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Linkages of dietary patterns, international trade and land use: the case of olive oil in the European Union

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ABSTRACT

Within only two decades olive oil developed from a niche product which could hardly be found in food stores outside the producing regions towards an integrated component in the diets of industrial countries. This paper discusses the impacts of the promotion of the "healthy Mediterranean diet" on land use and agro-ecosystems in the producing countries. It examines the dynamics of olive oil production, trade and consumption in the EU15 in the period 1972 to 2003 and the links between dietary patterns, trade and land use. It analyses the underlying socio-economic driving forces behind the increasing spatial disconnect between production and consumption of olive oil in the EU15 and in particular in Spain, the world largest producer during the last three decades.
In the observed period olive oil consumption increased 16 fold in the non-producing EU15 countries. In the geographically limited producing regions like Spain, the 5 fold increase in export production was associated with the rapid industrialization of olive production, the conversion of vast Mediterranean landscapes to olive monocultures and a range of environmental pressures. High amounts of subsidies of the European Common Agricultural Policy and feedback loops within production and consumption systems were driving the transformation of the olive oil system. Our analysis indicates the process of change was not immediately driven by increases in demand for olive oil in non-producing countries, but rather by the institutional setting of the European Union and by concerted political interventions.

Keywords: olive oil; diet; land use change; common agricultural policy; European Integration; international trade; Mediterranean agriculture

Foreword

The presented research was developed at and funded from the Institute of Social Ecology, IFF Vienna, Klagenfurt University. The close relation to the Institute of Environmental Science and Technology (ICTA) from the Autonomous University of Barcelona (UAB) during my visit in 2008 strongly influenced the work and its present state. I am thankful to both institutions for their great support.
Preliminary versions of this paper, presented at the international conference of the European society of ecological economics, Ljubljana 2009, and at the international conference of the international society of industrial ecology, Lisbon 2009, were written at the Institute of Social Ecology, Vienna. This present version has been prepared with support from my present affiliation, ICTA-UAB, Barcelona.

1 Introduction

Olive trees are a crop well adapted to the climate and environment of the Mediterranean region. The production of olives is constrained to a comparatively small area in a few countries, most of them located in the Mediterranean. Olives are mostly used to produce olive oil, an important element of Mediterranean economy since antiquity and the characteristic component of the so called Mediterranean diet. Although an important crop with a long history of trade, olive oil consumption has largely been restricted to the producing countries. During the last years this has changed: Olive oil, praised as a healthy food, increasingly appeared in food stores in non producing countries and developed from an expensive niche product to a standard component of diets. At the beginning of the 21st century, European supermarkets offer more varieties of olive oil than of any other cooking oil. This observation of everyday life inspired us to investigate the changes in olive oil production and consumption. How much has consumption of olive oil actually increased? What is the impact of the hyped healthy Mediterranean diet on land use change in the production-regions? What are the drivers behind the growing significance of olive oil and what is the role of European integration and the Common Agricultural Policy in this process?

Olive and olive oil production has been studied from a variety of different angles: A number of studies have investigated the ecological pressures exerted from olive production (e.g. EFNCP, 2000; Avraamides and Fatta, 2008; Guzmán and Alonso, 2008; Gómez et al., 2009). Others have discussed agro-economic aspects and the dynamics of the olive oil market (Mili and Rodríguez-Zuñiga, 2001; Tasdogan et al., 2005), the EU policy framework and its effects on olive production systems (de Graaff and Eppink, 1999; Beaufoy, 2001; de Graaff et al., 2010) or development scenarios for specific olive farming systems (Stroosnijder et al., 2008; de Graaff et al., 2008).

We are interested in a more comprehensive picture and take a socio-ecological perspective. In this study we link changing consumption and trade patterns to changes in land use and the production system and associated pressures on the environment. We use a commodity flow analysis approach to quantify patterns of production, trade flows and consumption of olive oil over the last three decades at the global level, in Europe and in particular in Spain, the most important and dynamic country with respect to olive production. We analyze the socio-economic drivers behind these changes and in particular highlight the role of European integration and the Common Agricultural Policy for the evolution of the olive oil system during the last three decades.

In the past, studies addressing links between trade, changing consumption patterns and land use have been focusing on major global cash crops such as soy bean (Grau et al., 2005; Grenz et al., 2007); palm oil (Henderson and Osborne, 2000; Corley, 2009) or for example the banana (Soluri, 2002). We add a unique European case, which, to our knowledge, has never been looked at in such a comprehensive way before. The case of olive oil may not be of equal global importance, but due to the role of olive cultivation as an integral element of Mediterranean agriculture and traditional cultural landscapes it is of high regional significance. The paper addresses prominent issues in land use science which also have gained increasing political attention: Globalization of agricultural products (Lambin et al., 2001) and the increasing spatial disconnect

between production and consumption (Würtenberger et al., 2006; Erb et al., 2009) and its significance for land use change. We use the case of olive production to investigate drivers of land use change and in particular the role of policies and institutions in land use change. We aim to contribute to the question how patterns in resource use link to economic drivers and what are the resulting changes in land use and pressures.

In the next section of the paper the conceptual background and data sources are presented; this is followed by a quantitative picture of production, international trade and consumption of olive oil (globally and in the EU15). Section 4 and 5 relate the observed changes in olive oil production and trade to changes in land use and environmental pressures associated to changes in the production system in Spain. Section 6 outlines the significance of marketing, CAP and technological development for the changes in consumption and production patterns. Finally we discuss the interrelation of the main olive oil system components and identify feedback loops that facilitated the rapid changes on the olive oil system (Section 7). The paper closes with remarks on the transformation of the European olive oil system as well as on the relations between diet change, international food trade and land use change.

2 Methods and data

We take a socio-ecological perspective which understands society and nature as coupled systems that interact and are connected through physical exchange relationships (Fischer-Kowalski and Weisz, 1999). Hence, socio-economic processes (e.g. changes in consumption patterns, markets developments) can be linked to ecosystem changes (e.g. land cover changes due to farming) by looking at the material exchange processes between society and nature (e.g. olives and olive oil production) as well as at human interventions into ecosystems (e.g. establishment of olive farming systems) in order to alter the resource flows provided by nature (Haberl et al., 2004).

We quantify the flows of production, consumption, imports and exports of olive oil on different spatial scales (global, EU15 and Spain) within the period 1972-20031. For this purpose we use data published by FAO (FAO, 2005, 2008). Regarding system boundaries and accounting principles, this study follows the general standards of Material Flow Analysis (EUROSTAT, 2001, 2007). In our analysis, we distinguish between domestic supply (i.e. apparent consumption: domestic production plus imports minus exports plus stock exchange) and the use for human nutrition (food use). Food use includes both household consumption and use of olive oil in the food processing and the catering sector. Data on *food* use have been used to analyze changing dietary patterns. Data on *domestic supply* have been used to analyze changing total demand for olive oil. Note that differences between *domestic supply* and *food* use are of minor significance in non-producing countries. In producing countries, in which wider applications of olive oil exist, *domestic supply* of olive oil can be up to 50% larger than *food* use.

