adapted to the local soil and climatic conditions, as well as making an important contribution to the Mediterranean diet. From a national perspective, the Maghreb countries have adopted different strategies, ranging from using the activity as a source of foreign exchange to ensure macroeconomic stability and socio-economic development, as is the case in Tunisia, to ensuring food security, together with cereals, as in Morocco and Algeria¹.

However, the globalization process has brought about changes that are transforming olive growing and olive oil production, posing significant economic, social and environmental challenges for the development of the region. The first of these changes is the increase in consumption in countries outside the Mediterranean region. The key moment for this change was the publication of the Seven Countries Study², which presented the benefits of olive oil consumption as part of the “Mediterranean diet” as a protective element against cardiovascular diseases. With the dissemination of this

study, olive oil consumption has been growing worldwide, especially in countries that are not producers and among social groups that increasingly value a healthier diet (Graphic 1).

The increase in global consumption has been accompanied by a rise in production. Over the last 20 years, the Maghreb countries, which have traditionally been less oriented towards olive oil production, have experienced the greatest increases, but all of them, including Tunisia, have grown much more than the world’s leading producer, Spain, and the world average (see Table 1). This divergence between the main producers and those less focused on production is also evident in consumption (see Table 2), as Algeria and Morocco have increased their consumption well above population growth (compare with Table 3). Tunisia, on the other hand, has followed the opposite path, as have the countries of southern Europe (see the data for Spain for comparison). However, Tunisia maintains a per capita consumption level of about three liters per year, while Algeria is at two liters. In any case, there is still much room for improvement in all of these countries, as they are far below the major consumers such as Spain (almost 12 liters per capita per year).³

Graphic 1. World exports of olive oil (tons)



Source: Faostat.

¹ Benassi; Labonne, 2004. Mokrani; Sai; Dhehibi, 2011. Rouibah; Belabbas, 2022.

² Keys, 1970.

³ The production and consumption data in the tables are in kilograms. One kilogram is equivalent to 1.11 liters.

Table 1. Changes in olive oil production in the Maghreb

	Average production for the 1992/93 to 2001/02 seasons (thousands of t)	Average production for the 2012/13 to 2021/22 seasons (thousands of t)	% change (20 years)
Algeria	39	79,2	103,07
Morocco	90,5	143,5	148,06
Tunisia	164,4	215,7	31,20
Spain	1.187,6	1.299,4	9,41
World	2.877,4	3.021,9	5,02

Source: International Olive Council.

Table 2. Changes in olive oil consumption in the Maghreb

	Average consumption for the 1992/93 to 2001/02 seasons (thousands of t)	Average consumption for the 2012/13 to 2021/22 seasons (thousands of t)	% change (20 years)
Algeria	39,2	78,8	100,89
Morocco	73,5	130,9	78,09
Tunisia	37,9	34,1	-10,02
Spain	558,5	509,2	-8,82
World	2.860,7	2.773,5	-3,05

Source: International Olive Council.

Table 3. Population growth (thousands)

	2001	2021	% change (20 years)
Algeria	31.201	44.178	41,59
Morocco	28.930	37.077	28,16
Tunisia	9.995	12.263	22,69
Spain	40.850	47.416	16,07
World	6.230.000	7.890.000	26,64

Source: United Nations.

These changes have a number of explanations. On the one hand, the decline in consumption in the countries with the highest production is explained by the trend towards eating out, which reduces the use of olive oil compared to other edible fats, and by the emergence of a new culinary culture, quite different from the Mediterranean diet, among the youngest segments of the population, which is also spreading in North Africa, as has already happened in the countries with the highest consumption of olive oil in southern Europe⁴.

On the other hand, the strategies to promote healthier consumption, which are also being implemented in the Maghreb, involve a growing trend towards the

consumption of olive oil in countries such as Morocco and Algeria. However, this trend remains constrained by the high price of olive oil in the domestic market of these countries, which is not only higher than that of other vegetable fats, but is even higher than that found in some European countries, such as Spain, according to samples collected in Maghreb shopping centers during the fieldwork carried out by the research team.

Lastly, the adoption of new technologies in olive cultivation, particularly those driving increased intensification, has led to reduced labor costs in the most intensive phases of production and improved economic yields on farms. In addition, state support throughout this century for crops better adapted to lower water requirements and more successful in international markets⁵, along with efforts in product valorization targeting new market niches that prioritize high quality oils as a symbol of social distinction⁶, have sparked significant quantitative changes in the Maghreb's olive growing region. The area under cultivation has already surpassed one million hectares in Morocco and almost two million in Tunisia, with Algeria experiencing the highest rate of change (see Table 4).

All these processes are framed, moreover, in a geographic area traditionally affected by rainfall restriction and its spatial and temporal variability⁷. The effects of global warming, moreover, increase evapotranspiration, leading to higher water requirements for crops⁸. These cascading impacts threaten food security, nutrition and, mainly, people directly dependent on agriculture⁹. Particularly, its effect has been demonstrated in crops well adapted to this region, such as olive groves¹⁰. However, the importance of irrigation has been increasing, and already reaches more than 23 % of the olive grove in the Mediterranean basin¹¹, as it favors agricultural production and keeps the population in rural areas, although it has drawbacks such as overexploitation of aquifers and soil salinization, among others¹². Therefore, the sustainability of intensification processes has been questioned¹³.

The changes that have occurred are of profound importance not only for the countries involved, but

⁵ FAO, 2015. Rouibah; Belabbas, 2022. Saidi; Diouri, 2017.

⁶ Sayadi; Erraach; Parra-López, 2017.

⁷ Prats-Rico, 2016.

⁸ EEA, 2019.

⁹ FAO, 2016.

¹⁰ Moriondo et al., 2013.

¹¹ Vilar; Pereira, 2018.

