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TESIS DOCTORAL

ANÁLISIS DE LA ESTRUCTURA PRODUCTIVA Y TERRITORIAL DE LAS PEQUEÑAS EXPLOTACIONES OLIVARERAS EN ANDALUCÍA.

CUANTIFICACIÓN Y PROPUESTAS PARA UNA GESTIÓN ÓPTIMA.

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UNIVERSIDAD DE JAÉN

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Aspirante al grado de doctor

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Jaén, enero de 2019

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ÍNDICE

		Páginas
RESUMEN		1-2
LISTA DE ACRÓNIMOS		3-5
INTRODUCCIÓN		7-11
	BLOQUE I: PRESENTACIÓN DE LA INVESTIGACIÓN	
Capítulo 1:	**La investigación y su objeto de estudio**	1-17
	1.1. Antecedentes y motivación de la tesis	19-20
	1.2. Finalidad de la tesis y objetivos	20-23
	1.2.1. Objetivos particulares y/o específicos	21-22
	1.2.2. Objetivos metodológicos	22-23
	BLOQUE II. FUNDAMENTACIÓN TEÓRICA	
Capítulo 2:	**Marco Teórico**	27-33
	2.1. Preámbulo	28-29
	2.2. Implicaciones económicas de la fragmentación	29-30
	2.3. Implicaciones socio-culturales y ambientes de la fragmentación de la tierra	30-32
	2.4. Implicaciones jurídicas: nuevas estrategias territoriales para el olivar	32-33
	BLOQUE III. CONTEXTUALIZACIÓN DEL TERRITORIO	
Capítulo 3:	**Caracterización del olivar**	37-50
	3.1. Introducción	39-40
	3.2. Área de estudio	40-42
	3.3. Metodología	42-46

3.3.1. Caracterización de los recintos de olivar 43-45
3.3.2. Caracterización de las parcelas agrarias de olivar 45-46
3.3.3. Caracterización de las explotaciones agrarias 46
3.4. Resultados 46-48
3.4.1. Caracterización de los recintos SIGPAC 46-47
3.3.2. Caracterización de las parcelas agrarias 47
3.3.3. Caracterización de las explotaciones 47-48
3.5. Discusiones y conclusiones 48
3.6. Bibliografía 49-50

BLOQUE IV. PUBLICACIONES DE LAS INVESTIGACIONES

Capítulo 4: Contexto y publicaciones de las investigaciones 53-56
Capítulo 5: Artículos científicos publicados 57-229
5.1. The inefficiency and production cost due to parcel fragmentation in olive orchards 59-85
5.2. Cost analysis of parcel fragmentation in agriculture: the case of traditional olive cultivation 87-114
Los efectos de la UMC en las tierras agrícolas de baja rentabilidad: el caso del olivar 115-142
5.4. Impact of parcel fragmentation on the calculation of the real estate value of land belonging to farms 143-169
5.5. Fully connected parcels with the same value. A practical method for the ex-ante evaluation of land consolidation initiatives 171-198
5.6. Analysis of the spatial relationship between small olive farms to increase their competitiveness through cooperation 199-229

BLOQUE V. ANÁLISIS DE DATOS Y DISCUSIÓN DE RESULTADOS

Capítulo 6:	**Resumen global de los resultados**	231-233
Capítulo 7:	**Discusión de resultados y líneas futuras de investigación**	235-239

CONCLUSIONES	241-243
REFERENCIAS BIBLIOGRÁFICAS	245-252

ÍNDICE DE FIGURAS Y TABLAS

Índice de figuras

Figura 1:	Esquema de la tesis y objetivos	23
Figura 2:	Características geográficas de la provincia de Jaén	41
Figura 3:	Distribución del olivar en función de la pendiente y comarcas agrarias	42
Figura 4:	Metodología general seguida	44
Figura 5:	Distribución espacial del olivar tradicional en función de su tipología	45
Figura 6:	Ejemplos del efecto borde en dos explotaciones del mismo tamaño pero con diferente fragmentación	67
Figura 7:	Ejemplos del efecto borde en dos explotaciones del mismo tamaño y número de parcelas pero con parcelas de forma diferente	68
Figura 8:	Ineficiencia debida al efecto borde en función del número de parcelas (Fig. A), espacio entre entidades (Fig. B) y tamaño de la explotación (Fig. C)	70
Figura 9:	Efecto borde (en metros cuadrados) de simple a concentración de parcelas resultado de la adyacencia de los límites de las parcelas. Área concentrada: 7,6 ha. Eficiencia ganada: 29%	72
Figura 10:	Localización de la zona de estudio	94
Figura 11:	Ejemplo de la distribución real de parcelas en la zona de estudio.	95

Se representa una explotación de 3 ha compuesta por 6 parcelas y una dispersión de 5,7 k

Figura 12: Ejemplo de itinerario seguido por el agricultor 96

Figura 13: Ejemplo del procedimiento por radios de 5, 10 y 25 m 98

Figura 14: Estructura de la dispersión en una explotación de 3 parcelas y 5 km 101

Figura 15: Relación entre dispersión (Y) y número de parcelas (X) 104

Figura 16: Descripción de la metodología empleada 126

Figura 17: Distribución del OTM en función de su rendimiento satisfactorio por hogar 134

Figura 18: Ejemplo de forma de las parcelas y dispersión típica de una explotación olivarera en la zona de estudio 152

Figura 19: Diferente estructura de fragmentación en una explotación típica de 1 ha 154

Figura 20: Correlación entre la superficie de la explotación y costes de penalización. Media de los valores en función de diferentes rangos 158

Figura 21: Zona delimitada por infraestructuras e hitos naturales donde existen tres subgrupos continuos 182

Figura 22: Distribución ex-ante y ex-post de parcelas olivareras en una FCASV 183

Figura 23: HIVVCA en función del diferente grado de homogeneidad en el valor 189

Figura 24: Mapa de localización del área de estudio 208

Figura 25: Metodología general seguida 210

Figura 26: Ejemplo de las relaciones espaciales entre parcelas 212

Índice de tablas

Tabla 1: Estructura de las parcelas de olivar en la provincia de Jaén (España) 73

Tabla 2: Número de parcelas de olivar en las explotaciones de la zona de estudio 74

Tabla 3:	Ineficiencia debida al efecto borde y costes de producción	75
Tabla 4:	Frecuencia del agregado de acuerdo con el número de parcelas y el número de agricultores que pertenecen al agregado	76
Tabla 5:	Estructura de las explotaciones de olivar en la provincial de Jaén (España)	100
Tabla 6:	Estructura de las explotaciones de olivar en la provincial de Jaén (España)	102
Tabla 7:	Dispersión parcelaria por intervalos	103
Tabla 8:	Costes de dispersión anuales	105
Tabla 9:	Parcelas y superficie segregables por comarcas en la provincia de Jaén	129
Tabla 10:	UMC establecida para el OTM de secano y regadío	130
Tabla 11:	UMC según tamaño de explotaciones	133
Tabla 12:	Explotaciones por tamaño. Caracterización de las explotaciones en base a su tamaño y el número de parcelas que la componen	156
Tabla 13:	Coste medio de la fragmentación y dispersión en la provincia de Jaén (España)	157
Tabla 14:	Costes de penalización debido a diferentes niveles de fragmentación y dispersión por intervalos	159
Tabla 15:	Cálculo del valor real de la explotación en función de su tamaño	160
Tabla 16:	Descripción de HIVVCA	187
Tabla 17:	Estructura de las parcelas olivareras de la provincia de Jaén	215
Tabla 18:	Número de explotaciones de grandes dimensiones en el área de influencia de SAHs	217
Tabla 19:	Número y superficie media de explotaciones pequeñas en el área de grandes de influencia de explotaciones olivareras	218

RESUMEN

El olivar es considerado un cultivo estratégico para el desarrollo económico y social de Andalucía. No obstante, y aunque la producción de aceite de oliva ha aumentado de forma paulatina gracias a procesos de modernización (densificación, implantación del riego, etc.), coexisten espacios olivareros que se encuentran en una situación de incertidumbre, especialmente por estar enclavado en estructuras de la propiedad poco favorables para la generación de economías de escala. Esta es la situación actual del Olivar Tradicional Mecanizable (OTM) de la provincia de Jaén que, siendo el principal modelo productivo, tanto por la superficie como por el número de propietarios, se asienta en un sistema de propiedad muy fragmentado y atomizado que hace que los costes de producción de cada kilogramo de aceite sean elevados, lo que provoca una disminución de la rentabilidad de los mismos y en ocasiones, la pérdida de capital para sus propietarios.

La actual situación se agrava en un contexto donde se proyecta una disminución de las ayudas comunitarias (evidente en las últimas reformas de la Política Agraria Común) y un envejecimiento de la población olivarera que obliga, con cada vez más frecuencia, a externalizar determinados servicios, en ocasiones su totalidad, encareciendo aún más los costes de producción.

Dicho contexto, que puede ser extrapolado a otros cultivos andaluces, se agrava en el olivar tradicional por ser un cultivo de baja rentabilidad, sujeto a precios de venta en origen muy fluctuantes y por afectar a la economía de más de 300 municipios de Andalucía. Su sostenibilidad es necesaria no sólo desde un punto de vista económico, sino social (principal fuente generadora de empleo agrario), medio ambiental y paisajística (reflejo de la multifuncionalidad del cultivo).

Centrándonos en el contenido esencial de la tesis, los costes de producción y su influencia en gestión de las explotaciones, es necesario resaltar que la mayoría de estudios de costes, e incluso las fuentes oficiales de información, publican valores de rentabilidad que en muchos casos se alejan de la realidad, al considerar como explotación modelo para el análisis una porción de olivar de mediana–gran superficie (20 ha-50 ha) constituida por una única parcela. La realidad geográfica y la estructura de la propiedad en gran parte de

Andalucía es muy diferente, pequeña y fragmentada, y por tanto, se hace necesario realizar una caracterización del olivar que integre estas variables estructurales y/o geográficas (superficie, número de parcelas, distancias entre ellas) junto a los tradicionales elementos agronómicos como son la densidad de plantación, el régimen de cultivo o la pendiente media. En esta tesis, el uso de las herramientas SIG nos ha permitido realizar una descripción del OTM fiel a la realidad, para posteriormente plantear metodologías que se centran en la cuantificación de los sobrecostes provocados por el régimen de propiedad en las explotaciones agrarias y cómo éstos afectan, tanto en el valor patrimonial de la explotación agraria, como en la superficie necesaria para que una familia pueda obtener del olivar una renta mínima de subsistencia.

A partir de las observaciones realizadas se proponen dos soluciones para mejorar la rentabilidad del OTM, que pueden darse de forma alternativa o complementaria. En primer lugar, se sugiere un escenario definido por la cooperación entre agricultores en función de las características estructurales y agronómicas de sus parcelas y el contexto geográfico circundante (cultivos asistidos y/o compartidos) y, en segundo lugar, se propone la concentración parcelaria en aquellas áreas que cumplan criterios de homogeneidad en la calidad del olivar y continuidad espacial. Estas medidas deben incluirse dentro de estrategias globales territoriales, donde se integren medidas que frenen la paulatina división de la tierra como el establecimiento de una Unidad Mínima de Cultivo (UMC) racional y acorde con la rentabilidad del cultivo o se aumenten los beneficios fiscales para la compraventa de colindantes.

Son las políticas públicas de reforma agraria las que deben promover dichos escenarios entre los agricultores. En este sentido, el Plan Director del Olivar (PDO) y la futura Ley de Agricultura y Ganadería de Andalucía proponen horizontes en los cuales la implementación de economías de escala, la cooperación y la mejora de la estructura productiva de las explotaciones son temas recurrentes que deben ser desarrollados reglamentariamente. La información generada en esta tesis contribuye en la consecución de estos fines.

PALABRAS CLAVE: Olivar, SIG, rentabilidad, costes, territorio, dispersión y fragmentación, minifundismo, valor patrimonial, concentración, cooperación.

LISTA DE ACRÓNIMOS

AEMO: Asociación Española de Municipios del olivo.

AES: Agri-environmental schemes.

ATLLUR: Texto Refundido de la Ley del Suelo y Rehabilitación Urbana.

BEA: Border effect area.

CAP: Common Agricultural Policy.

CAPDR: Consejería de Agricultura, Pesca y Desarrollo Rural, Junta de Andalucía.

CCAA: Comunidad Autónoma.

CEICE: Council of Economy Innovation, Science, and Employment.

CES: Consejo Económico y Social.

COI: Consejo Oleícola Internacional.

CV: Caballo de Vapor.

EAFRD: European Agricultural Fund for Rural Development.

EG: Efficiency Gain.

EIP-AGRI: European Innovation Partnership for Agricultural Productivity and Sustainability.

ESYRCE: Encuesta sobre Superficies y Rendimientos de Cultivos.

ETRS: European Terrestrial Reference System.

FADN: Farm Accountancy Data Network.

FAO: Organización de las Naciones Unidas para la Alimentación y la Agricultura.

FCASV: Fully Connected Areas with the Same Value.

FEADER: Fondo Europeo Agrícola de Desarrollo Rural.

FV: Real estate value of the set of agricultural plots that make up a farm.

FVL: Final value of the land in euros.

GESTOLI: Programa de Gestión de Olivar.

GIS: Geografical Information System.

IFAPA: Instituto de Investigación y Formación Agraria.

INE: Instituto Nacional de España.

JCR: Journal Citation Reports

KW: Kilovatio.

LC: Land Consolidation.

LF: Global location factor.

LMEA: Ley de Modernización de Explotaciones Agrarias.

LOA: Ley Olivar de Andalucía.

MAPAMA: Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente.

MARM: Ministerio de Medio Ambiente y Medio Rural y Marino.

MCU: Minimum Crop Unit.

OECD: Organización para la Cooperación y el Desarrollo Económico.

OM: Objetivos metodológicos.

OP: Objetivos Particulares.

OTM: Olivar Tradicional Mecanizable.

OTMR: Olivar Tradicional Mecanizable Regadío.

OTMS: Olivar Tradicional Mecanizable Secano.

OTNMS: Olivar Tradicional No Mecanizable Secano.

OTNMR: Olivar Tradicional No Mecanizable Regadío.

PV: Capitalization Value of the Parcel.

RIP: Real or Potential Annual Income.

PAC: Política Agraria Común.

PDO: Plan Director del Olivar.

POOLRED: Sistema de Información de Precios en Origen.

SAH: Small agricultural holdings.

SAU: Superficie Agrícola Útil.

SIG: Sistemas de Información Geográfica.

SIGPAC: Sistema de información Geográfica de Parcelas Agrícolas.

SMI: Salario Mínimo Interprofesional.

TRIF: Sum of the income from all the parcels.

UMC: Unidad Mínima de Cultivo.

URP: Umbral Riesgo de Pobreza.

UTM: Universal Transversal de Mercator.

WD: Wheel Drive.

INTRODUCCIÓN

Esta tesis está estructurada en 5 bloques de contenidos y 7 capítulos. El bloque I *"Presentación de la Tesis"* recopila los antecedentes y motivación de la tesis además de los principales objetivos. El bloque II *"Fundamentación teórica"* incluye un breve preámbulo y una descripción de las implicaciones económicas, sociales, ambientales y jurídicas originadas por la fragmentación de la tierra.