The data were analyzed for producing and non-producing EU15 countries[2], in order to identify the main developments of production and consumption in the EU15 countries

[1] From 2003 onwards, no comprehensive FAO data covering olive oil consumption are available.

[2] In 2004 and 2007, 12 new member states joined the Union. Except for Cyprus and Malta who have small olive oil production, all new members are non-producing countries and have a minor share in current olive oil consumption.

in relation to their cultural and geographical background (traditional vs. non-traditional markets). The producing countries (PC) in the EU15 are Spain, Italy, Greece, Portugal and France. The non-producing countries (NPC) are: Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, the Netherlands, Sweden and the United Kingdom.

With regard to the analysis of land use change and ecological impacts of olive oil production, we put an emphasis on the case of Spain, which is the worlds largest producer and exporter of olive oil. Quantitative and qualitative empirical data on olive farming in Spain were used to depict land use change. Land use data were retrieved mostly from the former Ministry of Agriculture, Fisheries and Nutrition (MAPA), the Institute of National Statistics (INE) and from the Andalusian Board (JA). Ecological impacts were assessed by a revision of literature and discussed in an expert meeting at the *Pablo de Olavide* University of Seville.

The discussion of the driving forces underlying the observed changes in production, trade and consumption of olive oil and ultimately in land use (Geist and Lambin, 2002) focuses on the institutional and organizational setting of the European and Spanish olive oil sector and in particular on the Common Agricultural Policy (CAP). Also changes in price trends and production technologies as well as resulting feedback mechanism are considered. Presented information regarding socio-economic drivers and their impacts on the olive oil system is based on an extensive literature survey and on an assessment of European Union law. Data on price developments were retrieved from the FAO databases (FAO, 2008d) and deflated using Implicit Price Deflators provided by the United Nation Statistical Division (UNSD, 2008).

3 Production, trade and consumption of olive oil, 1972-2003

The olive tree is native to the Mediterranean basin. It requires a mild climate but is draught resistant and can grow on poor soils and rocky hill sides (Tous and Ferguson, 1996). Olive cultivation is restricted to a comparatively small region: Global acreage of olive groves amounts to about 9 million ha (year 2005). More than 90% of this area is located in Mediterranean countries and about 50% in the three European Union member states Greece, Italy and Spain. France and Portugal together only account for about 4% (FAO, 2008). Spain is the country with the largest olive area: About 2.5 million ha or roughly 15 % of total cropland in Spain is covered by olive groves. More than 90% of Spanish olive area is dedicated to olive oil production; the rest is used for table olive production (MAPA, 1972-2007). About 100kg olives are necessary to produce 15 kg olive oil; depending on variety, oil yields range from 10% to 25% (EFNCP, 2000).

Global production, trade and consumption of olive oil have significantly changed during the last 35 years. From 1972/73 to 2002/03, olive oil production and consumption almost doubled and reached roughly 3 million tons in 2002/03. At this time, EU15 countries dominated global olive oil production with a share of 79% of total production and 70% of total consumption (Table 1). The only other countries which produce significant amounts of olives and olive oil are Tunisia, Turkey and Syria. A large share of the global trade with olive oil is intra-European trade: about 85% of the total olive oil exports of European producers (approximately one million tons, average of 2002-2003) are imported by EU 15 countries (UNCTAD, 2006).

Table 1
Olive oil consumption (domestic supply) and production in kilotons (kt) for selected region, 1972-2003.

Region	Production (kt)		Consumption (kt)	
	1972/73	2002/03	1972/73	2002/03
World	1492	2790	1693	2862
Europe	1266	2212	1349	2054
EU 15	1258	2206	1333	2012
Latin America &Caribbean	216	398	59	172
Asia	215	236	166	239
Africa	200	474	75	129
North America	0.1	1	32	235
Oceania	0.2	0.3	6	33

Source: Based on FAO, 2008b. Note: Data on production and consumption are averaged over 1972/73 and 2002/03.

In the EU15, the main producing countries Spain (59% of total production in 2003), Italy (24%) and Greece (15%) are also the main consuming countries; they account for 86% of total olive oil consumption in the EU. Portugal and France together consume 8%, whereas all non-producing EU15 countries together end up with only 6% of total olive oil supply.

Urban lifestyles and growing wealth have lead to globally changing dietary patterns, resulting in diets which contain higher amounts of oils/fats and sugar (Drewnowski, 2000). Since the 1970s, availability of edible oils has increased in developing and developed countries by 124% and 50% respectively (WHO, 2002). In the EU15, from 1972/73 to 2002/03, total food consumption of edible oils has increased from 4.5 to 7.2 million t/y and per capita consumption increased by 43% from 13 to 19 kg/cap/y (FAO, 2008b). Four categories of edible oils account about 80% of total edible oil consumption: sunflowerseed-, olive-, rape-mustard and soybean oil[3]. Each oil type accounts for a more or less equal share of roughly 20% of total consumption, but the significance of specific oils varies among countries. In particular, with respect to olive oil, distinct cultural and geographical backgrounds become visible: In the producing countries (PC), olive oil accounts for about 40% of total food consumption of edible oils, whereas in the non-producing countries (NPC) it has reached a share of 4% in 2003. Although comparatively low, the share of olive oil in the diet of non-producing countries has increased significantly.[4] In 1972 olive oil accounted for only 0.4% of

[3] The remaining 20% comprise of palm-, palm kernel-, maize germ-, groundnut- cottonseed-, and sesame seed oil.

[4] Food consumption of edible oils includes both direct consumption in households and the oil used in food processing industry (e.g. deep-fried food) as well as in the catering. Since olive oil is by far the most expensive edible oil (in 2003 producer prices of olive oil ranged between 2000 and 3000 USD/t, whereas prices for palm oil, sunflower and rapeseed oil ranged between 450 and 600 USD/t (UNCTAD, 2006), its use in the food processing industry is less significant, in particular in the non producing countries. We therefore assume that growth of olive oil consumption in the non producing

edible oil consumption in these countries. In the same period, overall consumption of edible oils has grown by nearly 60% (FAO, 2008b).

Table 2
Per capita consumption (food) of olive oil (liter/capita/year) in selected EU15 countries

Region	***Country***	***1972/73***	***1982/83***	***1992/93***	***2002/03***
Producing countries	Spain	9.8	10.4	12.7	12.9
(EU15)	Italy	13.4	11.5	12.6	14.4
	Greece	23.3	22.4	20.0	16.7
	Portugal	7.6	5.0	4.3	5.5
	France	0.4	0.4	0.7	1.8
Non-producing	United Kingdom	0.06	0.05	0.2	0.7
Countries	Germany	0.06	0.09	0.2	0.5
(EU15)	Austria	0.05	0.07	0.2	0.6
	NPC average	0.05	0.07	0.2	0.6

Source: Based on FAO, 2005, 2008b. Note: Data on consumption are averaged over the indicated years.