¹² Gómez-Espín, 2019.

¹³ Morgado et al., 2022.

⁴ Rodríguez-Cohard; Sánchez-Martínez; Garrido-Almonacid, 2020.

Table 4. Expansion of olive grove area in the Maghreb (in hectares)

Year	1980	2000	% change (20 years)	2020	% change (20 years)
Algeria	179.540	168.080	-6,38	438.828	161,00
Morocco	300.000	540.000	80,00	1.068.895	97,94
Tunisia	1.323.800	1.387.240	4,79	1.960.000	41,28
Total	1.803.340	2.095.320	16,19	3.469.743	65,59

Source: Faostat and ONH.

Note: We corrected the Tunisia 2020 data from Faostat with ONH (Office National de l'Huile, Ministère de l'Agriculture) data.

also for the global olive oil market, in which they are among the main producers. The consequences of the expansion of olive cultivation and the way in which the producing regions are responding to global competition while developing their productive structures have caught our interest and led us to pose the following research questions: How does this process affect the models of olive grove exploitation in the Maghreb? How do local entrepreneurs adapt to global competition and changing market demands? What strategies do regional actors employ? This paper attempts to answer these questions from a neo-Schumpeterian perspective¹⁴, with a preference for an endogenous development approach¹⁵. It aims to shed light on the economic and regional modifications undertaken in recent years to respond to the challenges of the new techno-economic paradigm¹⁶. These modifications have brought about institutional changes in the traditional agricultural activities of Mediterranean countries¹⁷.

Theoretical framework

The endogenous development approach began to emerge in the early 1980s, with contributions that sought to understand the new situation of companies and regions in the international environment resulting from growing economic integration¹⁸. In this approach, the ideas of Schumpeter¹⁹ (1934, 2005) are very present, as well as the thought-provoking contributions

to development theory made in the middle of the 20th century²⁰. It also incorporates new interpretations of growth theory that view technological change and human capital as internal mechanisms of the productive system that lead to increasing returns²¹.

Endogenous development considers institutions and the process of capital accumulation as a territorial process, in which the productive history shapes the evolution of companies and the strategies of actors who adapt to the context and competition with other organizations through processes of technological, productive, and institutional cooperation in the context of the market economy²². To this end, it draws on institutional economics, whose more traditional contributions consider that firms and other organizations carry out their activities in a cultural and institutional context that evolves with society and the economy²³. The new institutional economics adds that there is a reciprocal relationship between economic growth and institutions, which explains the process of structural change in the region²⁴.

Gerritsen et al.²⁵ draw attention to the importance of understanding the informal institutional context, rooted in the land, that shapes the implementation of development policies. These processes emerge as a product of the economic evolution of each region and the resolution of institutional conflicts that have left their mark on its productive history²⁶. However, these studies also reveal the potential for forging new development trajectories, either accidentally or deliberately, depending on unexpected external shocks and how they are managed²⁷. Adaptation is the result of improvements in behavior and the incorporation of new routines²⁸. Contracts, governmental mechanisms of agreement, codes of conduct among local actors, governance processes, and local culture play a role in shaping the development path of regions.

The introduction of technological changes in productive systems depends on the institutions that govern the area²⁹, which imprint their own characteristics on the entry of new routines into the productive

²⁰ Hirschman, 1958. Lewis, 1954. Myrdal, 1957. Rosenstein-Rodan, 1943.

²¹ Lucas, 1988. Romer, 1986; 1990.

²² Vázquez-Barquero; Rodríguez-Cohard, 2016.

²³ Commons, 1934. Mitchell, 1967. Veblen, 1899.

²⁴ North, 1986; 2005. Williamson, 1985.

²⁵ Gerritsen et al., 2019.

²⁶ Boschma; Martin, 2010. Hodgson, 1993.

²⁷ Martin; Sunley, 2006.

²⁸ Schmidt et al., 2023.

²⁹ North, 1990.

¹⁴ Nelson; Winter, 1982.

¹⁵ Vázquez-Barquero, 2002.

¹⁶ Pérez, 2010.

¹⁷ Rodríguez-Cohard; Sánchez-Martínez; Gallego Simón, 2019.

¹⁸ Becattini, 1979. Fuà, 1983. Garofoli, 1992. Stöhr, 1981. Vázquez-Barquero, 1987.

¹⁹ Schumpeter, 1934; 2005.

dynamics, especially when it comes to very traditional activities rooted in the local culture³⁰. This is a consequence of the fact that informal institutions evolve slowly³¹ and are often the result of generational changes that are resisted by the social classes that benefit from the *status quo*³². These processes of institutional hysteresis weaken the capacity for territorial resilience and thus limit the adaptation of local productive systems to the dynamics of international competition³³, which requires local coordination mechanisms³⁴.

The new rural paradigm resulting from the context of globalization and the current techno-economic paradigm³⁵ requires farmers to develop strategies for technological and organizational change on their farms that will allow them to obtain adequate yields in a context of increasing input costs and adaptation to climate change. Options range from an intensification strategy to the valorization of tradition and productive differentiation³⁶.

Key to this are the capabilities of human resources, which depend on the process of productive development that the region has undergone³⁷. These are difficult to commercialize because they are partly made up of tacit and land-based localized knowledge³⁸, which limits the diffusion processes in those areas with a traditionally less innovative culture and less organizational capacity³⁹, such as those specialized in agricultural activities. However, there are pipelines for the transmission of productive knowledge—in addition to codified knowledge—that go beyond local productive systems and are transmitted more rapidly in the new techno-economic context, thanks to the intervention of commercial and technological agreements with key actors in the productive activity or the creation of commercial trust throughout the continuity of economic exchanges⁴⁰.