El bloque III "Contextualización del territorio" se centra en la descripción territorial del área de estudio. Concretamente mediante diferentes análisis SIG y con el apoyo de varios mapas temáticos se representa la estructura geográfica de la provincia de Jaén y la distribución del olivar en el territorio. Junto a esta breve descripción se propone una caracterización del olivar que permite dividirlo en doce tipos o categorías, atendiendo a las tres principales características agrológicas del mismo: densidad de plantación, régimen de cultivo y pendiente media.

El bloque IV "Publicaciones de las investigaciones" aglutina textualmente las aportaciones científicas realizadas en revistas indexadas. En el capítulo 5.1 se realiza un análisis que permite valorar de forma cuantitativa la ineficiencia de las parcelas agrarias debido tanto a su forma como a su tamaño. Los resultados demuestran que los olivareros manejan de forma ineficiente una superficie significativa del OTM de la provincia. Esta realidad, claramente puesta de manifiesto en parcelas pequeñas y de formas irregulares, supone un hándicap para la gestión eficiente y requiere de medidas que minimicen su impacto entre las que se destacan los sistemas cooperativos de gestión. Además, los análisis permiten cuantificar la ineficiencia en costes de penalización para el agricultor.

En el Capítulo 5.2 se propone una metodología para cuantificar los costes adicionales para los agricultores provocados por la dispersión espacial entre las parcelas agrícolas en sus explotaciones. La metodología en primer lugar se centra en determinar la distancia que existe entre las diferentes parcelas de cada explotación, para posteriormente, teniendo en cuenta el número de desplazamientos anuales que requiere el manejo del olivar, traducir la distancia en coste de mano de obra y combustible. Los resultados indican que especialmente en las explotaciones de pequeño tamaño el impacto es significativo.

El capítulo 5.3 se presenta cuál debe ser la superficie suficiente que debe tener un olivar para alcanzar un rendimiento satisfactorio, considerando tanto el agricultor profesional como el agricultor a tiempo parcial. Los resultados indican que la mayoría de las explotaciones de OTM de la provincia de Jaén no alcanzan este umbral. Asimismo, ponen en evidencia que la UMC actual no se ajusta a los parámetros del cultivo y no cumple el objetivo para la que fue definida: impedir que la tierra se divida por debajo de umbrales que no garanticen su sostenibilidad económica.

El Capítulo 5.4 se centra en cuantificar el valor de la explotación agraria mediante el método de capitalización de rentas. Se propone una metodología que permite determinar la renta agraria anual y conocer el valor patrimonial de una explotación atendiendo no sólo a magnitudes productivas como superficie, tipo de cultivo e intensidad, sino también implementando parámetros originados por la fragmentación de la tierra. Los resultados indican que los valores de las explotaciones agrarias son significativamente inferiores en las explotaciones fragmentadas y atomizadas.

El Capítulo 5.5 analiza como la fragmentación de la tierra ha sido combatida por políticas de diversa índole que proponen principalmente acciones encaminadas a la interdicción de la fragmentación y a la reordenación de la propiedad a través de los procesos de concentración de la tierra. Centrados en este segundo aspecto, en este capítulo el análisis se centra en proponer una metodología que permite identificar zonas que cumplen una serie de criterios, tanto de homogeneidad en valor como de continuidad espacial del cultivo, para incrementar la probabilidad de éxito de las medidas de concentración parcelaria. Los resultados indican que existen espacios en la provincia de Jaén que cumplen los requisitos para que la concentración se realice de forma óptima, sin apenas generar compensaciones monetarias entre los agricultores y agilizando el procedimiento para la administración.

El Capítulo 5.6 se centra en la cooperación entre pequeños olivareros como estrategia de incremento de competitividad. Para ello, se identifican las áreas en las que la cooperación de los agricultores se puede implementar de manera efectiva atendiendo a las relaciones espaciales entre las explotaciones más cercanas. Los resultados indican que existen numerosos espacios que podrían aumentar considerablemente su rentabilidad apostando por estas técnicas.

El bloque V “Análisis de datos y discusión de resultados” concentra el capítulo 6 donde se realiza un resumen global de los resultados, concretamente se presenta un resultado global de cada uno de los temas abordados en los diferentes capítulos y el capítulo 7 donde se discuten los mismos y se presentan las líneas futuras de investigación.

Finalmente se esbozan las conclusiones principales del estudio realizado. Son conclusiones globales que dan respuesta a los objetivos particulares propuestos y que de forma coordinada pueden ayudar a mejorar la calidad de vida en el medio rural.

"Todo fluye, todo está en movimiento y nada dura eternamente. Por eso no podemos descender dos veces al mismo río, pues cuando desciendo al río por segunda vez, ni el río ni yo somos los mismos".

Heráclito de Efeso

BLOQUE I:

PRESENTACIÓN DE LA INVESTIGACIÓN

Capítulo 1. La investigación y su objeto de estudio

En este capítulo se pretende introducir al lector/a en la temática de la tesis, ofreciendo las primeras coordenadas del objeto de estudio, a través de los antecedentes y la motivación de la investigación. De igual manera, se presentan la finalidad y los objetivos, tanto particulares como metodológicos, que se quieren alcanzar con este proyecto.

1.1. Antecedentes y motivación de la tesis

El olivar tradicional presenta una serie de problemas que está poniendo en peligro su rentabilidad y su supervivencia (Rodríguez-Cohard y Parras, 2011). La ineficiencia en su gestión, derivada principalmente por el minifundismo y la fragmentación, provoca una falta de rentabilidad que, si se prolonga en el tiempo, podría desembocar en un abandono o transmisión del cultivo (Duarte et al., 2008), seguido de un éxodo rural con graves impactos para las áreas rurales mediterráneas por sus consecuencias ambientales (Palese et al., 2013) y socio-culturales (Rocamora-Montiel et al., 2014). La incógnita sobre la continuidad de los pequeños espacios olivareros, que en situaciones "difíciles" pueden ser absorbidos por los grandes propietarios mediante la compra-venta de terrenos, produciéndose un acaparamiento o concentración de la tierra, afecta a la distribución de los ingresos agrícolas y, en el medio-largo plazo, puede provocar una disminución de la calidad de vida y derivativamente el éxodo de la población de las áreas rurales. En este sentido el minifundismo, a pesar de sus impactos negativos en la rentabilidad, puede ser un elemento de sujeción de la población rural a la tierra, además de cumplir con unas series de servicios sociales, ambientales y paisajísticos diversos (European Parliament, 2014).

En este contexto de incertidumbre, uno de los motivos de la fragilidad del olivar tradicional es la elevada fragmentación y dispersión de las parcelas en el territorio, lo que ralentiza las tareas y eleva los costes de producción. No obstante, las fuentes oficiales no han tenido en cuenta estos factores en los estudios de costes que se publican, por lo que las líneas estratégicas y las políticas públicas toman decisiones sobre una realidad en parte sesgada en su análisis (CES, 2010; Cubero y Penco, 2012; CAPDR, 2015).

Por la representatividad del olivar tradicional y la inseguridad, en cuanto a su viabilidad futura ante escenarios futuros (mayor competitividad internacional, falta de relevo generacional, disminución de las ayudas comunitarias…), es necesario diseñar estrategias y modelos productivos acorde con la dimensión y estructura de la propiedad que permitan abaratar costes, mantener la población en el medio rural y aumentar la calidad de vida de los olivicultores.

Esta tesis aspira a generar el conocimiento suficiente para apoyar el desarrollo de medidas territoriales que aumenten la rentabilidad en el OTM[1], considerando los parámetros agronómicos y estructurales que mejor lo definen. En particular, en esta tesis se mide y cuantifica el impacto de la fragmentación y dispersión parcelaria en los costes del olivar, prestando especial atención en los sobrecostes que deben afrontar los titulares de explotaciones de pequeñas dimensiones por encontrarse en una situación de precariedad y de incertidumbre. La elevada fragmentación provoca ineficiencia en la gestión de la tierra, devalúa su valor patrimonial, dificulta la modernización de la explotación y desincentiva la vuelta de los jóvenes a la actividad agraria. Por ello, se proponen dos soluciones que pueden darse de forma alternativa o complementaria: la cooperación entre agricultores y la concentración parcelaria. Estas medidas, que se proyectan para reducir los sobrecostes causados por el minifundismo y la fragmentación, incrementan la rentabilidad de las pequeñas explotaciones agrarias y, por ende, favorecen su continuidad en el tiempo y la de los efectos positivos originados por ellas en el medio rural (Parlamento Europeo, 2014).

Por otra parte, es necesario destacar que el aumento de la rentabilidad puede ser abordado, además, por estrategias de singularización competitiva (Barreal et al., 2017; Vilar et al., 2017), fruto del resultado de un modelo de marketing (Rodríguez Cohard, Sánchez Martínez y Gallego Simón, 2017), o apostando por mejorar los canales de distribución e incluso en la modernización de las explotaciones a través de procesos de puesta en riego y/o intensificación del cultivo (Ruz, 2012). Estos aspectos, de extrema importancia para la rentabilidad del OTM, quedan fuera del alcance de este estudio.

1.2. Finalidad de la tesis y objetivos

La finalidad de esta tesis es la creación de información de utilidad, en relación a la estructura de la propiedad de las explotaciones de OTM, para la toma de decisiones, tanto por la Administración (dimensión pública) como por los agricultores (dimensión privada), que permitan aumentar la rentabilidad de las pequeñas explotaciones agrarias de olivar y mantener la población local en el medio rural.

[1] Se considera OTM aquél con una densidad de plantación inferior a 200 árboles/ha, en régimen de regadío o secano y con una pendiente media mayor o igual al 25%.

1.2.1. Objetivos particulares y/o específicos

Para cumplir con la finalidad enunciada, se ha requerido alcanzar la siguiente serie de objetivos particulares y/o específicos (OP):

- ***OP1:*** Caracterizar el OTM, atendiendo a las características agrológicas y estructurales de las explotaciones agrarias.
- ***OP2:*** Evaluar el impacto de la fragmentación en los costes de producción, en función del tamaño y forma de las parcelas.
- ***OP3:*** Cuantificar la dispersión geográfica entre las parcelas de una explotación y valorar el impacto económico en los costes de producción en la provincia de Jaén.
- ***OP4:*** Determinar la superficie olivarera suficiente para garantizar su sostenibilidad económica, tanto del agricultor profesional como del agricultor a tiempo parcial.
- ***OP5:*** Cuantificar el valor patrimonial de la explotación agraria como instrumento necesario para desarrollar procesos de ordenación de la propiedad racionales y justos.
- ***OP6:*** Identificar áreas homogéneas en la provincia de Jaén, donde las iniciativas de consolidación de tierras podrían llevarse a cabo limitando las transacciones monetarias involucradas en la re-parcelación.
- ***OP7:*** Identificar áreas en la provincia de Jaén en las que la cooperación entre los agricultores podría ser exitosa y efectiva, mediante cultivos compartidos y/o asistidos.

En resumen, el alcance del OP1 proporciona la base territorial de la estrategia que se propone, ya que permite conocer la realidad geográfica de la provincia de Jaén y ser la base de datos, espaciales y alfanuméricos, primaria que nos permitirá lograr el resto de los objetivos. Los OP2 y OP3 nos ofrecen una visión general y particular, a nivel de explotación agraria, del impacto de la fragmentación y dispersión parcelaria en la provincia de Jaén en la rentabilidad de las explotaciones. El OP4 pone en evidencia la importancia de frenar la excesiva fragmentación de la tierra y mantener un tamaño mínimo en las explotaciones para alcanzar la rentabilidad. El OP5 se encuentra asociado al OP6, ya que esencialmente se define como un instrumento para que las estrategias territoriales de concentración parcelaria sean justas atendiendo a las características de las tierras aportadas por cada propietario. Por último, junto con el OP6, el OP7 representa una estrategia de competitividad, basada en la cooperación, para minimizar los costes de producción agrarios.

1.2.2. Objetivos metodológicos

La consecución de los objetivos específicos de la tesis ha requerido satisfacer un conjunto de objetivos metodológicos (OM) para dar respuesta a las necesidades planteadas:

- ***OM1:*** Desarrollar un modelo SIG, atendiendo a una clasificación propia de los tipos de explotaciones agrarias en función de su estructura territorial.
- ***OM2:*** Generar un método SIG que cuantifica la superficie de ineficiencia en las tareas mecanizadas por el efecto de las lindes de las parcelas.
- ***OM3:*** Crear una metodología que permita cuantificar la distancia entre parcelas, teniendo en cuenta las relaciones topológicas establecidas entre ellas y definiendo a su vez la estructura espacial.
- ***OM4:*** Definir el umbral de sostenibilidad económica del OTM para definir la UMC y determinar la superficie olivarera potencialmente segregable.
- ***OM5:*** Desarrollar una metodología que valore la explotación agraria, en función de sus características estructurales.
- ***OM6:*** Originar un procedimiento SIG que permite identificar áreas geográficas idóneas, atendiendo a la homogeneidad y continuidad del cultivo, para implementar la concentración parcelaria.
- ***OM7:*** Desarrollar una metodología SIG, centrada en el tamaño de las explotaciones y las características de los olivares más cercanos, que permita predecir las relaciones de cooperación con mayor probabilidad de éxito.

Para la consecución del objetivo general, es decir, la generación de un marco político-territorial coherente con las notas que caracterizan el OTM y como estrategia a desarrollar a medio-largo plazo, los objetivos particulares y metodológicos se interrelacionan entre ellos como se puede observar en la *Figura 1*.

Fuente: Elaboración propia.