Table 2 shows the per capita level of olive oil consumption for human nutrition in different European countries. It exhibits the large differences in olive oil use between different geographic regions. The main producing countries show extremely high levels of consumption, reaching more than 20 l/cap/y in Greece. In the non-producing EU15 countries, consumption is below 1 l/cap/y, but has increased more than tenfold during the last 30 years to 0.6 l/cap/y.

This increases in per capita consumption resulted in a significant growth of olive oil demand in non-producing EU15 countries. Figure 1 shows that during the 1970s, domestic supply of olive oil in all NPC was stable at a low level of roughly 10kt/y, but began to increase drastically in the eighties. From 1980 to 2003 it has grown by a factor 16 at an exponential growth rate and reached 130kt/y. (A similar picture can be found regarding olive demand in NPC, only that the increase is more continuous (not shown)).

countries was driven primarily by increases in consumption at the household level and reflects changes in dietary patterns.

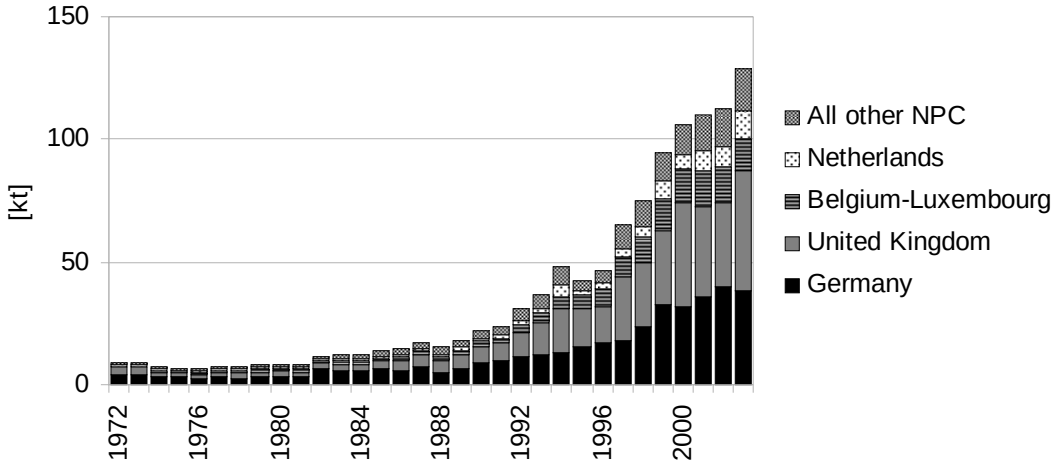

Figure 1: Domestic supply of olive oil in the non-producing EU15 countries, 1972-2003.
Source: Based on FAO, 2008b.
Note: kt = kilotons; NPC = Non-producing countries („all other NPC" are Austria, Denmark, Sweden, Finland, Ireland).

These changes in dietary patterns in non-producing countries directly relate to changes in production and trade of olive oil in the producing countries. Fig. 2 shows the development of olive oil trade, production and domestic supply of the world's largest olive oil producer Spain, in the period 1972–2003. With a three-fold increase in production (nearly 1.5 million tons of olive oil in 2003), Spain holds a share of 59% of total EU15 production. Production was already slightly growing during the 1970s, but started to increase in the 1980s, followed by a massive augmentation in the 1990s. Annual fluctuations are due to the ecology of olive trees that, under habitual conditions provide yields every two years. This effect is amplified by climatic conditions such as severe drought in the 1990s (González de Molina, pers. com., 2008).

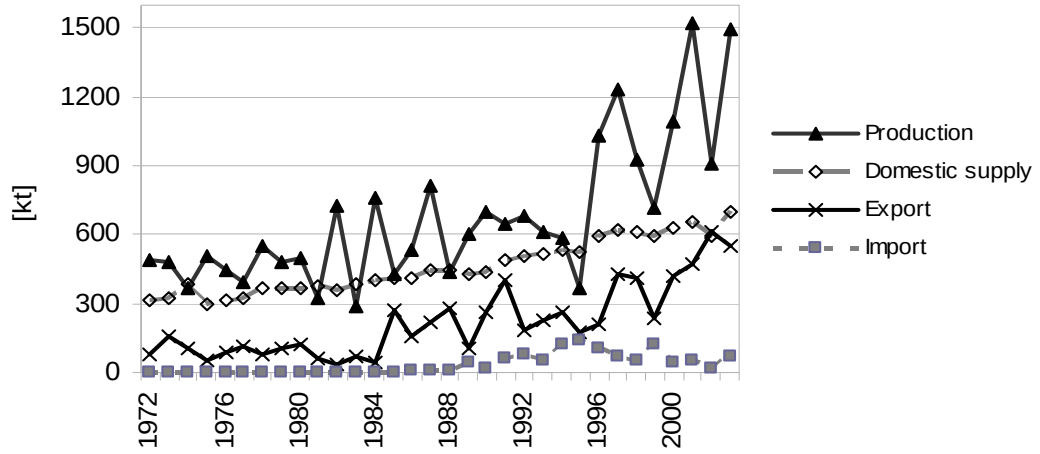

Figure 2: Production, domestic supply, import and export of olive oil, Spain, 1972–2003.
Note: kt = kilotons.
Source: Based on FAO, 2008b.

Regarding olive oil trade in Spain, imports have always been relatively low. A significant change occurred in the development of export volume: From 1985 on, one year before Spain's EU accession, it has increased more than five-fold from roughly 100kt/y in the period 1970s to 1985 to 554kt, reaching roughly the same level as domestic supply. Thus, until 1985, Spanish agriculture produced olive oil mainly for the domestic market. After 1985, the rapid increases in export quota indicate a shift towards a production for export. The Greek olive sector shows a very similar development, just that export quotas began to increase already in 1981, when Greece joined the EU (not shown).

Table 3 shows, that the EU15 is the most important foreign market for Spanish olive oil: 70-80% of the olive oil exports of Spain are exported to other EU15 countries. But within the EU15, only a small share of less than 10% (with the exception of 1986) reaches non-producing countries directly. Interestingly, the most important trade partners are other producing countries. Among them Italy is the most significant recipient and imports up to 60% of total Spanish olive oil exports.

Table 3
Olive oil trade flows from Spain and Italy into selected regions.

Olive oil exports from Spain	**Unit**	***1986***	***1990***	***1995***	***2000***	***2003***
Total	[kt]	150.6	241	165.4	397.4	511.8
	[%]	100	100	100	100	100
Imported by the EU15	[%]	71.9	79	73	76	80
Imported by NPC (EU15)	[%]	30.4	2.5	7.1	7.6	6.9
Imported by PC (EU15)	[%]	41.6	76.5	65.9	68.5	73.1
Imported by Italy	[%]	30.7	58.2	26.1	43.4	48.9

Olive oil exports from Italy	**Unit**	***1986***	***1990***	***1995***	***2000***	***2003***
Total	[t]	77.8	109.1	159.3	307	277
	[%]	100	100	100	100	100
Imported by NPC (EU15)	[%]	5.6	10.7	16.6	21.3	26.8
Imported by Australia, Japan, Canada, USA	[%]	43.2	58.6	52.6	60.6	51.6

Source: Based on FAO, 2008c. Note: PC=Producing Countries, NPC=Non-producing countries; kt =kilotons.