These pipelines are effective diffusers of strategic knowledge, whether intentional or accidental⁴¹. They depend not only on geographical proximity, but

above all on organizational, cognitive and institutional proximity⁴². They allow the sharing of routines and behaviors that are key in the current techno-economic paradigm, strengthening the role that external ties play in the innovation dynamics of any productive activity in the territory⁴³.

Therefore, the introduction and dissemination of new combinations of knowledge and production routines stimulate technological progress and economic growth⁴⁴. This open process to adopting innovations empowers local entrepreneurs to devise and execute strategies for maintaining and expanding into new markets. It facilitates the introduction and differentiation of new products through ongoing interactions between productive organizations and institutions along the global value chain, thus adding an interactive dimension to innovation processes⁴⁵.

In any case, when the difficulty of incorporating other productive routines and technological innovations is low, the most successful behaviors are imitated, which promotes the diffusion of productive knowledge⁴⁶. This mechanism also reduces entrepreneurial risk and contributes regionally to the process of collective innovation⁴⁷, allowing the rapid expansion of alternative organizational and techno-productive models, even in activities as traditional as agriculture⁴⁸. Therefore, the introduction of innovations is also possible in rural areas that are more distant from the centers of innovation and development of the world economy, as the capacity to absorb specific knowledge is high for some activities. This enables the rapid transfer of technical information and innovations⁴⁹.

Research design and methodology

The most appropriate approach to achieve the stated objectives is primarily qualitative research using an interpretive framework⁵⁰, which allows for the exploration of the subjective values that individuals create to shape their own reality as they interact with others⁵¹.

³⁰ Rodríguez-Cohard; Sánchez-Martínez; Gallego-Simón, 2017.

³¹ Williamson, 2000.

³² Acemoglu; Robinson, 2008.

³³ Simmie; Martin, 2010.

³⁴ Margarían, 2013.

³⁵ OECD, 2006. Pérez, 2010.

³⁶ Rodríguez Cohard; Sánchez-Martínez; Garrido-Almonacid, 2020.

³⁷ Nelson and Winter, 1982.

³⁸ Polanyi, 1967.

³⁹ Teece; Pisano, 1994.

⁴⁰ Bathelt; Malmberg; Maskell, 2004.

⁴¹ Martin; Sunley, 2010.

⁴² Boschma, 2005.

⁴³ Granovetter, 1973.

⁴⁴ Freeman; Soete, 1997.

⁴⁵ Lange; Schmidt, 2021. Nelson, 1993.

⁴⁶ Alchian, 1950.

⁴⁷ Maillat, 1995.

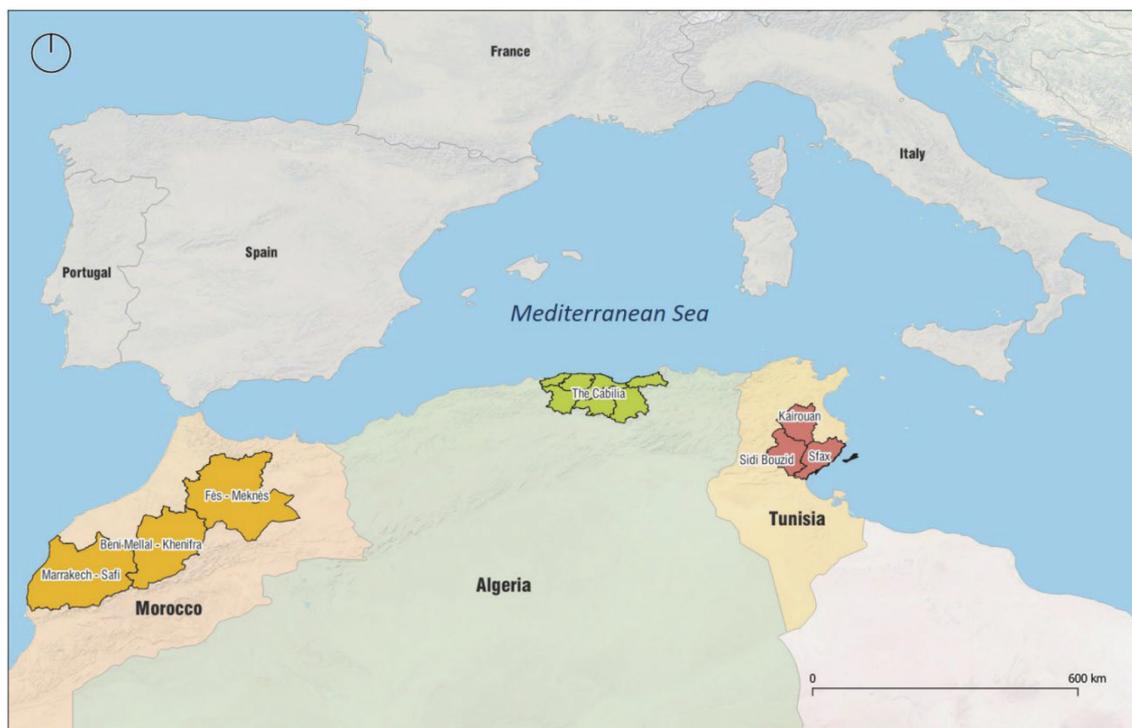
⁴⁸ Rodríguez-Cohard et al., 2022.

⁴⁹ Shearmur, 2015.

⁵⁰ Neuman, 2011.

⁵¹ Carson et al., 2001.

Map 1. Regions of study



Source: prepared by authors.

Qualitative research is a systematic, subjective approach that illuminates, explains and gives meaning to everyday life experiences⁵². Conceptually, individuals perceive the world differently as a result of their own experiences and perceptions in different contexts⁵³.