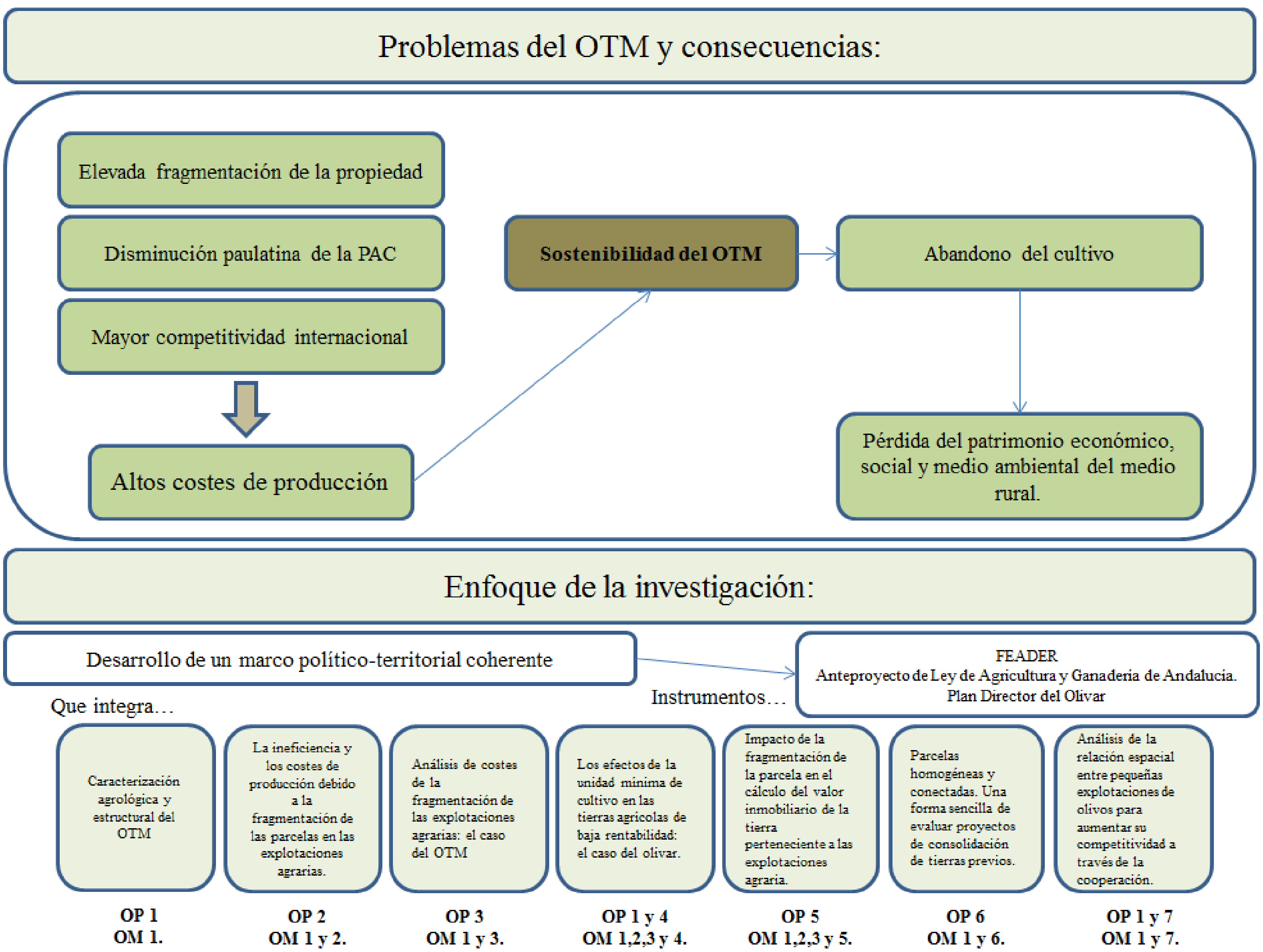

Figura 1. Esquema metodológico de la tesis y objetivos.

BLOQUE II:

FUNDAMENTACIÓN TEÓRICA

Capítulo 2. Marco teórico

Un enfoque integral de análisis del territorio nos lleva a reflexionar no sólo sobre las repercusiones económicas de la fragmentación de la tierra, sino que es necesario considerar otras implicaciones, como las sociales, ambientales o jurídicas, que afectan a la idiosincrasia del medio rural andaluz. En este bloque se esbozan las principales líneas de trabajo en este sentido.

2.1. Preámbulo

La fragmentación de la tierra puede ser definida como el número de parcelas espacialmente separadas de tierras cultivadas como una sola unidad (King y Burton, 1982). Es el resultado de la aplicación de un sistema hereditario que potencia la división del patrimonio entre los herederos y del fracaso de las medidas que están destinadas a frenar dicho proceso, y que por tanto, se encuentra íntimamente relacionado con la actuación del legislador en su intento de organización del territorio[2]. En definitiva, la fragmentación de la tierra es el resultado de un proceso histórico que deriva de las políticas públicas-legislativas (sucesiones legítimas, Unidad Mínima de Cultivo, derecho de retracto de colindantes, etc.) y las decisiones de origen privado (compra-ventas, permutas, etc.) que desembocan en un escenario de gran complejidad con notables repercusiones en la rentabilidad agraria, pero también en aspectos sociales (como el empleo, la fijación de la población, la vigilancia de los territorios rurales, etc.) y medioambientales (erosión, biodiversidad, preservación del paisaje, etc.) del medio rural.

En este escenario, es necesario considerar los fenómenos espaciales teniendo en cuenta la distribución e influencia de la población, economía, política, sociedad o historia (Suárez Ardura, 2014). El enfoque de síntesis, implícito en el estudio del sector olivarero realizado, hace que se consideren las implicaciones económicas, sociales-culturales, medioambientales y jurídicas para la redacción de las conclusiones y propuestas que permitirán obtener una mejora del olivar de forma armonizada con la idiosincrasia del territorio.

En esta tesis, dichas implicaciones han sido consideradas e incorporadas en los análisis mediante el uso de los SIG. Esta herramienta proporciona, dada la complejidad de la información geográfica medida tanto en su dimensión alfanumérica como espacial, instrumentos para el estudio de multitud de variables, permitiendo la superposición de información sectorial, análisis de proximidad, etc., para la obtención de información derivada, inédita en las fuentes oficiales, donde se representan las relaciones espaciales y atributos alfanuméricos. Estos análisis permiten un mejor conocimiento del ámbito de

[2] El término de territorio es más amplio que el de espacio físico, porque combina el medio físico natural y el ordenado o humanizado, que comprende a las personas que se apropian de él (Raffestin, 1986).

estudio y la creación de información geográfica de interés para realizar juicios de valor fieles a los problemas que presenta el espacio geográfico. En definitiva, ofrecen una ayuda en la resolución de problemas territoriales y en la optimización de recursos (Sitjar Suñer, 2009).

2.2. Implicaciones económicas de la fragmentación de la tierra

Los problemas derivados de la división parcelaria de la propiedad rústica han sido reconocidos desde muy antiguo (Maceda Rubio, 2014), siendo más agudos en territorios donde predominan las explotaciones familiares y manejos extensivos (Janus y Markuszewska, 2017). Los efectos negativos de la fragmentación de la tierra en la producción agrícola o en la ecología y el medio ambiente se han vuelto gradualmente más evidentes (Cai, 2008) a lo largo de los años. La existencia de explotaciones fragmentadas puede ser un obstáculo importante para la viabilidad de la agricultura porque dificulta la mecanización agrícola, causa ineficiencias en la producción e implica un gran coste para aliviar sus efectos (Najafi, 2003; Thomas, 2006; Thapa, 2007; Tan et al., 2008). Incluso los espacios agrícolas fragmentados llegan a considerarse como característicos de los sistemas agrarios menos desarrollados (Hristov, 2009), con efectos en el mercado de compra venta de las tierras que tiende a disminuir (FAO, 2004). En definitiva, la fragmentación podría reducir la productividad de la tierra y del trabajo, afectando a la producción agrícola (Ali y Deininger, 2014), por aumentar los costes de producción y disminuir los ingresos (Latruffe y Piet 2014).

Los costes de producción están muy influenciados por el tamaño de las parcelas que componen la explotación, el número y la distancia entre ellas, aumentando considerablemente cuanto más pequeñas, fragmentadas y atomizadas se encuentren (Delord, Montaigne y Coelho, 2015), debido a la reducción de la eficiencia en las labores mecanizadas (Janus, Glowacka, y Bozek, 2016; Colombo y Perujo-Villanueva, 2017; Perujo-Villanueva y Colombo 2017). Este aspecto ha sido totalmente ignorado por la literatura existente sobre rentabilidad agrícola. Por ejemplo, el estudio de AEMO (Cubero y Penco, 2012) asumió un tipo de explotación de 30 ha constituida por una parcela, en su estudio de costes; el MAPAMA (2015) realiza un análisis de costes en olivar para

Andalucía tomando como muestra una explotación de 28 ha en secano y 37,9 ha en regadío; Arbonés et al. (2014), en el estudio basado en el análisis técnico-económico de diferentes sistemas de plantación de olivos en áreas semiáridas, supusieron que no existían limitaciones para el uso de maquinaria.

Estas características estructurales de la explotación provoca en circunstancias adversas (fincas pequeñas y muy fragmentadas), la pérdida de tiempo en las labores mecanizadas (debido a la forma irregular de las parcelas, a los desplazamiento de personas y maquinarias de una parcela a otra), por lo que originan unos gastos extras al agricultor que disminuyen la rentabilidad y por tanto, dificultan la viabilidad futura de estas explotaciones. No obstante, hay diferentes autores que defienden ciertos beneficios de la fragmentación en el sentido de que permite dividir los riesgos (Van Hung et al., 2007).

Este encarecimiento de los costes de producción, que merman considerablemente el beneficio de las explotaciones pequeñas, se puede ver agravado por el aumento de la oferta de aceite de oliva a nivel mundial, donde la aparición de explotaciones más competitivas supone una amenaza al sector (Ruz, 2012). El sector olivícola se encuentra en un fuerte proceso de internacionalización, tanto productivo, como de consumo (Barjol, 2013), que podría condicionar los precios de venta del aceite de oliva en el futuro (Vilar et al., 2016). La evolución de los mismos es un dato incierto, y por ello, es necesario que el OTM acometa profundas reformas que, por una parte, tienen que ser auspiciadas por la Administración Pública y, por otra, por los propios agricultores y sus asociaciones. Las reformas tienen que considerar que el tejido productivo del olivar está caracterizado por un modelo de agricultura familiar, que puede y debe coexistir con otros modelos de agricultura a mayor escala estrictamente orientados a los mercados (Colombo, 2017).

2.3. Implicaciones socio-culturales y ambientales de la fragmentación de la tierra

El olivar, y considerando una dimensión que va más allá de la producción agrícola, contribuye a la producción de bienes públicos como la conservación del medio ambiente y el paisaje, la prevención del riesgo de incendios, el mantenimiento del empleo en áreas rurales (Villanueva et al., 2014; Arriaza et al., 2008; Colombo et al., 2006) y un conjunto completo de las funciones sociales y culturales vinculadas a la preservación de las tradiciones, las costumbres, el paisaje y el turismo (Rocamora-Montiel et al., 2014; Gallardo-Cobos y Sánchez-Zamora, 2017).

La fragmentación de la tierra, además de tener repercusiones económicas, presenta impactos sociales y ambientales (Backman, 2002). En particular, este fenómeno da lugar a procesos intensos de erosión de la tierra e incluso una mala gestión del agua (Niroula y Thapa, 2005). Los minifundios provocan, a lo largo del tiempo, una presión de uso que afecta los suelos, el agua, la flora, la fauna y los demás recursos naturales del predio en que se asientan (Murgueitio, 2003). La gestión ineficiente, originada también por su escasa capacidad innovadora, provoca que tanto la maquinaria como las infraestructuras en numerosas ocasiones sean obsoletas e ineficientes, provocando consumos extras de agua y combustible. La fragmentación es también un problema crítico que implica grandes desafíos para la conservación de la biodiversidad y la gestión de los ecosistemas (Larrey-Lassalle et al, 2018). Desde el punto de vista de la biodiversidad el impacto se define como la división de un área grande en varios hábitats más pequeños inadecuados para la salud reproductiva de las poblaciones (Harvey y Sáenz, 2007).

Por ello, se reconoce que reducir la fragmentación, por ejemplo mediante la concentración parcelaria, además de mejorar la eficiencia técnica y económica de las explotaciones, contribuye a la protección del medio ambiente (Vitikainen, 2004), reduciendo las emisiones a la atmósfera (Hiironen y Niukkanen, 2013) e incluso, mitigando los efectos del cambio climático (Hiironen y Niukkanen, 2014). En definitiva, apoya el desarrollo multifuncional del medio rural (Haldrup, 2015).

Por otro lado, la fragmentación también constituye una amenaza al empleo rural en el medio y largo plazo. Actualmente, a pesar de que las ineficiencias originadas por la fragmentación pueden generar mayor número de jornales (por ejemplo, por los mayores tiempos de ineficiencia que se provocan), en el futuro esta ineficiencia puede generar una falta de competitividad, que podría desembocar en un potencial abandono o concentración de la propiedad en manos de unos pocos propietarios. Por otra parte, la fragmentación provoca que el olivar no se modernice y, que por tanto, sea poco atractivo para los jóvenes, produciéndose un envejecimiento de la población con directas consecuencias para el medio rural y, por consiguiente, para el tejido social (Burton y King, 1982).

Así, se debe considerar que las estrategias dirigidas a disminuir los costes de producción y aumentar la rentabilidad de la población rural persiguen aumentar la calidad de vida de los olivareros y minimizar situaciones de abandono de determinadas tareas del olivar que, como ha quedado descrito, produciría una pérdida de funciones medioambientales y sociales irreversibles para la viabilidad del medio rural. Estos elementos, además de ser cada vez más demandados por la sociedad, han propiciado la diversificación económica del sector (Millán et. al., 2017) y son la base de la legitimidad futura de las ayudas públicas a la agricultura (García Azcárate, 2008; Salazar-Ordoñez, 2011).

2.4. Implicaciones jurídicas: nuevas estrategias territoriales para el olivar

Frente a los problemas que planea la fragmentación de la tierra, la Administración Pública ha intervenido mediante la reordenación del espacio agrario, principalmente a través de dos procedimientos: uno de forma activa, mediante la obligación a los propietarios de participar en procesos de concentración de la tierra y ordenación rural; y otro, de forma pasiva, mediante la limitación de determinados actos al propietario, como es la prohibición de enajenar si las fincas resultantes son inferiores a una determinada área.

En el ámbito agrario destaca, a escala nacional, la *Ley 19/1995 LMEA* (Ley de Modernización de Explotaciones Agrarias) como norma que define, como uno de los fines prioritarios, la formación de explotaciones agrarias de dimensiones suficientes impidiendo el fraccionamiento; y en el ámbito autonómico andaluz, la *Ley 8/1984, de 3 de julio, de Reforma Agraria* que, entre otras medidas, se ocupa de regular la concentración parcelaria.

Específicamente, en el ámbito material del olivar, es necesario destacar la Ley del Olivar de Andalucía (LOA) 5/2011, de 6 de octubre, instrumento en el que se proyecta la elaboración del PDO (CAPDR, 2015), herramienta básica para la coordinación y vertebración del sector y con eficacia vinculante para todos los olivareros y olivares en él comprendidos. En el PDO destacan las estrategias destinadas a mejorar las estructuras de las explotaciones agrarias bajo las que se enmarcan las actuaciones dirigidas a promover la reestructuración de las explotaciones y fomentar proyectos de gestión en común de las explotaciones. Además, de particular relevancia para esta tesis es la línea estratégica del PDO destinada a mejorar la información territorial y sectorial para la toma de decisiones, que prevé crear un nodo de infraestructura de datos espaciales de los territorios de olivar o construir un modelo de apoyo a la toma de decisiones, que esté soportado en un SIG de los territorios de olivar, entre otras.

Por otro lado, el denominado Plan de Acción del Sector de Aceite de Oliva en la Unión Europea (UE) ha ofrecido la posibilidad de incluir en los Planes de Desarrollo Rural subprogramas temáticos, que en Andalucía se ha traducido en un subprograma del olivar que se incluye en el Plan de Desarrollo Rural de Andalucía 2014-2020, principal fuente de financiación del actual PDO (Sánchez Haro, 2017).

Finalmente, es interesante, tanto por la novedad como por su importancia, citar el proyecto de Ley de Agricultura y Ganadería en Andalucía que plantea la necesidad de avanzar en una regulación más ambiciosa, que se acerque a la agricultura, la ganadería y la agroindustria desde una perspectiva global, centrada en las personas. Esta ley establece, entre otras acciones, el fomento de la agricultura para la gestión en común, además de proponer una serie de actuaciones de entre las que se destacan los Planes de Ordenación de Explotaciones, cuyo objetivo es favorecer la constitución de explotaciones competitivas en determinadas zonas de protección agraria o en comarcas o en pagos concretos.