Within the observed time period (1972–2003), international trade has always been a central component in the Italian olive oil sector: Domestic supply (814kt in 2003) is constantly higher than domestic production (663kt in 2003) and the import volume has increased massively from the 1980s on, reaching 518kt in 2003, whereas exports (312kt

in 2003) are significantly lower than imports (FAO, 2008b). Italy has a well established trade with non-producing EU15 countries, which imported 26% of all olive oil exported from Italy in 2003. The most important regions of consumption outside Europe - Australia, Japan, Canada and the US - are importing around 60% of exported Italian olive oil.

Even though Italian olive oil production and exportation is lower in comparison with Spain, Italy has a higher market power (Tasdogan et al., 2005) and a different position in the global olive oil market. Primary production of olive oil was more and more replaced by imports of olives and olive oil, above all from Spain. It can be assumed, that this relates to different price levels of olives in Italy and Spain, which was a deprived country at the time of EU-accession and had a much lower income level. In the period 1991–1995, average producer prices of olives from Spain were about 775$/t, whereas prices of olives from Italy were 50% higher (FAO, 2008d). A large part of imported olive oil coming from Spain, Greece and Tunisia leaves Italy in a refined form and is sold in overseas markets like the USA as "Imported from Italy". According to the Italian bulk producer Filippo Berio[5], not more than 20% of this olive oil comes from Italian olives (Levy, 2004).

4 Land use changes regarding olive production in Spain, 1972-2005

It has been shown (Figure 2) that production of Spanish olive oil has tripled during the last three decades. The fact that more than 90% of Spanish olive area is used to grow olives for oil production (MAPA, 1972-2007) shows the strong link of the olive oil sector to the olive farming systems. Olive groves show a high diversity in their structure and several ways of classifying types of olive farming have been suggested. In our analysis we discuss olive related land use changes on a national and regional scale and therefore focus on aggregated land use data. By distinguishing traditional versus intensive olive farming, we follow the line of EFNCP (2000) and Viladomiu and Rosell (2004) who distinguish between different degrees of industrialization (low input – low output systems vs. high input – high output systems) as well as on important structural qualities (location, tree density, management, etc.).

Olive and olive oil production was increased by a combination of both an expansion of olive area and yield per unit of area (Figure 3 and 4). Fig. 3 shows the development of rain fed and irrigated olive grove area in Spain and Andalusia since 1972. In the 1970s, a slight decline in the rain fed olive area was noticeable in Andalusia as well as in the rest of Spain. This was the result of the reconversion plan of 1972 (Plan de reconversión y reestructuración del olivar), that led to grubbing out traditional olive plantations. This national policy was adopted, because traditional olive farming had been recognized as unadaptive to the socio-economic conditions of the 1970s (Naredo and Guzmán Álvarez, 2007) when harvesting costs went up (Sánchez Martínez et al., 2008). After this initial decline, total olive area began to grow slowly in the middle of the 1980s. Growth accelerated in the 1990s, when cultivated area was expanded by about 30000ha every year (average1991-2000), reaching a record area of nearly 2.5 million ha in 2005. The increase in area was driven by the vast extension of irrigated plantations (Fig. 3) that have grown by a factor 4 from roughly 100000ha in 1985 to 400000ha in 2005 in only 20 years.

[5] www.Filippoberio.com

As shown in Fig. 3, this increase of irrigated area was mainly located in Andalusia. The commercialization and specialization of the Spanish olive oil sector has enforced the already in the 1970s apparent regional concentration of olive farming in Andalusia. Nowadays, it is the most important producing region world wide. 60% of the total Spanish olive grove area and more than 80% of irrigated plantations are located in Andalusia, in which 47% of the total cropland area is covered by olive plantations (MAPA, 1972-2007; INE, 2008). The increasing use of irrigation in Andalusia, a region that is gravely facing water scarcity and desertification, is a major sustainability issue in the region (Velázquez, 2007).

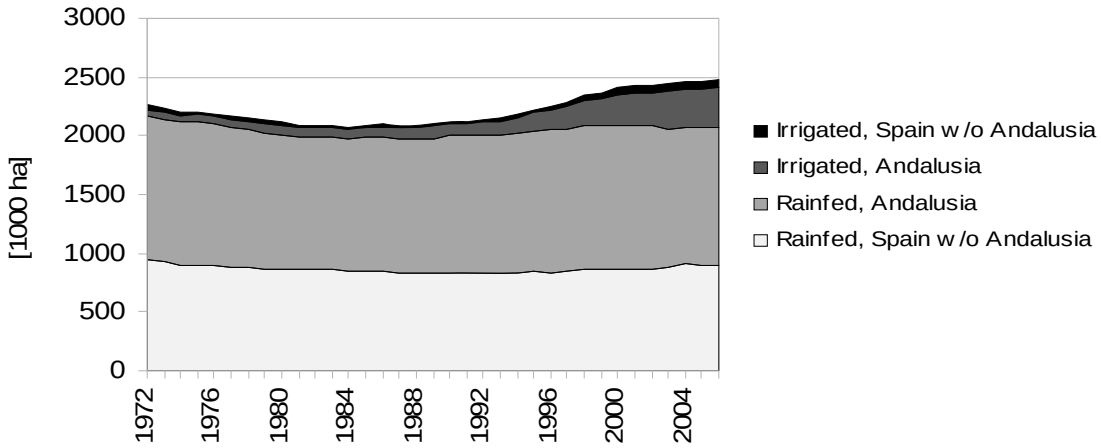

Figure 3: Total area of irrigated and rain fed olive plantations in Spain, disaggregated for Andalusia and the rest of Spain, 1972-2006.
Source: Based on MAPA, 1972-2007.

The extension of cultivated area was accompanied by an intensification process as well as by a structural change of land use patterns in the main producing regions. Novel production technologies massively increased land and labor efficiency of olive production. Even though total labor requirement is lower in traditional systems, labor productivity is almost twice as high in modern production systems (Viladomiu and Rosell, 2004).
Figure 4 shows that average annual yields of Spanish olive production have increased from around 1000kg/ha in the 1970s to more than 3000kg/ha around the year 2000. In intensified, modern plantations maximum yields can reach up to 15000kg/ha (Guerrero García, 2003). This increase in land productivity was the result of subsequent adoption of irrigation measures (ranging from 1500 – 5000m3/ha/y), mechanization, and the increasing application of agrochemicals (up to 390kg nitrogen/ha in the 1990s) (EFNCP, 2000). Further, olive groves were increasingly planted with high tree densities in lowland areas and in many cases, traditionally cultivated olive trees were grubbed out and new groves were replanted to make industrialized farming systems possible (Sánchez Martínez et al., 2008). While traditionally rain fed olive trees were grown mainly on marginal soils, industrial olive groves expanded primarily into agricultural land with high quality soils (Araque Jiménez et al., 2002).