Several regions of study were selected: the regions of Fès-Meknès, Beni Mellal-Khenifra and Marrakech-Safi in Morocco; Kabylia in Algeria; and the regions of Kairouan, Sidi Bouzid and Sfax in Tunisia (Map 1).

The choice of these regions is based on the relative importance of olive growing in each country, as shown in Table 5. In addition to the field work, carried out in 2019, 2020 and 2022, we have used the available quantitative data obtained from sectoral reports, together with other data from international organizations, which demonstrates the importance of olive growing in each country.

The fieldwork consisted of in-depth, face-to-face, semi-structured interviews with 60 individuals lasting a minimum of 60 minutes. These participants represented a diverse range of backgrounds, including public management and research institutions, processing companies, market intermediaries, and local farmers

Table 5. Main olive growing regions in the Maghreb

Country	Surface area (ha)	Region	Surface area (ha)	Percentage
Algeria	431.508	The Cabília	208.630	48,35 %
Morocco	1.073.487	Fes-Meknes/Beni Mellal-Khenifra/Marrakech-Safi	657.955	61,29 %
Tunisia	1.648.050	Sfax/Kairouan/Sidi Bouzid	471.030	44,96 %
Total	3.153.045	Total	1.607.615	50,99 %

Note: Data on hectares under cultivation differ from those provided in Table 4 from FAO, as they are obtained by aggregating regional data updated to 2018 in Tunisia, 2019 in Algeria and 2020 in Morocco.

Source: Ministry of Agriculture of each country.

of various types, capital, and size, with different economic dynamics and business structures. They were chosen after careful selection by technicians from each region, who were previously contacted by the authors⁵⁴ and interviewed online using digital platforms, which allowed the inclusion of participants from the three domains that drive innovation processes in the triple helix model⁵⁵. The demographic data of the interviewees

⁵² Burns; Grove, 2009.

⁵³ Khan, 2014.

⁵⁴ Hristov; Chirico; Ranalli, 2022.

⁵⁵ Etzkowitz; Leydesdorff, 2000.

Table 6. Demographic data of interviewees

Attribute	Modality	Percentage
Gender	Male	85,3 %
	Female	14,7 %
Age	Less than 40	31,2 %
	Between 40 and 50	58,7 %
	Over 50	10,1 %
Occupation*	Industrial employer	25,3 %
	Agricultural employer	60,4 %
	Technicians from public agencies and consultants	9,3 %
	Scientist	20,3 %
Experience	More than 10 years	46,4 %
	Between 6 and 9 years	30,5 %
	Up to 5 years	23,1 %
Education	University	50,5 %
	Secondary	32,6 %
	Primary education	16,9 %

* Occupation adds up to more than 100 % because there were several respondents with multiple roles.

Source: prepared by authors.

can be found in Table 6. Although the relatively small sample size could be considered a limitation of this study, the decision was made to end the fieldwork once the responses became redundant, i.e., when we reached the saturation point⁵⁶.

The interviewees were asked about the status of the olive grove and olive oils in their different regions and how they are being integrated into the globalized economy. The strategic choices made to confront the changes and challenges facing the productive activity formed the backbone of the interviews, so the innovation efforts, the modification of routines, the choice of new management and production alternatives, as well as the integration into new markets were the most discussed topics by all of them, each from their professional perspective. They also discussed the social and territorial obstacles to the implementation of strategies for change, which are introduced at different speeds depending on the national and international socio-political context. The notes taken during the interviews and the transcripts of the conversations were grouped thematically, in order to guarantee the anonymity of the data.

⁵⁶ Glaser; Strauss, 2012.

Content analysis allows us to contrast and analyze theoretical arguments and empirical evidence⁵⁷. This research tool is an empirical and methodologically controlled method of analysis in the context of communication with interviewees, following thematic rules of analysis and a step-by-step process without rash quantification. The deductive approach allows us to process the data by identifying categories⁵⁸. The step-by-step process is useful for identifying themes from the initial data extracted from the interviews. In this study, six steps were carried out: transcribing the data from the recorded interviews and reviewing the written notes; generating codes to identify topics for analysis; searching for relationships between topics; identifying themes; finalizing the thematic map (Figure 1); and writing the final fieldwork report⁵⁹.

Results

In the early years of the 21st century, the growth in international demand for olive oil led Morocco and Algeria to realize that stimulating olive grove production could be a long-term strategy to improve the balance of trade, as Tunisia had been doing, but also to increase employment in rural areas by diversifying production towards an agro-industrial structure with significant development potential. These options took shape in broader agricultural plans, such as Morocco's *Plan Maroc Vert*⁶⁰ and Algeria's *Plan National de Développement Agricole et Rurale*⁶¹.

Thanks to public incentives for investment in drip irrigation, the improvement of agricultural facilities and the participation of foreign companies—with a preference for public-private partnerships—the main olive-growing regions of Morocco and Algeria have increased their production, both by increasing the number of hectares under cultivation, even in regions where there was no olive-growing tradition, and by intensifying production, with a more efficient use of resources. However, although the results in terms of production are notable, the sustainability of the process poses a major challenge in the context of

⁵⁷ Berelson, 1952. Sola, 1959. Maxwell, 1996.