En esta tesis se han considerado todos los factores que se relacionan con la fragmentación de la propiedad rústica (económicas, socio-culturales, ambientales y jurídicas) para alcanzar los objetivos que se han presentado previamente.

BLOQUE III:

CONTEXTUALIZACIÓN DEL TERRITORIO

Capítulo 3. Caracterización del olivar

El capítulo compendia las características geográficas de la provincia de Jaén. Concretamente se adelantan los primeros resultados del análisis SIG realizado en el olivar tradicional, que servirán de base para el cálculo de las ineficiencias en las labores agrarias. La dimensión espacial nos ha permitido caracterizar este cultivo atendiendo tanto a sus características agrológicas como a las geográficas.

3.1. Introducción

El cultivo del olivar supone el 30% de la superficie agraria andaluza (1,5 millones de ha). En cuanto a la producción de kg. de aceite de oliva, la región de Andalucía representa en torno al 82% de la producción nacional. El 37% de la superficie olivarera corresponde a la provincia de Jaén (CAPDR, 2015).

El notable protagonismo del cultivo se refleja a su vez en su vertiente social, ya que aporta el 30% del empleo agrario en Andalucía. Para la mayoría de los municipios representa una de las principales fuentes de empleo a lo largo del año, siendo muchos de estos municipios jienenses. El olivar constituye la principal actividad de más de 250.000 familias de olivareros, distribuidas en más de 300 pueblos andaluces, pudiendo generar de manera directa -en una campaña media- unos 19 millones de jornales aproximadamente, de los cuales el 35,2% se generan en la provincia de Jaén (CAPDR, 2015).

A nivel provincial, el olivar ha experimentado durante el último siglo una expansión continuada (Gallego Simón el al., 2002) que nos aboca a un monocultivo que ocupa casi la totalidad de la SAU (Superficie Agraria Útil), concretamente 551.191 ha que representan el 94.7%. Esta superficie no es homogénea, ni atendiendo a sus condiciones agronómicas ni a sus características estructurales. Las diferencias repercuten directamente en la rentabilidad del olivar y, por tanto, en la sostenibilidad del cultivo. Las principales razones de este crecimiento de la superficie olivarera son, entre otras, la expansión del regadío, la mejora de las condiciones en la recolección, una ampliación de los mercados a partir de la integración en la UE, una política favorable de subvenciones (López Ontiveros, 2003) y la progresiva aceptación del aceite de oliva como el más sano y el de mejor calidad gastronómica, aunque siguen existiendo errores de diferenciación que dependen, entre otros factores, de la falta de información (Salazar-Ordóñez et al., 2018) y conocimiento del consumidor final (Sayadi Gmada et al., 2017), No obstante, en los últimos años, el crecimiento de la superficie olivarera se ha ralentizado en las provincias más orientales de la Comunidad Autónoma (CCAA), caracterizadas por una orografía accidentada, explotaciones de pequeñas dimensiones y una limitada disponibilidad de agua, lo que genera escasa rentabilidad y una insuficiente inversión financiera (Colombo et al., 2015).

Conocer la tipología de olivar del área de estudio y sus patrones de distribución es esencial para el cumplimiento de los objetivos que se proponen en esta tesis. Por ello, en este capítulo se describe minuciosamente la metodología seguida y los resultados obtenidos en cuanto a los tipos de olivares existentes y sus principales características en función de su rentabilidad. Por tanto, es uno de los objetivos esenciales caracterizar las explotaciones agrarias de olivar tradicional para determinar la estructura de costes y los efectos económicos sociales y ambientales de posibles cambios de sistema de gestión y producción, definiendo las estrategias de cambio a través de un modelo dinámico georreferenciado que permita analizar distintos escenarios.

3.2. Área de estudio

La provincia de Jaén se encuadra en el sureste de España, en la Comunidad Autónoma de Andalucía. Queda delimitada al norte, por la cadena montañosa herciniana de Sierra Morena, que representa los suelos de mayor acidez debido al predominio de materiales metamórficos, colonizados principalmente por especies forestales; al sureste aparece la estructura orogénica alpina que constituye el Prebético (Sierra de Cazorla y Segura), formado por materiales sedimentarios (calizas, dolomías, margas…) donde conviven especies forestales, principalmente coníferas, y pequeñas explotaciones de olivar de montaña; al sur y suroeste aparecen eslabones del Subbético (Sierra Mágina), también dominado por materiales básicos y las asociaciones entre el monte mediterráneo y explotaciones de olivar. Finalmente, entre Sierra Morena y la estructura alpina de los Sistemas Béticos se desarrolla el Valle del Guadalquivir que ganando espacio hacia el oeste (provincia de Córdoba), constituye el territorio de mayor potencial agrícola de la provincia.

Fuente: Elaboración propia.

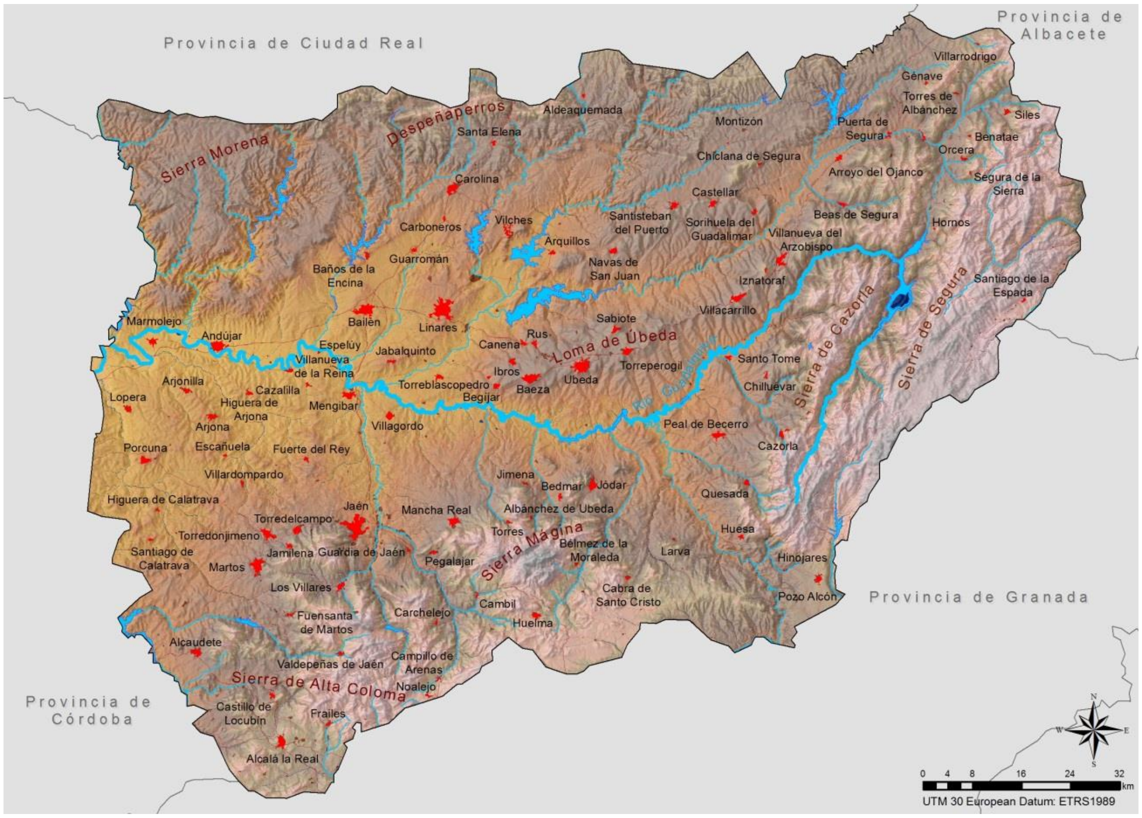

Figura 2: Características geográficas de la provincia de Jaén.

Las diferencias geográficas comentadas, centradas principalmente en el relieve, establecen grandes diferencias en los usos del suelo, especialmente porque la pendiente se torna en un factor limitante para el desarrollo de la agricultura. El tipo de suelo, la erosión, el uso de la maquinaria agrícola o los accesos a las explotaciones han provocado que en la provincia de Jaén se puedan diferenciar claramente dos espacios geográficos: de un lado, aparecen los espacios de montaña que circundan la provincia, excepto por el oeste, con un predominio casi absoluto de la masa forestal y la ausencia de las labores agrícolas, salvo pequeños retazos de olivar en pendiente que se encuentra en una crisis de supervivencia cada vez más acusada; por otro lado, en las zonas de menor pendiente, especialmente en la Depresión del Guadalquivir, se desarrollan los agrosistemas de mayor potencialidad dominado casi de forma exclusiva por el olivar, que, en función de las condiciones hídricas del entorno, aparecen como cultivos en regadío (principalmente en el centro-norte del Valle del Guadalquivir, o en régimen de secano (sur-oeste).

Fuente: Elaboración propia.

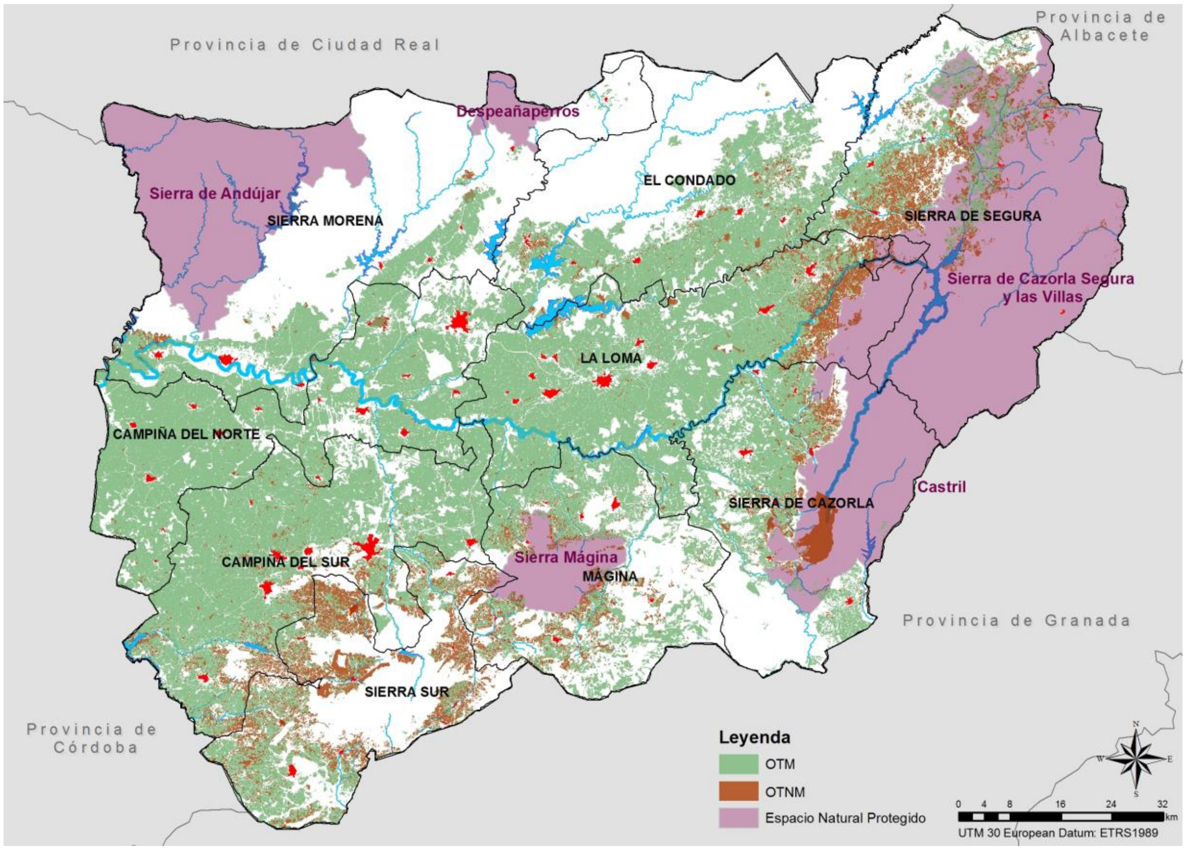

Figura 3: Distribución del olivar en función de la pendiente y comarcas agrarias.

Desde un punto de vista puramente administrativo, la provincia de Jaén se encuentra dividida en nueve comarcas agrarias. Por su monocultivo olivarero destacan la comarca de la Loma y de la Campiña Norte y Sur. Las comarcas de topografía más accidentada son en las que el olivar cede terreno a espacios eminentemente con vocación forestal. Con respecto a los espacios naturales, destacan, por ser declarados como Parques Naturales, el de Sierras de Cazorla, Segura y las Villas, Sierra Mágina, Sierra de Andújar y Despeñaperros.

3.3. Metodología

La metodología que seguimos, basada en el uso de los SIGs, se esquematiza en la figura 4. En un principio se clasifican los tipos de olivares atendiendo tanto a factores agronómicos o estructurales o territoriales de las explotaciones agrarias. La información de partida utilizada procede del archivo shapefile del Sistema de información Geográfica de

Parcelas Agrícolas (SIGPAC) (MAPAMA, 2016). SIGPAC es el sistema oficial de información geográfica del gobierno que delinea la configuración espacial de las parcelas agrícolas en España y las declaraciones de cultivo correspondientes a 2013 (SIGPAC 2013). A partir de ellas, se ha generado el mapa de recintos de olivar de la provincia de Jaén, como base cartográfica, sobre el que ha realizado un análisis espacial previo de caracterización y selección del olivar objeto del estudio, seguido de análisis espaciales a nivel de parcelas agrarias y a nivel de explotaciones agrarias[3] de acuerdo con los objetivos del trabajo.

3.3.1 Caracterización de los recintos de olivar

Los recintos de olivar se han caracterizado atendiendo a las tres variables normalmente consideradas para definir las características estructurales y agronómicas del olivar: 1) la densidad de plantación (número de olivos por ha), corrientemente utilizada para diferenciar entre el olivar tradicional (hasta 200 árboles/ha), el intensivo (entre 200 y 700 árboles/ha) y el superintensivos (más de 700 árboles/ha); 2) el régimen de cultivo, ya sea de secano o de regadío; y 3) la pendiente media, normalmente utilizada para diferenciar entre el olivar mecanizable y no mecanizable. La información relativa a la densidad de plantación se ha extraído de la base de datos del SIGPAC de la edición de 2009, última en la que consta dicho atributo. En los recintos de los que no se disponía de la misma, se ha atribuido el valor a través de interpolación por el vecino más próximo. La discriminación entre olivar de secano y de regadío se ha realizado por compilación de la capa creada por la Confederación Hidrográfica del Guadalquivir para el año 2008 y el SIGPAC 2013. En cuanto a la pendiente media, se ha utilizado el valor contenido en el SIGPAC 2013. Previamente, se han realizado los controles de calidad y comprobaciones a pie de campo de dichas fuentes, así como la depuración de errores de atributo (principalmente usos del suelo incorrectos) y topología (principalmente inconexiones de nodos y vértices).

[3] El recinto es la UMC según el apartado 25 del artículo 2 del Reglamento Delegado (UE) nº 640/2014 de la Comisión, caracterizado por ser una superficie continua de terreno, delimitada geográficamente, dentro de una parcela con un uso único. En el presente trabajo, se definen las parcelas agrarias como el conjunto de recintos que son adyacentes, pertenecen al mismo propietario y tienen las mismas características productivas, y el conjunto de parcelas agrarias de un mismo propietario forma una explotación agraria.