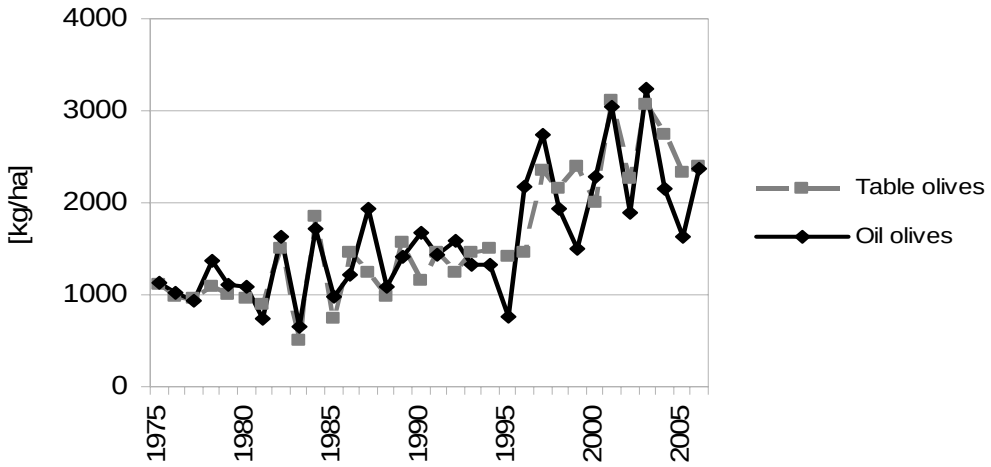

Figure 4: Average annual yields of Spanish olive production, 1972-2006.
Source: Based on MAPA, 1972-2007.

Fig 5a and 5b illustrate the drastic changes in land cover and land use in Southern Spain that are associated with changes in olive production. Fig 5 shows an areal image of the village Arjona in Andalusia and the close by fields. In 1956 (5a) a diverse land use mix of different crops and grassland can be identified. 50 years later in 2008 (Fig. 5b), an areal image of the same region shows a completely altered landscape: Practically all fields were converted into olive plantations (every black dot on the picture is an olive tree) and the olive trees were extended over the fertile land and converted into olive monocultures. The case of Arjona is not just a single example. This is a common pattern of development, which can be observed all over Andalusia (Sánchez Martínez et al., 2008). The changes in the Spanish olive oil sector relate not only to the extension and intensification of olive farming (in Andalusia), but to a structural transformation of the Mediterranean landscapes.

Figure 5a: Diverse land use patterns around Arjona (Jaén), Andalusia, in the year 1956.
Note: White line = 1km.
Source: JA, 2008, accessed through Google Earth.

Figure 5b: Olive monocultures around Arjona (Jaén), Andalusia, in the year 2008.
Note: White line = 1km.
Source: JA, 2008, accessed through Google Earth.

5 Environmental impacts of olive farming in Spain

The high ecological adaption of olive trees to the Mediterranean climate and to marginal soils and the many positive ecological functions associated with traditional olive growing as well as the seasonal complementary labor requirement of olive cultivation to traditional agriculture[6], made traditional olive farming an adequate and sustainable type of Mediterranean land use (Montiel Bueno, 1998; Araque Jiménez et al., 2002; EFNCP, 2000). The rapid intensification of olive groves based on the large scale application of agrochemicals, irrigation and mechanization together with the extension and regional concentration was related with a number of environmental impacts.

Landscape and biodiversity

Due to their structural diversity, traditional olive plantations show high habitat diversity. Plantations on terraces, supported by stone walls, with old trees and understory, and low uses of herbicides and pesticides offer many different types of habitats for flora and fauna (EFNCP, 2000; Montiel Bueno, 1998). The disappearance of the originally diverse land use patterns and the changes in the olive farming practices have resulted in a massive reduction of ecological infrastructure which is related to a drastic decrease in biodiversity. The regional concentration of olive production in Andalusia has transformed landscapes into wide areas of monocultures (Sánchez Martínez et al., 2008).

Soil

Soil erosion caused by olive farming is a central and largely irreversible problem in Spain (de Graaff and Eppink, 1999; EFNCP, 2000; Fleskens and Stroosnijder, 2007). In intensified plantations, olive trees have been cultivated on naked soils through tillage and/or repeated use of herbicides. The ground is kept free of weed to avoid competition for nutrients and water and productivity can be increased up to 25% per tree (Guerrero García, 2003). Cultivation on naked soils results in high levels of water run-off and soil erosion, especially in farming systems on inclined terrains without traditional terraces. In the 1990s, when intensified plantations were largely extended in Andalusia, soil erosion rates increased drastically. The Andalusian board (Junta de Andalucía) reported average annual erosion rates of Andalusian olive groves at 62t/ha/y topsoil loss. The most affected 15% showed average top soil losses of 92t/ha and the least affected 15% of total olive plantations showed average top soil losses of 36t/ha (JA, 2002), while the annual rate of top soil regeneration has been estimated at merely 2-12t/ha (EFNCP, 2000). Top soil loss results in decreasing soil fertility and increasing desertification. This leads on the one hand to a decline in agricultural productivity and economic losses and on the other hand to growing dependence on external inputs like fertilizers, to counteract losses in productivity see (Colombo, 2004). The problem of soil erosion has lead to political measures like the National and Andalusian Action Plan against Desertification and to the compulsory application of good farming practices (JA, 2006; Gómez et al., 2009).

Water

The water-intensive sectors tourism and agriculture are an important part of the economy in Andalusia, a region that faces serious water scarcity (Velázquez, 2007). The

[6] The main labor requirement of olive farming is during the harvesting period from December to February.

enormous increase of irrigation in olive farming has resulted in rising agricultural water demand. In the catchment area of the Guadalquivir[7], the agricultural sector accounts with an annual consumption of 2,9 million m^3 of ground- surface- and re-used water for 80% of total socio-economic water consumption in this region (CHDG, 2005). Assuming an average irrigation rate of 2.200 m^3/ha/y (Hidalgo et al., 1998), the 325.000 ha that are located in the catchment area consume (additionally to rainfall) about 715 million m^3 water from surface- and groundwater reservoirs. This corresponds to 25% of total agricultural water consumption in the catchment area. Data from Cyprus indicate, that more than 3900 liters of water are needed to produce 1 liter of olive oil (Avraamides and Fatta, 2008).

Contamination of water, soils and air

Industrial olive production requires high inputs of fertilizers and herbicides (Guerrero García, 2003). The use of these agrochemicals in olive cultivation is often associated with the contamination of soils and water bodies (Lizana et al., 2005). The application of herbicides can result in air pollution in intensified plantations, especially through the application of aerial sprays against the olive fly (EFNCP, 2000).

Avraamides and Fatta, (2008) estimate CO_2-, NO_X- and SO_2 emission per liter of olive oil at 3,9kg, 32,2g and 13,7g, respectively. 90% of these emission result from olive cultivation. Spanish olive plantations show average yields of 3000 kg/ha (Fig. 4) which allows the production of 500 liter olive oil per hectare[8]. Using the average emission values of Cyprian olive oil production implicates average annual emission of 1755kg CO_2, 14,5kg NO_X, and 6,2kg SO_2 per hectare caused by olive farming in Spain.