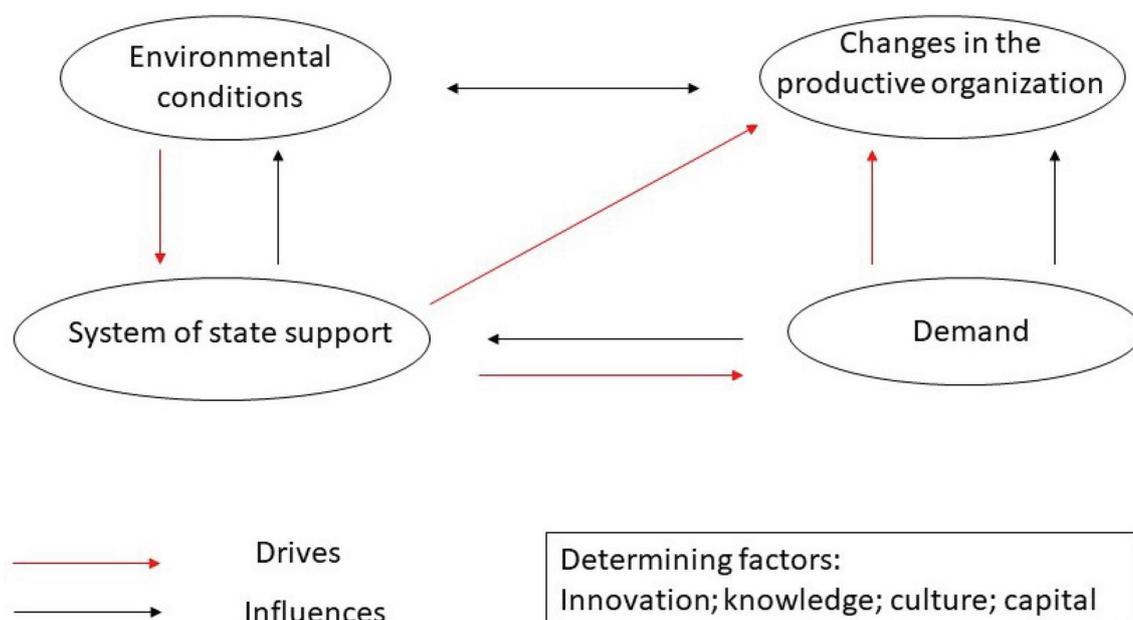
⁵⁸ Mayring, 2000.

⁵⁹ Braun; Clarke, 2006.

⁶⁰ Direction de la Stratégie et des Statistiques, 2020.

⁶¹ Mouloud, 2014.

Figure 1. Thematic map



Source: prepared by authors.

climate change and the consequent reduction in water reserves.

The fact is that surface water is unevenly distributed. Sedimentation of reservoirs due to upstream soil erosion, the pollution by untreated urban and industrial wastewater, and the intensive agricultural management practices have resulted in the low quality of the fresh water⁶². Regarding groundwater, the region has two transboundary aquifer systems shared between Morocco, Algeria and Tunisia⁶³: the *Errachidia Basin*, between Algeria and Morocco (60.000 km²) with low rainfall rates (less than 200 mm/m²/year) and with rates of abstraction higher than the recharge ones; and the *North Western Sahara Aquifer System*, shared by Algeria, Tunisia and Libya, the largest groundwater reserve in the North of Africa, extending over 1 million km². Their resources are largely non-renewable.

Morocco, Algeria and Tunisia suffer from salinized ground water and this problem is predicted to get worse in the future⁶⁴. Furthermore, there are large water losses in the conveyance for the agricultural sector due to non-functional or broken irrigation systems, evaporation losses or even an over application of irrigation in crops. The situation becomes more problematic in

Tunisia, since this country shows a clear imbalance in the estimated water demand for all sectors compared to the total water resources⁶⁵.

In this context, and in favor of expanding irrigation, the interviewees argue that olive groves require less water than other crops, even if they are tree crops. In any case, it seems to them that the expansion of olive groves will increase in the future, because if there are tensions in the supply of water from aquifers, olive groves will be the preferred choice. This idea is reflected in the Moroccan *Plan Maroc Vert*⁶⁶:

“A program for the conversion and intensification of fruit tree growing has been launched, aimed at converting cereal crops sensitive to climate variability to other more resilient and value-enhancing crops”.

These statements are widely shared in the rest of the Mediterranean, where olive grove expansion is based on the same reasoning⁶⁷. In any case, in most of the Maghreb regions, the increasing frequency of droughts are leaving the rainfed olive grove in repeated unproductive situations, creating an increasingly differentiated duality between rainfed olive groves, which are far below the level of economic profitability, and irrigated

⁶² Djedjai et al., 2016.

⁶³ UNESCO, 2009.

⁶⁴ Hamed et al., 2018.

⁶⁵ Acacia Waters; The Salt Doctors, 2021.

⁶⁶ Direction de la Stratégie et des Statistiques, 2020, 41.

⁶⁷ Rodríguez-Cohard; Sánchez-Martínez; Garrido-Almonacid, 2020.

olive groves, which are managed from a professional perspective and with promising results.

The quest for national food autonomy is undoubtedly behind these agricultural development efforts, as recognized by the interviewees, since until a few years ago cereal production was favored and oilseed fats were imported. The aim now is to gradually modify national consumption, which is much lower than in the rest of the Mediterranean, except in the most traditional olive-growing regions, including all of Tunisia, Kabylia in Algeria and the Fèz-Mèknes and Rif regions in Morocco, and also to stimulate national demand, which can be met by increasing production. This double strategy would help to improve the balance of trade, both by reducing imports of oilseeds and, in the case of Morocco and Algeria, by increasing exports of olive oil, since Tunisia has long been one of the world’s leading exporters, mainly to the European Union.

The consequences of public incentives for olive production, particularly in Morocco and Algeria, on the one hand, and the impact of the growth in international demand on the whole Maghreb region, on the other, are leading to changes in the organization of the productive activity. These changes can be classified into two main types and four management models, as presented in Table 7:

- a) Traditional rainfed family farms, some of which are abandoned due to lack of productivity, while others persist despite experiencing low productivity in most harvests or are maintained for non-economic reasons.
- b) Professional management of olive groves, either with capital attracted by public incentives or by the entry of a younger generation of olive growers who bring a new entrepreneurial vision of the productive activity and who also introduce, although not always, the use of irrigation.