Fuente: Elaboración propia.

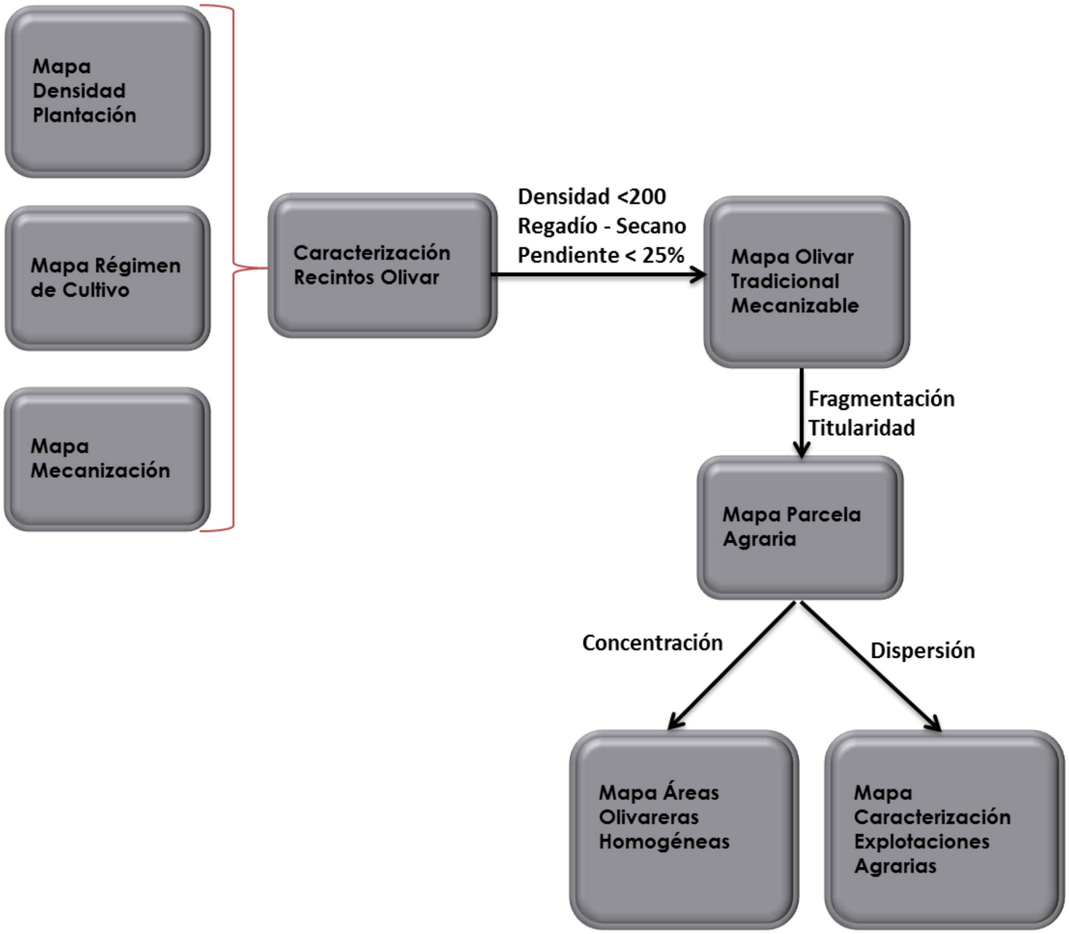

Figura 4: Metodología general seguida.

Posteriormente, se ha generado el mapa del olivar tradicional (Figura 5). Dicho olivar se ha caracterizado en cuatro tipos: OTNMS (Olivar Tradicional no Mecanizable de Secano), OTNMR (Olivar Tradicional no Mecanizable de Regadío), OTMS (Olivar Tradicional Mecanizable de Secano) y OTMR (Olivar Tradicional Mecanizable de Regadío). Finalmente, por selección de aquéllos recintos cuya densidad es menor de 200 olivos/ha (criterio utilizado para considerar el olivar como tradicional) y una pendiente media menor del 25% (criterio utilizado para considerar el olivar como mecanizable) se ha identificado el OTM, objeto de estudio en esta tesis.

Fuente: Elaboración propia.

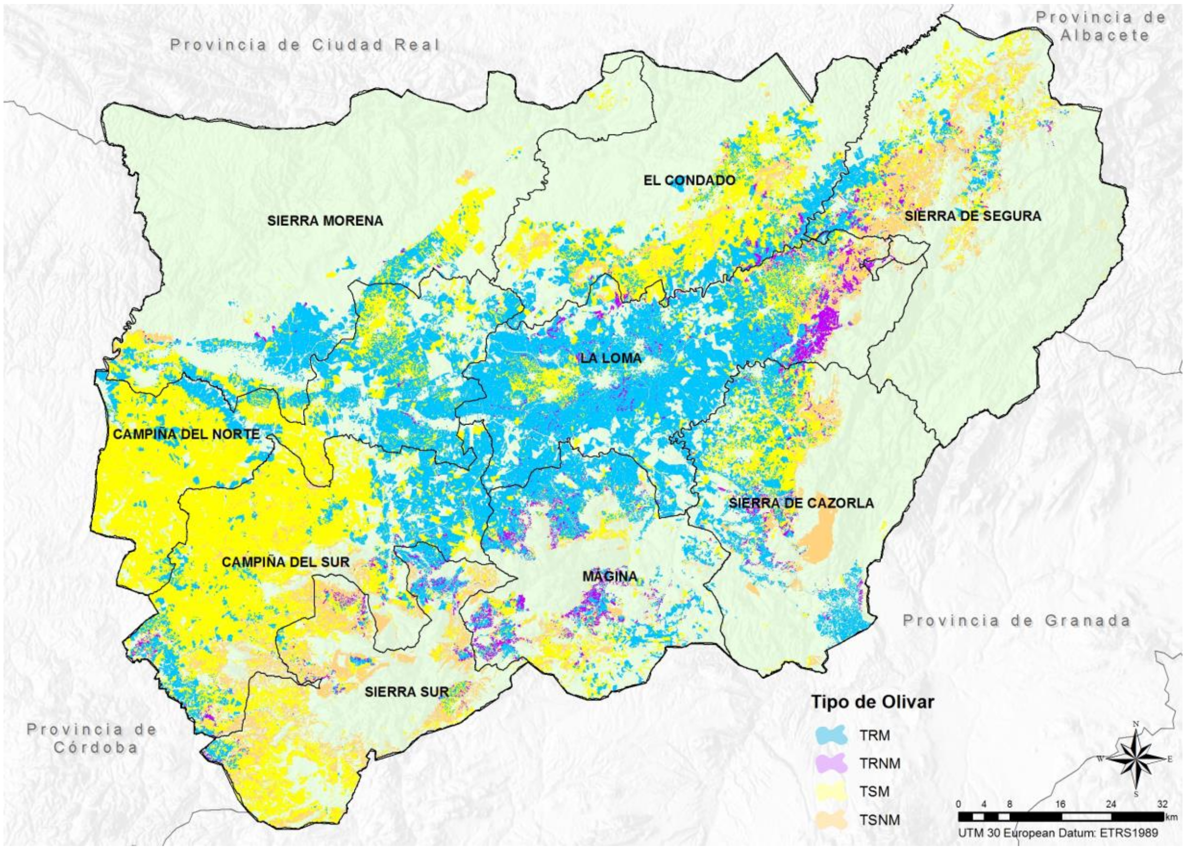

Figura 5: Distribución espacial del olivar tradicional en función de su tipología.

3.3.2. Caracterización de las parcelas agrarias de olivar

A partir del mapa de recintos descritos más arriba, se ha generado el mapa de las parcelas agrarias, mediante la unión de los recintos de olivar adyacentes y pertenecientes a un mismo propietario, dado que cada recinto lleva asociada la información relativa a su titularidad. Las parcelas agrarias, así definidas, constituyen las verdaderas unidades de trabajo de las labores de manejo en cada explotación agraria, razón por la que deben ser la base para el cálculo de los costes reales de explotación y por lo que han sido consideradas en esta tesis doctoral como referencia para los estudios de concentración parcelaria y caracterización de las explotaciones agrarias.

En el conjunto de los datos, se han observado recintos declarados por más de un propietario, que han sido atribuidos al propietario que mayor superficie ha declarado en los mismos. Por otro lado, los recintos aislados con superficies inferiores a 0,1 ha (10 olivos, al marco de plantación medio de la provincia de 10 m) han sido asignados a las parcelas agrarias con las que comparten mayor longitud de linde, pues en su mayor parte obedecen a errores geométricos y tan sólo suponen en torno el 0,06% de la superficie total.

3.3.3. Caracterización de las explotaciones agrarias

Un análisis a escala de parcelas agrarias da información sobre la fragmentación espacial, la forma y el tamaño de las parcelas de un mismo propietario, pero no permite deducir el grado de dispersión de las mismas en el territorio. Explotaciones agrarias cuyas parcelas estén más dispersas necesariamente deben tener mayores costes de explotación que explotaciones agrarias con parcelas más concentradas, a igualdad de superficie y números de parcelas agrarias. En esta fase se han identificado las parcelas que corresponden a un mismo propietario con el fin de aglutinar en una misma entidad todas las características afines a ella (superficie, distribución geográfica, número de parcelas, etc.).Como resultado final de la caracterización, se han generado mapas que permiten identificar, por un lado, las explotaciones agrarias en función de la estructura productiva que directamente afecta a los costes de gestión, entendida como la dimensión, fragmentación y dispersión de sus parcelas agrarias, y por el otro, las áreas del territorio más idóneas para la aplicación de instrumentos de gestión basados en la cooperación de olivareros próximos entre sí y el aumento de la superficie cultivada de forma unitaria, para beneficiarse de economías de escala que reduzcan los costes de producción.

3.4. Resultados

3.4.1. Caracterización de los recintos SIGPAC

El análisis del mapa de recintos del SIGPAC revela que hay 488.028 recintos de olivar que representan una superficie de 569.903 ha. La superficie media de los recintos olivareros es 1,16 ha. Del conjunto de los recintos de olivar, un 94,38% están constituidos por olivares tradicionales con densidades inferiores a los 200 olivos/ha. Por encima de éste umbral, se sitúan los olivares intensivos y superintensivos (27.414 recintos). Con respecto al régimen de cultivo, los recintos en regadío alcanzan el 30,38% de la muestra (173.140) y una superficie del 45,67% (260.312 ha). La superficie media de este tipo de recinto es de 1,5 ha. Los recintos de secano tienen una superficie media inferior (0,98 ha) y suponen el 69,62% de la muestra cubriendo una superficie de 309.591 ha. El 74,99% de los recintos son mecanizables, es decir tienen una pendiente media inferior al 25% y se extienden sobre una superficie de 476.800 ha (83,66%). La dimensión media del recinto mecanizable es de 1,3 ha, sensiblemente superior a la del recinto no mecanizable, que es de tan sólo de 0,76 ha.

3.4.2. Caracterización de las parcelas agrarias

Los datos de la caracterización de las parcelas agrarias de OTM de la provincia, obtenidos a partir del mapa de parcelas agrarias, ponen de manifiesto el intenso grado de minifundismo de este cultivo en la provincia de Jaén, resultando un tamaño medio de parcela de 1,71 ha, y una elevada proporción de parcelas agrarias de dimensiones reducidas: el 62,93% de las parcelas presentan una superficie inferior a 1 ha (17,80% del suelo olivarero), y el 54,56% la presentan inferior a 5 ha.

A nivel provincial, la distribución de las parcelas con superficie inferior a 1 ha no es homogénea. Los valores oscilan entre el 8,15% del suelo olivarero de la comarca de Sierra Morena y el 33,24% de la Comarca Sierra Sur. También se observan diferencias según el régimen de cultivo, dado que las parcelas agrarias en régimen de regadío promedian 1,72 ha, mientras que las que se encuentran en régimen de secano tan sólo presentan una superficie de 1,47 ha, por término medio.

3.4.3. Caracterización de las explotaciones

Considerando todas las parcelas agrarias de un propietario independientemente de su relación espacial, los análisis indican que el 77,62% de las explotaciones agrarias (65.820) presentan una superficie inferior a 5 ha, lo que supone una superficie de 11.217 ha (24,55%). En contraste, sólo un 1,37% de las explotaciones tienen más de 50 ha, si bien estas últimas abarcan una superficie del 24,8% del total. El valor medio de la superficie de las explotaciones agrarias de olivar tradicional en la provincia de Jaén es de 5,29 ha. En cuanto al número de parcelas, las explotaciones agrarias jiennenses constan de 3,08 parcelas por término medio, que están muy dispersas en el territorio (6,27 km de media provincial).

3.5. Discusiones y conclusiones

La dimensión, fragmentación y dispersión de las parcelas agrarias que componen una explotación influyen directamente en los costes de producción. A pesar de esto, no existen estudios en la literatura que hayan investigado el impacto de estos factores (fragmentación y dispersión parcelaria) en la rentabilidad. Tampoco existen estadísticas oficiales que ofrezcan detalles sobre la composición parcelaria intra-explotación. Caracterizar las explotaciones en función de su dimensión, fragmentación y dispersión en el territorio es, así, un paso necesario para que futuros estudios de costes puedan afinar sus estimaciones a la realidad.

La caracterización de las explotaciones agrarias pone de manifiesto que las explotaciones de la provincia de Jaén se caracterizan por el minifundismo y la atomización parcelaria. En el conjunto, la dimensión media de las explotaciones es de poco más de 5 ha distribuidas en varias parcelas dispersas a una distancia media de casi 6,3 km. Además, si consideramos como escala de análisis la parcela agraria, la fragmentación es aún más importante, alcanzando las parcelas un tamaño medio de poco más de 2 ha. En estas condiciones, se hace necesario implementar políticas para favorecer la concentración parcelaria y/o la gestión en común de las tierras en aras de mantener la competitividad de las pequeñas explotaciones.

En definitiva, la caracterización de la estructura espacial de las explotaciones agraria proporciona una descripción más fidedigna de la realidad estructural del sector olivarero jiennense, y facilita información útil al diseño de políticas para el fomento de la competitividad. En el caso de la provincia de Jaén, creemos que el nuevo Plan Director del Olivar de Andalucía es una estrategia de futuro que debe considerar los resultados aquí destacados.

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BLOQUE IV:

PUBLICACIONES DE LAS INVESTIGACIONES

Capítulo 4. Contexto y publicaciones de la investigación

Esta tesis doctoral se ha llevado a cabo durante el periodo 2015-2018 en el Área de Economía de la Cadena Alimentaria (IFAPA) en Mengíbar (España), en el marco del proyecto P11-AGR-7515. ***"La reconversión del olivar tradicional hacia un modelo cooperativo integral de producción: análisis de la perspectiva de los agricultores y de la sociedad de formas de implementación y de sus efectos",*** con financiación de la Consejería de Economía, Innovación, Ciencia y Empleo de la Junta de Andalucía y del Ministerio de Economía y Competitividad. Dentro de este proyecto, el doctorando fue contratado como geógrafo (especialista en SIG), con el objetivo de modelizar territorialmente el OTM y determinar las distintas estrategias enfocadas en la cooperación y ahorro en costes de producción.