Because of widespread olive pollen allergy, biological air pollution caused by high olive pollen concentrations is a serious problem in Andalusia. Especially during the 1990s olive pollen concentration has increased significantly (Belmonte, pers. com., 2008; De Linares, pers. com., 2008).

6 Drivers of change in the European olive oil system

It has been shown in the previous sections, that the European olive oil system has undergone a rapid transformation process. A major component of this transformation has been globalization: Within only a few decades olive oil turned from a product of regional significance towards an important component in the diet of many industrialized countries. Trade flows have increased much faster than demand in producing countries and are directly interrelated with the expansion of cultivated areas and intensification of land use. This has increased the pressure on local agro-ecological systems and was associated with significant environmental degradation. In the following section we discuss the socio-economic drivers underlying the changes in consumption, trade and production patterns and ultimately in land use.

Marketing and diet change:

100 years ago the quality of olive oil had been considered so low that exports to

[7] The Guadalquivir is the fifth longest river in Spain. 90% of its catchment area is located in Andalusia.

[8] 100 kg of olive are needed to produce 15kg olive oil, its specific gravity is 0.9 (FAO and WHO, 2001).

England were used as burning fuel for street-lamps (Guzmán Álvarez, 2007). Today olive oil has gained status in the kitchens of the industrial world. It is not just another type of edible oil, but has captured the market as a product that stands for quality and health. The "healthy Mediterranean diet" is booming as an alternative to diets rich in animal fats.

Olive oil promotional campaigns have been organized by different organizations. The International Olive Oil Council (IOOC) emphasizes a wide range of positive health effects with respect to anti-aging, cardiovascular diseases, blood pressure, diabetes, pregnancy and even obesity (IOOC, 2009). Its worldwide promotion campaigns in non-producing countries were partly financed by the EU with annually €5 million until 2002, and afterwards €0.5 million (EC, 2003a). EU promotional campaigns, financed by a levy on consumption aid of the olive oil CAP regime (this section, Table 7), stimulated constantly olive oil demand. In the period 1985-2000, more than €150 million were spent on such campaigns (Astrup et al., 2000). Another €35 million were provided for the VII promotional campaign in the period 2000-2002 (EC, 2003). One of the results was the international consensus statement "Olive oil and the Mediterranean diet: implications for health in Europe"[9] (Assmann et al., 1997) which was sent to European health centers (Astrup et al., 2000).

The National Food Trade Promotion Organization (NFTPO) of Spain, ICEX[10], has also played an important role in the marketing activities for olive oil. NFTPOs have emerged in many European countries (e.g. Food from Britain (FFB) in the UK) mainly in the 1980s and have the objective to promote agricultural products on national and international level.

Table 6

The promotion of olive oil by the Instituto Español de Comercio Exterior (ICEX) and the comparison of ICEX and Food From Britain (FFB), 1990.

NFTPO	Budget	Promotion (%)		Market priorities	Product priorities
		Domestic	Overseas		
ICEX (Spain)	€ 65 Million	0	100	1.) USA 2.) Germany 3.) UK 4.) Netherlands	1.) Wine 2.) Olive oil 3.) Fruit and vegetables
FFB (UK)	€ 9 Million	50	50	1.) France 2.) USA 3.) Germany 4.) Benelux	1.) Products, containing cereals 2.) Dairy products 3.) Meat products

Source: adapted from Nicholls et al., 1991; Nicholls et al., 1992.

In the beginning of the 1990s, as olive oil consumption in non-producing EU15 countries was about to take off, the ICEX showed in comparison to the FFB a relatively

[9] Many studies have criticized lacking reliability and objectivity of the consensus statement (see Astrup et al., 2000).
[10] Instituto Español de Comercio Exterior.

high budget of €65 million, which was spent only on the promotion of Spanish products abroad (Table 6). Olive oil has been a prior product of promotion and Germany as well as the UK, nowadays the largest non-traditional consumers (see fig. 1), have been prior market targets. The promotion of the healthy Mediterranean cuisine was an important driver in the establishment of new dietary patterns in non-producing EU15 countries.

The EU Common Agricultural Policy:

The Common Agricultural Policy (CAP) of the EU, with its main objectives of encouragement of agricultural productivity, market stabilization and the livelihood protection of European farmers, had massive influence on the development of the European olive oil system, by promoting olive oil consumption, trade and production. The two main types of policies before the CAP reform of 2003 had been market based policies to support products and producers (market regimes) and structural policies to improve production systems and infrastructure.

The olive oil sector has benefited from structural aid as well as from the market regime for oils and fats, dating back to 1966[11]. In the market regime, the support of the olive oil sector was justified by the importance of olive oil production and consumption in certain regions of the community. The main policy instruments had been production and consumption aid, price supports and trade barriers with third countries to avoid cheap olive oil imports (EC, 1966, 2003). For large producers (more than 500kg oil/year), production aid was paid in direct proportion to the amount of oil they produced, small producers (less than 500kg) received an aid per tree. On the national level, production aid was limited to a national guaranteed quantity. Consumption aids were paid as export subsidies and as support for promotional campaigns.

Table 7
EU subsidies for the olive oil sector, 1975-2003 (annual averages, rounded)

Subsidies (million €/year)	***1975***	***1976-80***	***1981-85***	***1986-90***	***1991-95***	***1996***	***1998-2003***
Production aid	n.a.	n.a.	429	542	934	1792	---
Consumption aid	n.a.	n.a.	183	419	675	132	---
Other	n.a.	n.a.	148	180	140	84	---
Total	**160**	**251**	**760**	**1.141**	**1.749**	**2.008**	**>2.300**

Source: Data until 1980: Friedeberg, 1983; data from 1981-1996: EC, 1997; data from 1998 - 2003: EC, 2003. Note: n.a. = not available.

Table 7 shows the development of EU subsidies for the European olive oil sector. A massive increase from annually €160 million in 1975 to annually more than €2300 million in 1998-2003 can be seen. The significance of these institutional measures in relation to international trade becomes clear, when the amount of CAP subsidies are

[11] Regulation Nr. 136/66/EEC (EC, 1966).

compared with the annual average export value of total olive oil exports of all producing countries in the EU15: In the period 1991-95 annual average export volumes amounted to €1100 million, while subsidies to the olive oil sector were about €1749 million (based on (FAO, 2008c).

The development of the olive oil sector required the reformation of the CAP support system (UNCTAD, 2006). The 1998 reform[12] of the market regime for oils and fats abolished the aid per tree system as well as price supports. This interim regime assigned production aid as main policy measure, set at €132,25 per 100kg olive oil until 2004[13,] which corresponds to a total annual budget of around €2,3 billion (EC, 2003). In 2004, the olive farming sector was integrated in the single farm payment scheme, in which production based subsidies were abolished and cross compliance has become obligatory (de Graaff et al., 2010).