The modality that we have called *Traditional* (see Figure 2) is carried out through a conservative and rainfed management system. This productive activity

usually fails to reach levels of profitability because the scarcity of rainfall in the driest regions, such as Sfax, for example, is coupled with the farmer’s mentality of doing the minimum with the crop—or doing nothing more than sweeping the soil to retain as much rainwater as possible—which reduces its productivity. This model, strongly linked to local culture and varieties, involves a commitment to identity that makes transmission difficult for those owners who maintain it more for emotional than productive reasons. In the words of one of the interviewees:

“The rainfed olive grove does not bring me more than a little oil every two or three years, without economic profitability. It is for family consumption and I keep it because it belonged to my grandparents”.

This model is most common in the Rif and Marakech (Morocco), Kabylia (Algeria) and Sfax (Tunisia). As a result, the oil obtained is often of low quality, consumed by the farmers themselves or sold on regional markets, often informally, which opens the door to fraud through blending with other cheaper vegetable oils⁶⁸.

The *Densification with renewal* model (see Figure 3) involves a more hands-on style of agriculture, as it adds to traditional management the densification of rainfed farms, which in low rainfall areas does not exceed 40 trees per ha. The objective of this model is to ensure that the new trees—in some cases with the introduction of allochthonous and more productive varieties such as *koroneiki*—maintain production in the long term, while the old trees decline in production until they are uprooted, which occurs when the new trees reach maturity. This process brings a new dynamism to the farms and is carried out with the advice of the technological institutes of the producing regions, among which the Tunisian regions of Sfax, Sidi Bouzid and Kairouan stand out, with the support of the Sfax Olive Institute, which contributes to changing some of the farmers’ routines by incorporating scientific knowledge into the productive activity. The impact can already be seen in the region, although assimilation, like all institutional changes, is slow.

In the case of irrigated olive groves, two management models are also recognized. The first, called *Densification without renewal*, involves the use of irrigation in a traditional planting framework. This makes it

Table 7. Organization of the productive activity

Cultivation regime	Management models	
	Dynamic management	Conservative management
Rainfed	Densification with renewal	Traditional
Irrigated	Super intensification	Densification without renewal

Source: prepared by authors.

⁶⁸ Lamani; Ilbert, 2016.

Figure 2. Traditional olive grove plot (40 trees/hectares)



Source: authors.

Figure 3. Olive grove plot with densification with renewal



Source: authors.

possible to increase the density of plants per hectare (Figure 4). This is a modernization approach based on the construction of wells supported by public subsidy projects. Examples of this model can be found in all the regions studied: profitability increases as a result of the increased availability of water. Although the work of the farm is traditional, the productive activity is managed as a business, which is reflected in the production of high-quality oils, with careful handling of the fruit at harvest and rapid milling.

The *super intensification* model mainly involves companies in partnership with the state, in which both local and foreign companies participate. An example of this is GVAPRO, an Algerian company with Spanish participation, which is introducing this model of super-intensive planting—more than 800 plants per hectare—in the steppe regions bordering Kabylia, where until a few years ago the olive tree served as a windbreak shrub⁶⁹.

⁶⁹ Hadjloune et al., 2021.

Figure 4. Olive grove plot with densification without renewal

Source: authors.

In Morocco, this plantation model is associated with companies that reach an agreement with the state on the subsidy framework and the leasing of the land—if it is publicly owned—and commit to hiring local workers, with particular emphasis on female labor as support for mechanized harvesting. Farmer-to-farmer cooperation is not a model that has been successful in the Maghreb. However, Morocco has implemented an instrument that allows it to achieve the economies of scale that agricultural cooperation enjoys in other countries, such as Spain. This is known as *aggregation*, which consists of incorporating small farmers in the agro-industrial project of large companies, for which they undertake to mill their crops in the aggregator's facilities, in order to achieve greater economies of scale and, therefore, greater profits for the small farmers as well, since:

“Many of the small farmers do not have sufficient training to form cooperatives or to market their products on their own. This project also allows them to achieve economies of scale and get a better price for their fruit”.

These agreements with the state include not only the hiring of local people and thus the creation of jobs, but also actions with a broader socio-territorial commitment, such as agreements for the construction of schools and mosques by companies, as we have seen in some of the projects carried out in the Marrakech

region. However, it is in the Fès-Mèknes region that the number of hectares dedicated to the super-intensive model is increasing the most, due to the greater availability of water.

In the case of Tunisia, state aid does not have a policy of change as significant as in Algeria and Morocco, as it is based on subsidies for the modernization of farms and oil mills. However, there are some cases of super-intensification linked to investments by large companies. But it is also common for local farmers to modify the traditional plantation structure and invest in groundwater extraction, apply modern techniques for fruit maturity analysis and professionalize farm management. This is possible thanks to generational change, with the arrival of people with technical training, international culture and business relationships, which have changed the way farms are managed, fruit is marketed and connections are made within the international value chain.

In any case, the limitation arises from the use of water. Some of the regions where olive cultivation is expanding in the Maghreb have rainfall well below 400mm/m²/year, especially in the Algerian steppes, where it is less than 200mm/m²/year, and in the central regions of Tunisia, which are fed by the North-Western Sahara Aquifer System, whose abstraction rate is three times greater than its natural recharge capacity⁷⁰,

⁷⁰ UNECE, 2020.

Figure 5. Super-intensive olive groves

Source: authors.

increasing the problems of salinization, the elimination of artesianism and the drying up of outlets⁷¹. During our fieldwork, we were able to verify the impact of soil salinization in the Sfax region and the productivity problems it causes for some farms. Notwithstanding, local farmers are used to deal with salinization and public bodies are boosting the drip irrigation in order to minimize its effect.