Desde mi participación en este proyecto y de doctorado en la Universidad de Jaén (Departamento de Antropología, Geografía e Historia), bajo tutela del Dr. D. José Domingo Sánchez Martínez, se han derivado los siguientes documentos y premio de investigación. Además de más de una decena de contribuciones a congresos nacionales, tres a congresos internacionales y trece publicaciones en revistas sectoriales de divulgación:

- **Listado de publicaciones en revistas indexadas en JCR:**
    - Colombo, S. y Perujo-Villanueva, M. (2017). The inefficiency and production costs due to parcel fragmentation in olive orchards. *New Medit*, 2, 2-10. Este artículo se representa textualmente en el capítulo 5.1 de la tesis.

    - Colombo, S. y Perujo-Villanueva, M. (2017). Analysis of the spatial relationship between small olive farms to increase their competitiveness through cooperation. *Land Use Policy*, 63, 226-235. Este artículo se representa textualmente en el capítulo 5.6 de la tesis.

    - Perujo Villanueva, M., Colombo, S. (2017). Cost analysis of parcel fragmentation in agriculture: the case of traditional olive cultivation. *Biosystem Engineering*, 164, 135-146. Este artículo se representa textualmente en el capítulo 5.2 de la tesis.

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- Perujo-Villanueva, Manuel y Colombo, S. (2018). Impact of parcel fragmentation on the calculation of the real estate value of land belonging to farms. *Journal of rural studies*. Actualmente en revisión. Este artículo se representa textualmente en el Capítulo 5.4 de la tesis.

- Colombo, S. y Perujo-Villanueva, M. (2019). Fully connected parcels with the same value. A practical method for the ex-ante evaluation of land consolidation initiatives. *Land Use Policy*, 81, 463-471. Este artículo se representa textualmente en el Capítulo 5.5 de la tesis.

- **Premios a la investigación:**

  - Colombo, Ruz Carmona y Perujo-Villanueva (2017). Premio José Humanes (IV edición) para el desarrollo del sector oleícola y del aceite. La rentabilidad del olivar tradicional en la provincia de Jaén: un análisis desde una perspectiva real.

Capítulo 5. Artículos científicos publicados

5.1. THE INEFFICIENCY AND PRODUCTION COSTS DUE TO PARCEL FRAGMENTATION IN OLIVE ORCHARDS*

*Este artículo es copia literal del publicado en: Colombo, S. y Perujo-Villanueva, M. (2017). The inefficiency and production costs due to parcel fragmentation in olive orchards. New Medit, 2, 2-10.

5.1.1. ABSTRACT

Olive trees in the Mediterranean countries comprise the most widespread fruit-tree crop. Spain, Italy and Greece, the three main producer countries in Europe, account for 65% of the total world production. The production structure of olive farms in these countries is characterized mainly by traditional small-scale management. In addition to a small size, these farms also have a highly fragmented structure, typically made by several scattered parcels. The fragmented structure hampers farm competitiveness by raising production costs. This leads to a progressive exclusion of these farms from international markets and eventually to land abandonment. Here, we quantify the inefficiency due to parcel fragmentation, in particular losses due to the border effect, and we propose farmers' cooperation as a measure to reduce such losses. The results indicate significantly lower efficiency due to parcel fragmentation. Currently, farmers are managing around 14.4% of olive orchards inefficiently relative to a comparable situation without fragmentation. The results call for specific agricultural policies that foster cooperation among farmers in order to reduce parcel fragmentation and production costs.

Jel Code: Q12, O13.

Keywords: Fragmentation, olive orchard, production costs

5.1.2. RÉSUMÉ

L' Olivier est l'arbre le plus courant dans les pays méditerranéens. L'Espagne, L' Italie et La Grèce, les trois principaux pays producteurs en Europe, repréensentent le 65% de la production mondiale totale. La structure de production des oliveraies dans ces pays se caractérise principalement par la gestion traditionnelle à petite échelle. En plus d'êtres petites, ces oliveraies ont également une structure très fragmentée, généralement composée de plusieurs parcelles dispersées. Cette fragmentation complique la compétitivité agricole tout en augmentant les coûts de production. Cela conduit à une exclusion progressive de ces fermes sur les marchés internationaux et, éventuellement, à l'abandon des terrains de culture. Ici, nous remarquons la baisse de rendement due à la fragmentation des parcelles, en particulier les pertes dues à "l'effet de bord", et nous proposons la coopération des agriculteurs en tant que mesure visant à réduire ces pertes. Les résultats indiquent que

l'efficacité est significativement plus faible en raison de la fragmentation parcellaire. Actuellement, environ 14,4% des oliveraires sont gerées par les agriculteurs et elles seraient plus rentables se les parecelles n'étaient pas fragmentées. Au vu de ces résultats il serait nécessaire d'établir des politiques agricoles spécifiques qui favorisent la coopération entre les agriculteurs afin de réduire la fragmentation des parcelles et des coûts de production.

Jel Code: Q12, O13.

Mots-clés: Fragmentation, oliveraie, coûts de production

5.1.3. INTRODUCTION

Land fragmentation can be defined as a number of spatially separated parcels of land which are farmed as a single unit (King and Burton, 1982). This results from institutional, political, historical, and sociological factors over the time, which provoke the geographical scattering of the agricultural parcels. Land fragmentation is generally considered an impediment to efficient crop production, because it hampers agricultural mechanization, generates more intensive management with the corresponding costs for the extra time and fuel necessary to travel between parcels, and it reduces economic profits (Akkaya *et al.*, 2007, Chukwukere Austin *et al.*, 2012). On the other hand, studies also point to beneficial effects due to land fragmentation such as risk reduction through spatial dispersion (Blarel *et al.*, 1992) or improvements in landscape quality and farm biodiversity (Di Falco *et al.*, 2010).

The impact of land fragmentation on farms' performance has been studied under different approaches, among which the use of production function has been the most widely used (Blarel *et al.*; 1992; Hang *et al.*, 2007; Kawasaki, 2010). In these studies, land fragmentation is assumed to affect either production costs or production efficiency. Results indicate that fragmentation impedes efficient production, even when the benefits are explicitly taken into account (Kawasaki, 2010). Other studies have analysed the impact of land fragmentation on a set of farm-performance indicators related to production costs, yields, revenues, and efficiency scores. Latruffe and Piet (2014) regressed a set of 10 land-fragmentation descriptors referring to the number, size, shape, and distance between parcels, with the farm-performance indicators and found that land fragmentation raises production costs and lowers yields, revenue, profitability, and efficiency.

In the case of olive orchards, the information available on land fragmentation is scarce. Although it is well recognized that the production structure is typically very fragmented (European Commission, 2012a), no studies available have characterized the fragmentation within the olive-orchard sector and estimate the impact of fragmentation on production costs. For example, Eurostat (2015) reveals that the average farm size in the three main European olive-oil producers, Spain, Italy and Greece is just 5.8, 1.8 and 1.5 ha, but does not provide any information concerning the production structure within the farms, such as the parcel numbers, size, shape, or their geographical distribution. In a similar vein, previous studies on crop-production costs do not take fragmentation into account, typically assuming labour times for homogeneous fields, normally of large dimensions, and without any impediment to machinery performance. The production-cost study by AEMO (Asociación Española de Municipios del Olivo (Cubero and Penco, 2012)) assumed a field type of 30 ha in pricing the mechanized labour by the companies providing services. Arbonés *et al.* (2014), in their study based on the technical-economic analysis of different olive-tree planting systems in semi-arid areas, assumed that there were no limitations to machinery use. Therefore, the results of these studies may diverge significantly from reality, since they are not based on the real conditions of olive-orchard fragmentation and territorial scatter of fields that make up the farms.

The economic situation of olive farms has significantly worsened over the last decade (European Commission, 2012a), leaving the traditional olive farms barely profitable and at abandonment risk without the subsidy of the Common Agricultural Policy (CAP). The last CAP reform, made within a context of budget reductions and redistribution, has reduced the support for olive farming, a typical high-subsidized sector, making the continuity of traditional olive orchards even more precarious. In this context, improving farming performance is essential for the survival of traditional olive farms, and saving on production costs via the reduction of inefficiency due to parcel fragmentation may be a valuable option especially in areas where, for topographical and climatic limitations, no other alternatives are feasible in order to boost profitability, as for example irrigation or intensive cultivation (Sánchez Martínez and Gallego Simón, 2011).

In this study, we analyse the parcel fragmentation of the traditional olive orchards in the province of Jaen (Andalusia, Spain), in order to assess its impact on production costs. The analysis was made considering the production inefficiency resulting from land fragmentation in the management of the borders of the parcels. We did not consider the distances between parcels or between the plots and the farmsteads[4]. We defined this inefficiency as the "border-effect area". This concept quantifies the impact of mechanization on the borders of the parcel, where efficiency is lost because only the outer side of olive row is treated, while between rows the treatment can be applied to two rows of olive trees at once. Consequently, the efficiency of a management task at the border of an olive parcel is reduced by 50% relative to the efficiency of the same task in the centre of olive orchards. For a given size, farms with more parcels, i.e. more fragmented, have proportionally more borders than farms with fewer parcels and, as a consequence, greater inefficiency. By relating the inefficiency to the time farmers need to apply the field treatments, it is possible to translate the inefficiency into production costs. No available studies have made this analysis and thus the present paper aims to fill this gap.

This paper also analyses farmer cooperation as a mean of reducing the impact of parcel fragmentation on farm profitability. Typically, to reduce parcel fragmentation, land-consolidation programs have been implemented, especially (but not exclusively) in less developed countries (Blarel *et al.*, 1992; Niroula and Thapa, 2005; Van Hung *et al.*, 2007; Kawasaki, 2010). The main aim of these programs was to enable farmers to amalgamate their fragmented parcels to introduce ostensibly better farming techniques and improve the competitiveness of their farms. Land-consolidation programmes require the re-allocation of parcels with substantial changes in land tenure according to the basic principle that all farmers must not be worse off after consolidation than before it. However, this is quite difficult to implement in practice, given that the assessment of property values is generally

[4] There is no source of information on rural paths at the province scale that enables a map to be drawn of isochrones between plots of a farm. The sources of information available lack exactitude (work scale), are partial (do not cover the entire study area), or do not separate the ownership of the lanes (public/private) and therefore the distance between plots cannot be modelled using existing roads.

based on the natural productive capacity, while other issues concern the farmers' subjective value of their lands, such as the position relative to other parcels, available infrastructures, roads, farm buildings, and facilities. Intangible values may even be involved, such as the participation in the existing social network, inheritance details, and environmental issues. In the case of olive orchards, a perennial crop that would be costly to change and where the production varies greatly according to the alternating biological cycle of the olive tree (alternating seasons of heavy and light yield), olive variety, soil, and local climatic conditions, land consolidation is even harder to accomplish. Therefore, farmer cooperation, where no land tenure is changed and farmers enters in management arrangements only of their lands, offers an option to reduce land fragmentation.

The paper is organized as follows. Firstly we describe the study area in terms of the economic, social, and environmental importance of the olive orchard and several aspects relative to the existing production structure. Next, we outline the methodology used for data analysis. Then we report the results and discuss implications for decision-making. We end the article with a set of conclusions.

5.1.4. STUDY CASE

Andalusia (Spain) is the world leading olive-oil production region, with 75% of national olive-oil production and the 62% of growing area (Mili *et al.,* 2013). With an area of more than 1.5 million ha, olive orchard is the characteristic agricultural crop of Andalusia per excellence. The study case focuses on the traditional olive orchards of the province of Jaen, in Andalusia. In this province the olive grove is by far the most important agricultural activity. Orchards cover 83.3% of the agricultural surface area, constituting approximately 26% of the total surface area of olive orchards in Spain (CES, 2011).

It is noteworthy that the olive-oil production in this province alone is larger than the olive-oil production in the other two most important production countries in the world, Italy and Greece. As such, the olive industry in this province has overwhelming economic, social, and environmental importance (Gomez Limón and Riesgo, 2012). In the economic terms, olive orchard is the leading agricultural sector, representing the 74% of the total agricultural production value. Also, olive groves have been identified as "the social crop" for the significant impact it has on employment, generating the most jobs in the province (36,360 direct jobs, [CAPDR, 2015]). Traditional olive orchards have also been associated with high natural value agricultural systems, despite that the ecological value has diminished in recent decades due to the modernization of olive farming, resulting in olive monoculture systems in large areas of the province (Areal and Riesgo, 2014).

Semi-intensive and extensive olive-growing systems prevail in the province and are characterized by highly fragmented structure. The traditional olive orchard would be barely profitable if not for the common agricultural policy (CAP) subsidy from the European Union (Colombo *et al.,* 2015). Thus, improved performance by reducing production costs is essential for the survival of olive farms.

5.1.5. METHODOLOGY

Information about the olive-orchard parcels was taken from the shapefile of SIGPAC 2013. SIGPAC is the official government geographic information system which delineates the spatial configuration of the agricultural parcels in Spain. It provides the spatial details of all "reference parcels", defining the minimum unit of cultivation, characterized by being a continuous land surface delimited geographically within a parcel having a single use. It was enforced by Council Regulation (EC) No 1593/2000 for the identification of agricultural parcels when carrying out administrative checks on areas declared by farmers. SIGPAC does not represent the real fragmentation structure of the agricultural parcels because it does not consider whether the reference parcels are adjacent or not and splits the olive grove parcels into several reference parcels. Thus, starting from the reference parcels included in SIGPAC 2013, we joined all the olive parcels that belong to the same owner. Additionally, given that we are interested only in the traditional olive orchards that can enter into farmers' cooperation arrangements, i.e. those that can be managed by means of a tractor and that share the same management, we included in the analyses only the reference parcels for which slope was lower than 25% and tree density was less than 200 trees per ha. Considering slope restriction, we filtered out the non-mechanizable olive orchards where no tractor could be used. For density restrictions we removed the intensive orchards that had different management requirements. Thus, the traditional olive orchard considered in this study covers the 78.5% of the olive-orchard area and is the most representative crop of the province.

Parcel fragmentation causes inefficiency due to the border effect because treatments using tractor-pulled equipment can be applied only to one side of the edge row of olive trees instead of two rows at once as inside the orchard. All parcels have borders, and therefore an intrinsic degree of inefficiency. Therefore, parcel fragmentation increases the inefficiency because farms with separated parcels have proportionally more borders than the same-sized farm having one or fewer separated parcels. As such, the border effect is directly related to land fragmentation. As an example, for demonstrative purposes, Figure 6 delineates the border effect for two identical-sized farms with different degrees of fragmentation. Of course, this effect only occurs in treatments that, within the olive orchard field, reach two rows of olive trees simultaneously, such as spraying for weed control, fertilizers, manure applications, and vegetal cover control. Although these are not all of the tasks, they represent the majority of the work undertaken by most farmers[5].