The high amounts of production aid paid until 2004 have to be considered as one of the most important driving forces for the development of the sector. These subsidies, paid in direct proportion to the produced oil, were a strong incentive to increase yields through intensification (de Graaff and Eppink, 1999; Beaufoy, 2001), because the more olive oil the farmers produced with a given area, the more subsidies they could receive. A new production paradigm in Spanish olive farming, favoring highly intensified plantations, had been fostered in this period.

Technological development

The efforts at the European level were accompanied by Spanish policies supporting the development of new technologies to increase land- and labor efficiency of olive production. In 1992, the Andalusian board (Junta de Andalucía) together with private olive farmers initiated R&D programs for the development of an effective irrigation system. The strong incentives of the CAP to increase yields as well as drought periods in the beginning of the 1990s, that resulted in significant losses in production (see Fig. 2), were the main drivers for this development (Hidalgo et al., 1998). The so called *fertirrigation* system, a drip system that allows for precise irrigation according to the seasonal needs as well as the adequate application of fertilizers through the irrigation system (Guerrero García, 2003) revolutionized olive oil production and drastically increased land productivity. Its effects on olive farming in Spain are reflected in the increase of irrigated area and yields per hectare after 1992 (see Fig. 3 and 4).

7 Interrelations of diet, trade and land use in the case of olive oil

The dynamics of change in the European olive oil system are shown in Fig. 6. It compares the development of olive oil consumption in the non-producing EU15 countries, irrigated olive area in Spain and olive oil gross-exports[14] of all producing EU15 countries. From 1972 until 1980 all three components remained more or less stable. Gross-export volume of all producing countries was the first component that began to increase: It doubled shortly after Greece joined the EU in 1981, followed by

12 Regulation Nr. 1638/98 (EC, 1998).

13 Initially, production aid were set until 2001, but than extended until 2004. See Regulation Nr. 1513/2001 (EC, 2001).

14 In contrast to the net-exports shown in Fig. 7, gross-exports of all producing countries indicate export activity, regardless of imports. It therefore contains also trade flows between producing countries.

Spain in 1986. From that point on, gross-export volume of the producing countries has grown continuously. It has roughly reached the seven-fold volume in 2001. Slowly and with a certain delay to the increasing gross-export volume of the producing EU15 countries, also olive oil consumption in the non-producing EU15 countries has started to increase. Growth accelerated at an exponential rate, resulting in the observed sixteen-fold increase in less than 25 years in the period 1980-2003. Irrigated olive area in Spain grew slowly during the eighties, but showed a sudden increase beginning in 1993, one year after R&D programs of Andalusian board regarding irrigation had started (see above). It quadrupled until 2003.

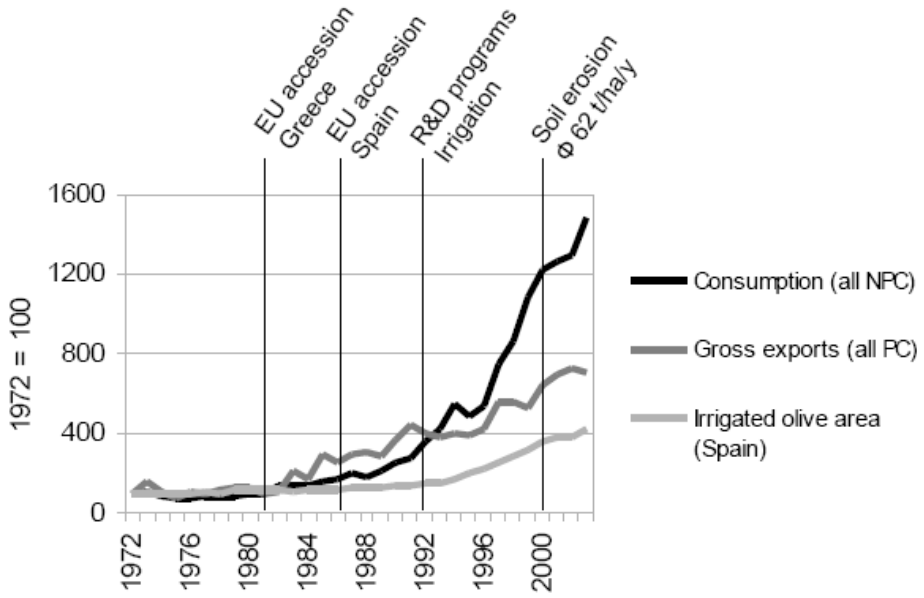

Figure 6: The dynamics of olive oil consumption, olive oil gross exports and irrigated olive area for selected regions within the EU15, 1972-2003.
Note: Graphs are indexed, 1972 = 100; Gross exports (all PC) = Sum of export of all producing EU15 countries. Consumption (all NPC) = Sum of domestic supply of all non-producing EU15 countries. Black lines indicate important years, that relate to the development of the European olive oil system.
Sources: see text.

As shown here and in section 6, institutional factors played a crucial role in the evolution of patterns of diet, trade and land use. With the accession of Greece and Spain to the European Union, the olive oil sector came under the rule of the Common Agricultural Policy. Tariffs and trade barriers were abolished and replaced by export subsidies for olive oil, facilitating the export of olive oil within the community (EC, 1966, 2003). This is reflected in the rise of exports in Figure 6 in the years after Greece and later Spain joined the EU. Further, the analysis shows an interesting relation between olive oil supply and demand in non-traditional markets (Fig. 6 and 7). It seems that increasing consumption and diet change in the non-producing EU15 countries have been the effect of a created market, in which consumption patterns in non-traditional markets follow with a certain delay the promotional campaigns and rising gross export production, rather than being the initial driver of rising exportation. In the case of olive oil, it seems that supply has driven demand, whereas both components were fostered by

the massive institutional measures of the EU Common Agricultural Policy.