The reuse of water is happening on a large scale in Argelia—16 out 144 treatment plants operating in the country are concerned with the use of purified wastewater in agriculture, irrigating more than 11.000 ha⁷²—and we could find some examples in Tunisia with some advantages to the protection of the environment—the sustainability of agricultural production and the reduction of saline water intrusion thanks to the recharge of groundwater—, and the expansion of irrigated areas⁷³.

Water infrastructures are expanding. In Morocco, the solutions to the scarcity of water will come mainly from the support of more rainy regions to the driest, using a water highway to transfer surfacing resources⁷⁴. In Argelia, the construction of dams will supply an extra volume of water of 12.500 Hm³ after 2030, that is the double of the current volume of the country⁷⁵. On the other hand, Tunisia has the highest rate of groundwater

using to irrigation, consequently it has the highest risk of overexploitation. Furthermore, Tunisian government is subsidizing the use of photovoltaic energy in order to extract groundwater. This has led to contradictory effects to the preservation of water resources because of making the resource completely free.

The problem is aggravated by the fact that the irrigation requirements of the super-intensive plantation models are much higher than those in Europe, which average about 2.500 m³/ha/year⁷⁶, reaching 9.000 m³/ha/year in the Sfax region, according to data provided by the owners of these farms and confirmed by technicians from the Sfax Olive Institute, due to the lower rainfall in the region, which averages about 250mm/m²/ha/year. It should be noted that the needs of the olive tree are the same, since the most suitable varieties for this plantation model are *Koroneiki* and *Arbequina*—*Arbosana*, which is widely used in other Mediterranean regions, is less able to withstand water salinity—instead of the traditional varieties better adapted to each region, such as *Chemlal*, *Chemlali* or *Picholine Marocaine*, among others. This poses a challenge to the long-term management of super-intensive farms, especially in the Algerian steppe and the central regions of Tunisia, where they are beginning to expand. In other regions, such as northern Tunisia, Fès-Mèknes or Marrakech, super-intensive farming is irrigated with water from

⁷¹ Acacia Waters; The Salt Doctors, 2021.

⁷² Acacia Waters; The Salt Doctors, 2021.

⁷³ Hamrita; Rejeb, 2019.

⁷⁴ Hssaisoune et al., 2020.

⁷⁵ Ouamane; Sekkour; Athmani, 2022.

⁷⁶ Rodriguez-Cohard; Sánchez-Martínez; Garrido-Almonacid, 2020.

aquifers fed by the Atlas Mountains, so the risk of water scarcity, while present, is lower.

Yet, the new technologies introduced on irrigation equipment are improving the efficiency of the use of water: drip irrigation, digitalization of systems, soil moisture sensors and others are deploying in the region quickly, thanks to the implication of big companies but also of the governments, especially supporting smallholders. However, the governance of the water resources is poor: the diversity of the bodies involved and the low level of coordination constitute a barrier for the best use of water in agriculture⁷⁷.

On another organizational level, regardless of the density of planting, within a strategy of differentiation between quality oils, we find the recent incorporation of organic production, which has a very attractive market in the European Union. In fact, the most traditional form of olive cultivation is already organic, since it does not apply chemical products, but uses a natural approach to cultivate the plant. However, the arrival of a new generation of better educated farmers with international experience and culture has set in motion a strategy of irrigated plantation management, with modern machinery for harvesting, scientifically validated ecological criteria and organic certification. The process includes the introduction of alternative crops that complement the olive grove, such as fodder crops or legumes, and the introduction of livestock for fertilization. In some cases, even the irrigation ponds are managed organically instead of using chemicals to prevent the filters from clogging. This is achieved by introducing algae-eating fish and microfauna, as we saw on some of the farms we visited in the Sfax region.

Two processes of change can also be observed in the agro-industrial sector. The first is related to the super-intensive model, with the installation of modern mills linked to investments co-financed by the state. This is particularly the case with entrepreneurial initiatives in the regions of Fès-Mèknes and Marrakech, but also with the Algerian strategy of super-intensification. The olives are harvested at the right time, thanks to the replacement of tradition with technical analyses that indicate the time of greatest yield for the chosen quality. These new routines improve the quality of the product, allowing access to new markets, both national and international, in bulk or under private label. The second change focuses on the modernization of oil

mills and the management of oils from the perspective of the search for quality bulk. In both cases, the incorporation of European technology, mainly German, Italian and Spanish, brings maximum efficiency to the process. Although it is not yet a majority proportion, this change is led by the younger generations, where we find innovative projects aimed at boosting the local market. It is a combination of tacit knowledge and the incorporation of new technologies that makes it possible to obtain a final product linked to tradition and *terroir*, but with the quality demanded by the new market conditions.

Nevertheless, even in the most traditional regions, the strategy of differentiation based on territorial brands is rare. Despite the institutional impetus behind these initiatives, some of the specialists interviewed recommend focusing mainly on the production of organic oils as a differentiating element, which are in greater demand in the European Union, rather than on obtaining designations of origin or protected geographical indications:

“Most of the time they do not contribute to a greater attraction of consumers to these oils”.

Despite all the processes of change and innovation that are underway, most of the productive activity is carried out with traditional or two-stage olive mills, which are already out of use in Europe due to the risk associated with the management of liquid waste, which is highly polluting to water courses. In addition, the pollution of olive groves close to population centers is increasing as a result of poor management of solid urban waste, which poses major challenges for commercial projects related to production quality and environmental protection or to olive oil tourism.

Discussion

If we understand, from Schumpeter⁷⁸, that innovations are deviations from the behavioral routines of economic actors, it is clear that technological changes require organizational transformations, which affect business strategies, including those of farmers. However, given the slowness of institutional change in development processes, especially in more traditional activities,

⁷⁷ Acacia Waters; The Salt Doctors, 2021.