Source: Authors' elaboration

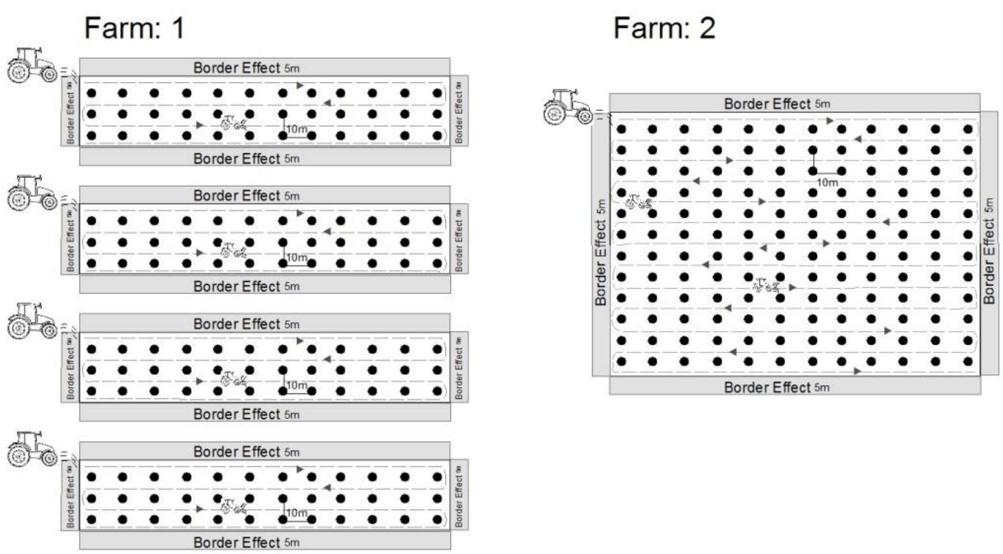

Figure 6*:* Examples of the border effect area for two identical sized farms with different parcel fragmentation.

[5] On average, a farmer carries out a total of 8-10 field tasks each year. Clearly, the number of tasks finally undertaken depends on the management system of each farm. In Andalusia, the most common management system is reduced tillage, followed by the use of vegetal covers and traditional management ESYRCE (2012).

The border effect also depends on the shape of the parcels. Squared parcels have a lower border effect than rectangular parcels, as the more elongated the shape the higher the border effect (Figure 7). Thus, both parcel number and shape need to be considered when calculating the border effect.

Source: Authors' elaboration.

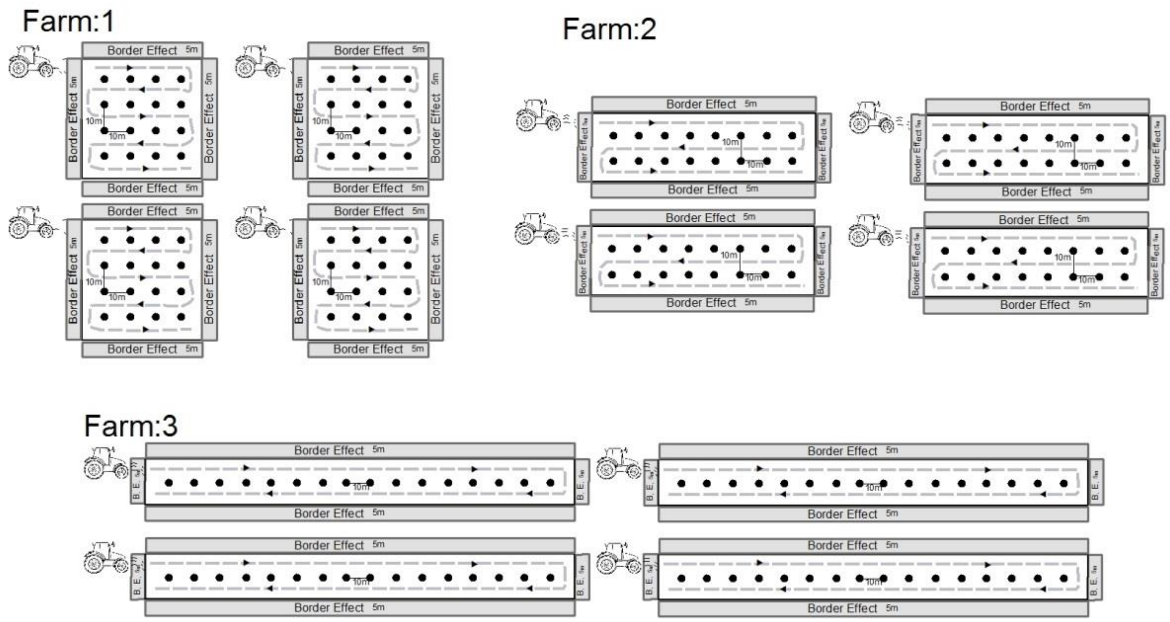

Figure 7: Examples of the border effect area for two identical sized farms with the same number of parcels but different shapes.

The inefficiency due to the border effect can be expressed quantitatively in terms of agricultural area managed inefficiently, by considering the area that is "lost" due to the impossibility of treating two olive rows at once along the perimeter of the parcels. Assuming a typical planting frame of 10 * 10[6], in the inner lines of the olive trees a farmer treats 10 square meters of the olive orchard per meter travelled with the tractor, while in the outer line just 5 square meters are treated. As such, for each agricultural parcel, the area lost due to the border effect can be calculated as follows:

$$BEA_j = \left(\frac{M}{2}\right) * P_j \qquad [1]$$

[6] In the province of Jaén the typical tree density per ha is 100, which corresponds to a planting scheme of 10 x 10.

where BEA_j is the border effect area of parcel *j*, M is the planting scheme, and P is the perimeter of the parcel.

Given the specific parcel-fragmentation structure of each farm, the BEA of farm *i* can be calculated by adding together the BEA_j of the J parcels making up the farm:

$$BEA_i = \sum_j^J BEA_{ji} \qquad [2]$$

The BEA calculated following Eq. 2 describes the area that a farmer loses when treating the borders of his parcels. This is an absolute value for each farm which is not comparable among farms. To estimate the loss of efficiency due to parcel fragmentation in a comparable way among farms, we need to calculate the BEA relative to total area of the farm and at the same time, to consider that all farms, even non-fragmented ones, have borders. The first criterion is achieved by dividing the BEA by the area of the farm. The second is met by subtracting from the BEA of farm *i* the BEA of a hypothetical "optimal farm" -in terms of fragmentation- of the same size. For optimal farm we consider a farm that is no fragmented and is composed by a single square parcel. The BEA of this optimal farm represents the minimum border area that exists in the case that a farm does not show any loss of efficiency due to its borders. For each farm, an estimate of the area lost (inefficiency) due to land fragmentation (Eq. 3) is represented by the expression

$$I_i = \frac{BEA_i - BEA_{NFi}}{A_i} * 100 \qquad [3]$$

where BEA_{NFi} is the border effect area of farm *i* in the ideal no fragmented case, BEA_i is the border effect area for the same farm in the real situation, and A_i is the total area of the farm. As can be seen, when farm *i* is made up of just a single square parcel, the inefficiency is equal to 0.

The inefficiency from the border effect depends on the area, shape, and number of parcels making up a farm. Figure 8 shows the inefficiency resulting from three hypothetical cases where we vary these structural farm characteristics. In particular, Figure 8.a, with constant farm size (5 ha) and the shape (rectangular with border 1 = 2* border 2), shows the inefficiency on varying the number of parcels. Figure 8.b, with constant parcel size (5 ha) and number (1), indicates the inefficiency by varying the parcel shape, assuming a rectangular form. Finally, Figure 8.c, presents the inefficiency on varying the farm size but keeping constant the number of parcels (1) and the shape (rectangular with border 1 = 2* border 2).

Source: Authors' elaboration.

A

B

C

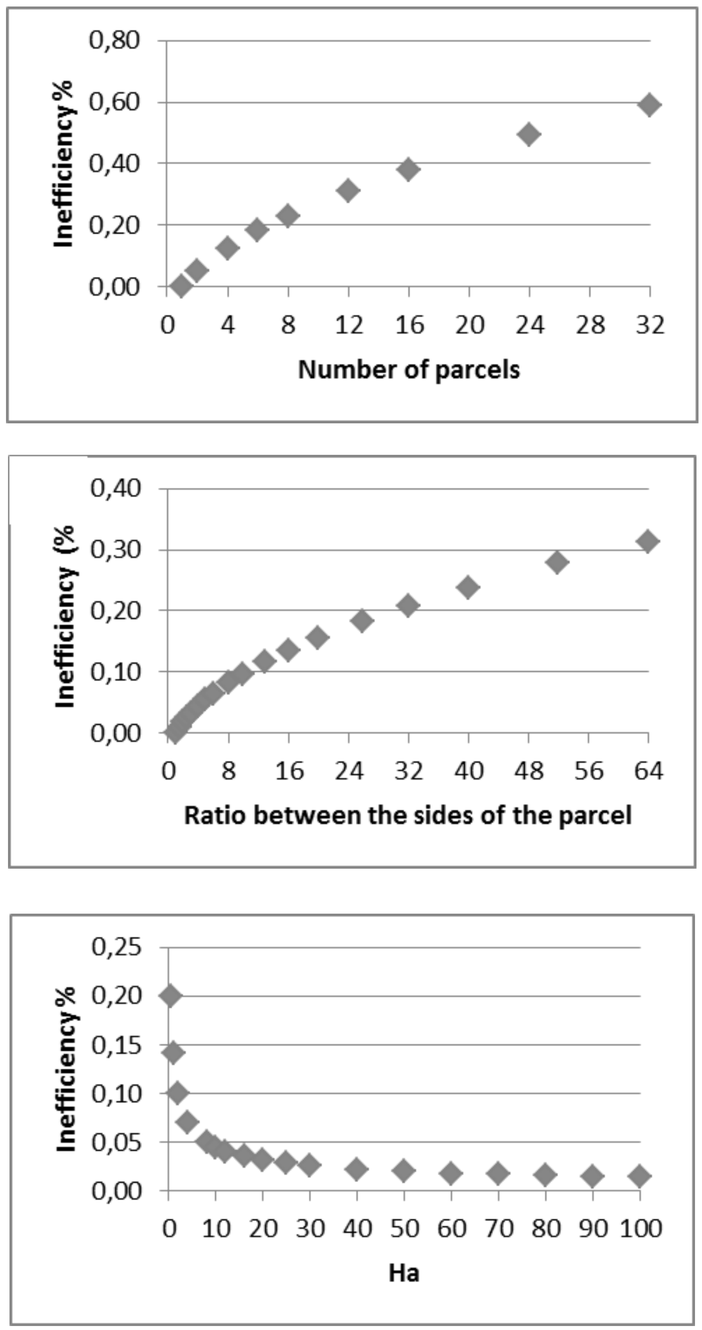

Figure 8: Inefficiency due to the border effect as a function of number of parcel (Fig. A), ratio between sides (Fig. B), and farm size (Fig. C).

As can be seen, the inefficiency rises rapidly when the number of the parcels increases, reaching very high values when the number of parcels is higher than six. Under these conditions, the higher proportion of the border relative to the total area causes farmers an efficiency loss of more than 20% of the land in their management operations. The same happens, although to a lesser extent, when the parcels are more elongated. Rectangular parcels in which the longest side is more than 10 times the shortest cause an inefficiency of 10%. All else being equal, the larger the farm the lower the inefficiency, given the lower weight of the borders relative to the total area of the parcel.

The value of inefficiency estimated in Eq. 3 corresponds to the "overall" effect of land fragmentation and is relative to the ideal case in which all agricultural parcels belonging to a farm can be joined to form a large square parcel. Clearly, this is not possible in practice where only the adjacent parcels can be joined to reduce the inefficiency due to the border effect, and the shape of the resulting agglomerate of parcels may differ from a square. Assuming that all farmers that share a common border cooperate in the field operations such that the adjacent parcels form an aggregate of parcels[7], we can calculate the increase of the efficiency due to the reduction of the border effect via farmers' cooperation by comparing the BEA of the *J* parcels which belong to the agglomerate *k*, with the BEA of the agglomerate *k*. The resulting efficiency gain (EG) is given by the following formula,

$$EG_k = \frac{\sum_{j=1}^{J} BEA_j - BEA_k}{A_k} * 100 \qquad [4]$$

where A_k is the area of the agglomerate *k* and the other terms have been defined previously. Figure 9 shows an example of the aggregation process taken from the study area, where we form an aggregate from four parcels that belong to four different farmers. As can be seen, the efficiency gain is highly significant (29%) given that the agglomerate reduces the number of parcels and increases the area (rendering it more squarish) in relation to the perimeter.

[7] The resulting aggregates represent spaces of olive orchards internally homogeneous with the same management operations. They are separated from other aggregates by roads, rivers or other physical boundaries.

Source: Authors' elaboration.

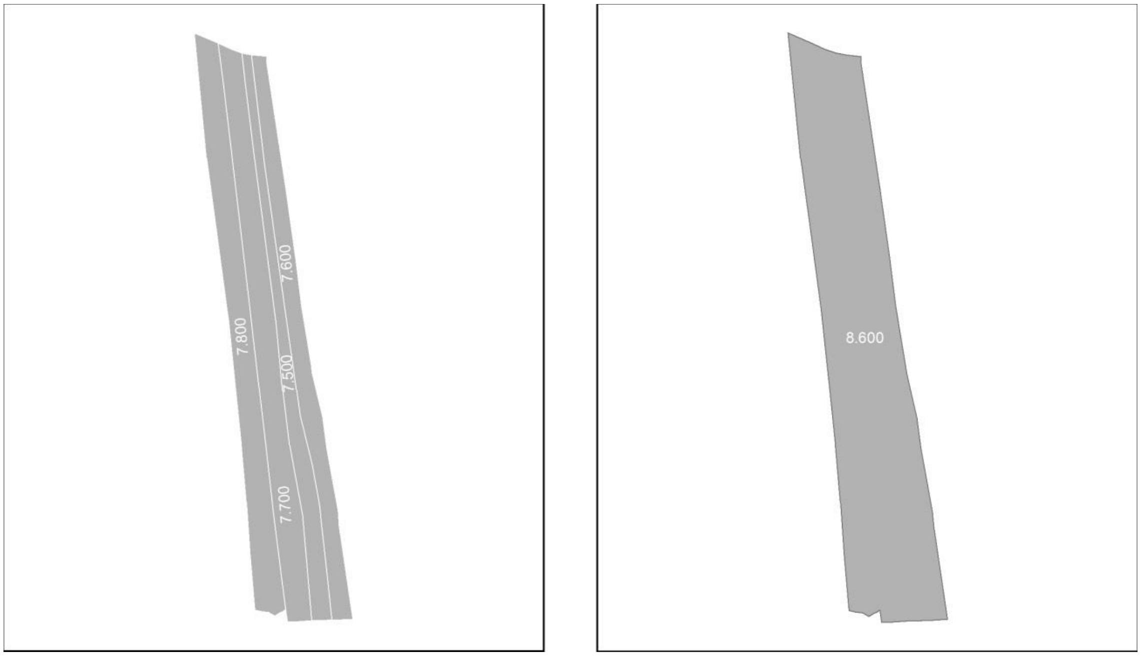

Figure 9: BEA (in square metres) of single and agglomerate of parcels resulting from joining the adjacent borders. Area of the agglomerate: 7.6 ha. Efficiency gain: 29%.

To translate the inefficiency value into production costs requires calculating the time farmers loose in their treatments for the inefficiency due to the border effect and quantifying it in monetary terms. According to data of the Spanish Ministry of Agricultural Food and Environment (MARM, 2008), the time needed to manage one ha of traditional olive orchard is 206.5 hours per year. Out of this time, the field operations affected by the border effects require an average of 33 hours ha^{-1} $year^{-1}$ (MARM, 2008)[8]. Thus, a 1% of inefficiency due to the border effect causes the farmer to employ almost 0.33 hours more per ha y^{-1} in field operations. This time can be converted in to production costs considering an average wage of 9.85 €/hour for the tractor driver and 10.91 €/hour for tractor utilization (Márquez, 2007). Using these values, it results that each 1% of inefficiency due to the border effect costs around 6.85 € ha^{-1} y^{-1} to farmers.