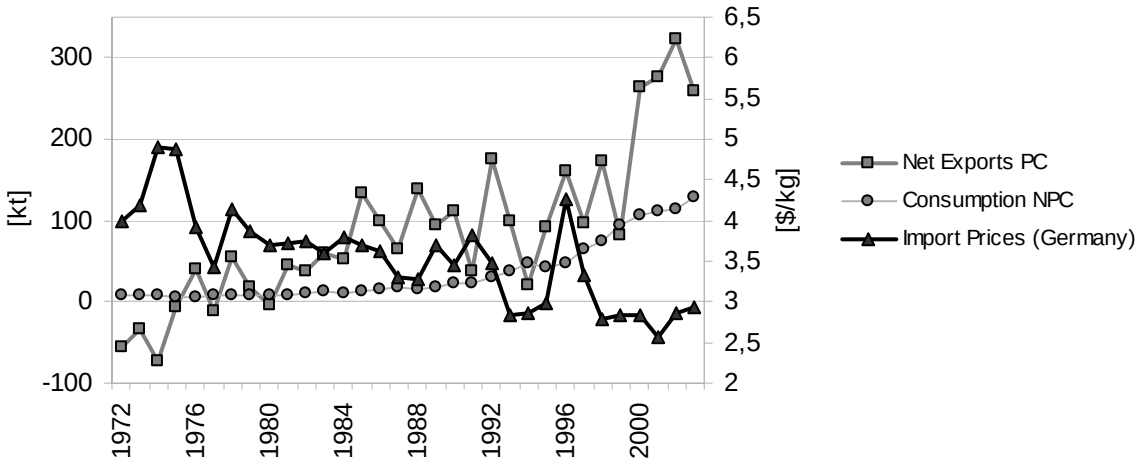

Figure 7: The development of import prices of virgin olive oil (Germany), olive oil consumption in the non-producing countries (NPC) and olive oil net-exports of all producing countries (PC) in the EU15, 1972-2003.
Note: Primary Y-Axis: Net-Exports (PC) and consumption (NPC) [kt = kilotons]; secondary Y-axis: Import prices [$/kg]; Net-exports PC = Sum of olive oil exports minus olive oil imports of all producing countries of the EU15; Consumption NPC = Domestic supply of olive oil of all non-producing countries; Import prices of virgin olive oil, Germany (constant prices, 1990, $/kg).
Sources: Based on FAO, 2008b; FAO, 2008d; UNSD, 2008.

Two positive feedback loops can be identified as important triggers of the transformation of the olive oil system (for a chart see Fig. 8):
The interactions between the CAP subsidy system, technological development and production volume form a positive feedback loop driving changes in the production system. The production based subsidy system, which was at work until 2004, provided a strong incentive to develop new production technologies. New technologies boosted yields and the overall amount of olive oil production (see Fig. 4) and lowered relative production costs through economy of scale effects (see Viladomiu and Rosell, 2004). Increasing amounts of production subsidies could be received and allowed for further investments into production technology and for the expansion of this type of olive plantations (see Fig. 3). This further increased olive oil production, and exportation rates were growing constantly (Fig. 6 and 7), stimulated by the CAP export subsidies.

The interaction between the promotion of the Mediterranean diet, the CAP subsidy system and declining product prices form a positive feedback loop driving consumption in non producing countries. The stimulation of consumption outside the producing region by EU, IOOC and ICEX has allowed for growing export rates (Fig. 6 and 7). With the decrease in relative production costs, CAP export subsidies, and the rising availability of olive oil in the global market, import prices of virgin olive oil in non-producing EU15 countries started to fall. In the case of Germany – the largest consumer in the NPC – import prices of virgin olive oil declined from averagely more than 4$ in the 1970s to less than 3$ in 2003 (Fig. 6), which made olive oil more

affordable over time[15]. This further stimulated demand in non-producing countries (Fig. 6)[16].

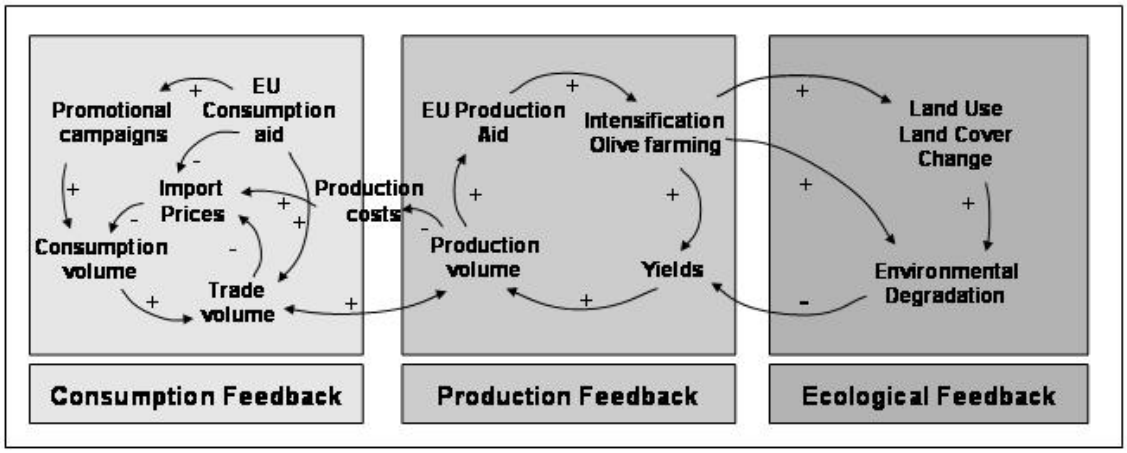

Figure 8: Feedback-loops within the European olive oil system. Source: own elaboration

These rapidly evolving positive feedback loops interrelate with negative feedbacks on an ecological time scale. The emergence of olive production as global cash crop and the related intensification of the production system have altered agro-ecosystems and lead to significant environmental degradation (see section 5). While some negative consequences may only appear in the future, the high levels of soil erosion in the 1990s already now have negative effects on olive farming: Natural productivity of soils has decreased (Colombo, 2004) and the maintenance of production levels requires high inputs of agrochemicals and ground water.

8 Conclusions

Production and consumption patterns of olives and olive oil underwent a fundamental transformation. It is striking how rapidly a crop, which has been particularly valued for its adaptation to the specific climatic limitations of the Mediterranean and its frugality has been converted into an industrial cash crop based on irrigation, agrochemical inputs and mechanization. The transformation of the production system took less than 20 years and had fundamental impacts on Mediterranean agro-ecosystems and landscapes. The emergence of new markets played a decisive role in that process. Our analysis indicates that the transformation was not immediately initiated by consumer driven increases in demand for olive oil in the non-producing countries but rather by concerted political interventions which simultaneously drove industrialization of olive production in the producing countries and created new markets for olive oil in non-producing countries. It was the integration of the producing countries into the European market in combination

[15] Import prices (constant, 1990) have been calculated for all non-producing countries in the EU15: They all show the same trend.

[16] As it can be seen in fig. 6 the 1970s, the producing region had been net-importer of olive oil, an interesting fact, if one takes into account that nowadays producing European countries are the largest exporters in the world (UNCTAD, 2006). This was mainly due to the fact, that in the 1970s, Italy had low export rates and very high import rates.

with export and production subsidies and offensive marketing strategies that created this new market, enhanced by positive feedback loops, which soon obtained a momentum of growth.

Olive oil is another example for the increasing spatial disconnect between producing and consuming regions as a consequence of the globalization of the food system (Erb et al., 2009; Kissinger and Rees, 2009). The olive oil case shows, how changes in food trade and food consumption patters, in this case with the positive connotation of a shift towards a healthier diet, effect land use and agro-ecosystems in distant regions. In particular for products with a distinct regional character such as olive oil, the creation of new markets may cause substantial environmental pressure in producing regions. The globalization of the food system allows consumers to overlook the environmental consequences of their consumption patterns. But our analysis also emphasizes the significance of institutional factors and political interventions in the evolution of food consumption, trade and production systems and thus questions the effectiveness of environmental campaigns targeting on individual consumption patterns and underlines the importance of environmental governance (Paavola, 2007). Environmental consequences of international agricultural trade are complex, nevertheless they should be better included into agricultural policies like the CAP and international trade agreements in order to guarantee sustainable global production chains and avoid global shifts in environmental pressures.

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