⁷⁸ Schumpeter, 1934.

there is a coexistence of strategies and organizational models before the winning combination imposes its success on other models and techniques, which are then condemned to obsolescence.

The innovations introduced into the agro-industrial activity by large companies that have signed agreements with the state spread fairly rapidly throughout the region, since they cannot be exploited monopolistically. As a result, those innovations in the productive activity that show higher yields than the previous systems of technological organization are imitated⁷⁹.

The change that is taking place in the region depends on three fundamental factors that act as an external shock⁸⁰: the development of international markets, the incorporation of foreign technology, and the emergence of local entrepreneurs with capital, either in collaboration with external entrepreneurs or with the arrival of new generations of farmers and agro-industrial entrepreneurs who have the productive know-how of tradition and the ownership of land or industrial facilities granted by inheritance. In the latter case, external influence is crucial, but it comes from the incorporation of knowledge and institutional know-how that local actors have acquired abroad and through contacts with foreign individuals and organizations. This external immersion has introduced elements of change in the local production function, thanks to the exploitation of organizational, cognitive and institutional proximities⁸¹ and other proximities of a temporal nature that keep the preceding ones alive⁸².

The process is path-dependent, not only because of the productive history itself, which is part of the culture of the region, but also as a consequence of the impact of physiographic conditions on agricultural activity. The modification of routines, such as earlier harvesting, the alteration of production patterns, the introduction of a higher quality product, etc., depends on the skills of local actors. And these are acquired or modified thanks to a set of organizational and cognitive factors that determine the combination of the production set of the agro-industrial firm⁸³: on the one hand, there is the fusion of tacit and codified knowledge, acquired during international sojourns or introduced through business collaboration agreements; on the other hand, there

is the capital invested by large companies external to the farming operation. The latter also has an endogenous component due to the restructuring of traditional farms through the introduction of dynamic management and/or a focus on an organic strategy. In any case, the new management models are aimed at markets that are more demanding in terms of quality and at improving the rural environment, in line with rural development strategies⁸⁴.

Vicious circles are present in the management of water. The globalization of the crop has led to a loss of profitability of rainfed olive groves, conducting farmers to intensify their production, incorporating more technology, more energy and more water. In addition, olives trees need less water than other crops, such as fruits or cereals, encouraging new irrigated lands, feeding back the cycle of irrigation. In regions where rainfall is scarcer, more irrigation is needed, so the sustainability risks increase, especially in the scenario of global warming and climate change, which will widen the differential between rainfed and irrigated land and, as a consequence, will intensify the process again.

Conclusions

This paper presents a novel and evolutionary perspective on the transformation of olive groves in the most productive regions of the Maghreb. Although it shares the limitations of studies that focus on a close-to-the-land analysis of changes, it compensates by providing a rich and qualitative exploration of the process through the firsthand experiences of its key participants.

The transformation taking place in Maghreb olive groves is the consequence of changes adopted by both business organizations and local farmers and entrepreneurs. Technological innovations are driving institutional change, resulting in agreements between local stakeholders, as well as with international companies, supported and encouraged by state agencies. Thus, the rural development strategy is rooted in a top-down approach, but its effects also permeate endogenous development initiatives.

Achieving rural development necessitates technological, institutional and organizational adaptation, all of which require investment and the introduction of new knowledge. It also involves the incorporation

⁷⁹ Maillat, 1995. Rodríguez-Cohard; Sánchez-Martínez; Gallego-Simón, 2017. Rodríguez-Cohard et al., 2022)

⁸⁰ Schienstock, 2007.

⁸¹ Boschma, 2005.

⁸² Zhang; Huang, 2021.

⁸³ Teece; Pisano, 1994.

⁸⁴ Ploeg; Roep, 2003.

of both formal and informal standards, and the development of human resource capacity to introduce and adapt innovations. This process requires the adoption of routines that drive changes in the productive and commercial behaviors of farmers and others involved in the value chain. Consumers also play a role in this transformation by demanding products that are aligned with society's evolving values, including greater environmental awareness and a deeper understanding of product origins, production processes, and the ethical conduct of all actors involved.

The integration of new skills, adopted technologies and updated production models are combined with traditional know-how, preserving the essence and continuity of patterns of behavior within local companies. This dynamic facilitates the region's integration into the globalized landscape, not merely as a supplier of commodities, but also as a competitive force offering high-quality, distinctive products obtained through the use of available technology. By embracing external knowledge, the Maghreb region has unlocked the potential for rural development linked to the olive sector, overcoming the lock-in effect and paving the way for innovative paths of productive diversification.

Therefore, in this process of change, two clearly differentiated types of relationships emerge: those established between the local actors of the traditional agro-industrial system, bound by strong connections (bonding ties), and those developed between the new actors that join the productive activity and the external companies that bring innovative knowledge to the activity (bridging ties). Here, the pipelines of these European companies, owners of plant nurseries adapted to the new super-intensive systems, play a fundamental role as transmitters in an interactive process with local farmers, building bridging capital that permeates the productive activity of the region.

The territorial impacts of these processes alter the relationships between actors, modify the strategic roles of organizations and, in the case of agriculture, change land use, natural resource management, and the participation of productive activities in the interterritorial division of labor. The final outcome of these transformations is uncertain and depends on the choices made by local actors in response to the challenges they encounter. Development processes are not linear, but rather the result of diverse interactions between their components. In the case of the Maghreb olive sector and other similar examples, the evolution of international olive oil markets, climate change, the management of

the scarce water for irrigation, technological dynamics and consumer needs and values all play a crucial role. These determining factors turn the process of regional economic development into a wicked problem, given the characteristics of path dependency and adaptive behavior. Addressing this complex problem therefore requires deep thinking to understand and navigate its intricacies⁸⁵.

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⁸⁵ Foster, 2005.

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