[8] We include the time needed for 3 treatments for pest control, 1 fertilizer application, 1 treatment for weed control using herbicides, and 2 treatments by cultivation methods such as hoeing, cultivating, or using weeding tools.

5.1.6. RESULTS

The province of Jaén has a total of 460,614 “reference" parcels of traditional olive orchards which occupy an area of 448,831 ha. The joining of the adjacent parcels which belong to the same owner provides a total of 261,450 parcels of traditional olive orchards. These parcels, thus defined, constitute the true work units of labour and machinery on each farm, and therefore should be used to calculate the real impact of land fragmentation. The area of the smallest parcel is only 0.04 ha while the largest is 350 ha. Table 1 shows that the distribution of the olive parcels is positively skewed, with the mass of the distribution concentrated on the left. That is, 63% of the parcels have less than 1 ha, with an average of 0.5 ha in this group. About 94% of the parcels have less than 5 ha and extend over more than half of the total olive-orchard area of the province. On the other hand, there are less than 400 parcels larger than 50 ha.

Source: Authors’ elaboration.

Size (ha)	Parcels		Average surface area (ha)	Accumulated surface area	
	N.	%		(ha)	%
0 – 1	164,526	62.93	0.48	79,896	17.80
1.01 – 5	81,576	31.21	2.02	164,975	36.76
5.01 – 10	9,103	3.49	6.87	62,564	13.94
10.01 – 15	2,764	1.05	12.12	33,515	7.47
15.01 – 20	1,253	0.47	17.16	21,506	4.79
20.01 – 50	1,832	0.70	29.52	54,081	12.05
50.01 – 100	314	0.12	66.15	20,772	4.63
>100	82	0.03	140.84	11,519	2.56
Total	**261,450**	**100**		**448,831**	**100**

Table 1: Structure of olive-orchard parcels in Jaén province (Spain).

In total, there are 84,788 farms, of which 36% show no fragmentation, being composed by only one parcel. The rest have different degrees of fragmentation with the majority made up of 2 to 4 parcels for an average of 4.3 parcels. The most fragmented farm had 101 parcels, though farms with more than 10 parcels made up just 3.4% of the total. Table 2 summarizes the distribution of these parcels according to the number of parcels comprising a farm.

Source: Authors' elaboration.

N. Parcels	N Farms (abs.)	N Farms (%)	Area (ha)	Area (%)
1	30816	36	53932	12
2-4	38010	45	156158	35
5-7	10004	12	95913	21
8-10	3257	4	52457	12
11-15	1790	2	45386	10
16-20	544	1	22167	5
>21	367	0.4	22819	5
Total	**84788**	**100**	**448831**	**100**

Table 2: Number of olive-orchard parcels in the farms of the study area.

The inefficiency due to the border effect in a specific farm of the province of Jaen would be the result of the inefficiency values of its parcels' composition and characteristics, namely number, shape, and size. Overall, the fact that the olive farms of Jaen province are characteristically small, fragmented, and irregularly shaped implies significant inefficiency due to parcel fragmentation. Specifically, the 84,788 farms contain 26,1450 parcels, and of these, only 6% (5256) show no marginal inefficiency due to border effect, being an ideal square parcel. The rest of the farms show different degrees of inefficiency, which average 14.4%. According to an average cost 6.85 € ha^{-1} y^{-1} for each 1% of inefficiency, the average impact of land fragmentation on production costs is 98.6 € ha^{-1} y^{-1}. Considering that the mean production costs of the traditional rainfed olive orchard is 1513 €/ha and 2262 €/ha for the irrigated one (Cubero and Penco, 2012), we find that land fragmentation causes a significant rise in production costs, i.e. a 6.5% and 4.4% higher costs for the rainfed and irrigated olive orchards, respectively. Table 3 shows the distribution of inefficiency due to the border effect for all the farms of the study area and the associated production costs.

Source: Authors' elaboration.

Inefficiency (%)	**Number of farms**	**Cost (€ ha^{-1} y^{-1})**
I=0	5256	0
I <5	7935	0.1 – 34.2
5 ≥ I < 10	20755	34.3 - 68.4
10 ≥ I < 15	21333	68.5 – 102.7
15 ≥ I < 20	14044	102.8 – 136.9
I >20	15465	> 137.0

Table 3: Inefficiency due to the border effect and its production cost.

From Table 3 it is worth noting that a significant proportion of farms (18%) have more than 20% inefficiency. This means that the impact of the inefficiency due to the border effect raises the production costs of these farms more than 9% in the case of rainfed olive orchards and 6% for the irrigated ones. In practice, these values are even greater due to the time that farmers need to move around their parcels. This time can become highly significant when the number of parcels is high and the distance between them large.

The inefficiency calculated above gives the economic cost that farmers currently bear due to their specific farm fragmentation. It represents the results of an ideal consolidation programme that agglomerates all the agricultural parcels of each farm into a square. As pointed out, it is a theoretical value which summarizes the impact of land fragmentation on production costs. However, in practical terms, under the assumption of no changes in land tenure, the maximum reduction in inefficiency due to the border effect can be achieved if all the farmers cooperate in the management of their adjacent parcels. The analysis of the resulting aggregates reveals that out of the 261,450 parcels only 16,260 (6% of the total area) have no neighbouring parcels, and thus cannot benefit from a reduction of the border effect by cooperation. The rest of parcels form a total of 15,689 aggregates, with an average size of 26.8 ha, where cooperation can reduce the inefficiency due to parcel fragmentation (Figure 9).

Table 4 shows the frequencies of the agglomerates of parcels according to the number of farmers and parcels that make up the agglomeration. As can be seen, the majority of the aggregates are composed of a reduced number of farmers and parcels. In fact, more than half of the aggregates are made up of less than four parcels and farmers. In this situation, farmer cooperation should be relatively easy to implement. On the other hand, around a quarter of the aggregate is formed by more than 10 parcels or farmers. Here, farmer cooperation would be more difficult to implement and would involve larger transaction costs. The last column of table 4 lists the average efficiency gain resulting from joining the adjacent olive groves parcels into the *K* aggregates as in Eq. 4. As expected, the efficiency gain is larger when more parcels are joined in the aggregate. It bears mentioning that the joining of just 4 (small) parcels represents an efficiency gain of more than 10%, for an average saving of 72 € ha^{-1} y^{1}.

Fuente: Source: Authors' elaboration.

N	Number of agglomerates with N farmers	Cumulative frequency	Number of agglomerates with N parcels	Cumulative frequency	Average Efficiency Gain (EG_k %)
2	4333	27,6	4186	26,7	7.1
3	2335	42,5	2264	41,1	9.3
4	1470	51,9	1485	50,6	10.5
5	1023	58,4	981	56,8	11.2
6	772	63,3	780	61,8	11.9
7	536	66,7	540	65,2	11.9
8	451	69,6	439	68,0	12.7
9	419	72,3	375	70,4	12.4
10	344	74,5	370	72,8	13.6
>10	4006	100	4269	100	15.0

Table 4: Frequency of the aggregate according to the number of parcels and number of farmers that belong to the aggregate.

Table 4 also indicates a strong similarity between the number of parcels and the number of farmers in the aggregates (columns 2 and 4). This means that a large majority of farmers has just one parcel in each aggregate. As the average number of parcel is 4.3, the olive groves parcels belonging to a farm are highly scattered throughout the territory. Thus, a farmer wishing to reduce the fragmentation of all parcels owned would need to cooperate with different groups of farmers in the common management, and this could hinder the practical implementation of the cooperation, which would require specific incentive policies.

5.1.7. DISCUSSION

At the European scale, the size of the basic unit of farm production is small or very small. In 51% of the countries of the European Union, farms covering less than 2 ha exceed 25% of agricultural land. In Europe, 69% of the farms have a surface are smaller than 5 ha and only 2.7% exceed 100 ha (European Commission, 2013). Olive cultivation is no exception to this rule and shows a production structure typically formed by small agricultural holdings. In addition to the small size, these holdings typically have a large degree of spatial fragmentation into scattered parcels. In Spain, this structure of land ownership is due partly to a process of splitting up farm property, which began in the 16th century and reached its height in the 19th century with the civil and ecclesiastical disentailment, on the one hand, and the breaking of the majorat system by the Liberal Reform, on the other (Alía and Del Valle, 2004).

Land fragmentation may have significant impact on production costs because farmers have to move from one agricultural parcel to another and because the efficiency of some management tasks decreases along the border of the parcels. In this study, we analyse the impact of the latter cause, leaving the quantification of the former to future research. We found significant production inefficiency due to land fragmentation, which caused inefficient management of around 14.4% of land relative to the ideal case of no fragmentation. This inefficiency translates as a significant increase in production costs, reducing the competitiveness of fragmented farms.

The study focuses on the province of Jaén, the world-leading province in olive-oil production. However, the proposed methodology is fully transferable to other sites and crop systems. In the case of olive orchards, we expect that in the other main producer countries, Italy and Greece, the inefficiency due to land fragmentation may be even more severe, because amongst the three main world olive-oil producers, Spain is the country where farms are on average larger and possibly less fragmented than elsewhere (European Commission, 2012b). In the case of other perennial crops, as for instance pistachios and almond, we expect comparable results given the similar production structure. However, future research should be undertaken to determine the final impact of the border effect on production costs in these crops.

The inefficiency due to parcel fragmentation is proportional to the shape, number and size of the parcels that belong to a farm. Thus, to reduce inefficiency, either the area of the farm must increase (reducing the number of parcels), or the shape needs to be squared as much as possible. Land-consolidation programmes have been used for these purposes in several countries, but they require modifications of the production structure such as land reparcelling and tenure changes, which are difficult to implement in the case of olive orchards. Farmer cooperation may be a viable alternative to reduce the inefficiency due fragmentation while maintaining the current production structure and land tenancy.

Farmer cooperation can take two main forms, namely shared cultivation and assisted cultivation. Shared cultivation should be defined as the activity of a group of farmers who cooperate in the care of their orchards using means in common. In assisted cultivation, owners turn over the management of their olive orchards to an entity with the necessary human, technological, and mechanical resources for professional farming. Both approaches increase the homogeneity in the cultivated surface area and reduce land fragmentation. In the study area, the cooperation between a small number of farmers who share any border of their parcels would significantly lower production costs. In the clusters formed by 4 parcels the average gain is 72 € ha^{-1} y^{-1}, corresponding to a 4.7% saving on production costs in the case of rainfed olive orchards.

Farmer cooperation, by increasing the average size of the agricultural parcels, also creates economies of scale that have proved significant in reducing production costs. According to the EU report on olive-oil farms based on FADN data[9], high income can be related to large olive orchards. This is particularly true in Spain, where farms with higher

[9] FADN is a European system of sample surveys that take place each year and collect structural and accountancy data relating to farms. The aim is to monitor the income and business activities of agricultural holdings and to provide representative data in three dimensions: by region, economic size, and type of farming.

income are on average three-fold larger than the national average (European Commission, 2012b). The main reason is the greater labour productivity due to the mechanization of the harvest of olives. In the study area, the aggregates that result from the joining of the adjacent parcels have an average size of 26.7 ha, which is significantly greater than the 1.7 ha of average size of the parcels which form the aggregates. Thus, the effect of economies of scale is also expected to be significant and should be investigated in future research.

Additionally, farmer cooperation has the potential to improve other matters related to production, such as input supply, marketing, and credit provision. Although parts of these matters are already covered by well-designed marketing and credit cooperatives, farmer cooperation has the potential to offer improvements. This is because such cooperation implicitly creates social capital[10] that would help improve coordination and the transmission of information and knowledge, contributing to reduced operational costs and also to uphold farmers' involvement in the cooperation (Jones *et al.*, 2009). Along the same line, farmer cooperation can improve rental market systems for specialized services, possibly organized by farmers themselves.

Farmer cooperation also has the potential to improve the environmental performance of farming, a cornerstone of the current and future CAP. Fragmented parcels and properties are obstacles to undertake territorial planning, as well as to improve environmental management. This is because the ecological processes take place at landscape-scale and, consequently, the policies aimed at avoiding ecological damage or biodiversity conservation cannot be designed at the individual level, but rather need joint effort among farmers. Making agriculture more economic viable for the future whilst at the same time restoring and maintaining natural capital, should be core functions of agriculture beyond 2020 and reflected in the objectives of the forthcoming CAP (IEEP, 2014).

On the other hand, cooperation involves additional transaction costs which should be adequately compensated. This compensation should cover not only the costs borne by farmers in drawing up a cooperation plan and the associated operational costs, but also should reward farmers for the time and effort necessary to organize the networking and

[10] Social capital comprises the networks, shared norms, values, and understandings that facilitate cooperation within or among groups (OECD, 2001).

other activities related to improving the social capital. In this context, policies that aim to foster cooperation should include measures for training, testing activities, and disseminating results through demonstrative actions. The presence of a technical adviser who serves as a reference for all members to address the farmer's potential doubts should also be promoted. Rocamora *et al.*, (2014) found the latter a principal condition to improve the likelihood of olive farmers to cooperate.

The current rural development policy framework explicitly favours collective actions to enhance the economic, social and environmental performance of agricultural activity. Article 35 of the European Rural Development Regulation (European Parliament and the Council of the EU, 2013) specifically includes measures focused on supporting co-operative approaches. Among the costs covered, it supports farmer organizations, networking between members, and the recruitment of new members. Also it offsets the running cost of cooperation. These measures have been widely adopted in the current rural-development program of Andalusia (Junta de Andalucía, 2015) which incorporates measures aimed at supporting both the creation and the functioning of farmer groups and at providing the technical assistance to them.

Finally, we should mention several limitations of this study. First, the results refer only to the traditional olive orchard that can be mechanized. The impact of parcel fragmentation in the production costs of mountainous or non-mechanizable olive orchards are not identifiable with the methodology proposed. Second, we have not considered the dispersion of the parcels in the territory and as a consequence did not account for the time and costs farmers have to bear in order to move around their parcels. Third, the values of inefficiency have been calculated assuming a scenario of perfect cooperation between farmers. However, it is likely that some farmers will be unwilling to cooperate, and the exclusion of parcels from the aggregate will decrease the efficiency gained by joining together the parcels. Finally, the generalization of this study to other areas or countries requires the prior characterization of the olive orchards at the parcel level. In the European Union this task is straightforward because of common geographic information systems used for the payment and control of the aids to olive-oil production (Council regulation

(EC)1593/2000). However, for other countries this high level of information may be not available.

5.1.8. CONCLUSIONS

The production structure of traditional olive orchards in the Mediterranean countries is highly fragmented. Land fragmentation significantly raises production costs and lowers farm competitiveness.

In a context of continuous reduction of CAP support and intensifying international competition, it is necessary to find alternative production options that promote savings in production costs. Farmers' cooperation, as a way to reduce parcels fragmentation and in turn production costs, is a valuable alternative for this purpose.

At the same time, in line with the objectives of the forthcoming CAP midterm review and the next 2020 reform, there is a need of promoting farming systems that are in tune with environmental and social demands in Europe. Farmers' cooperation in olive groves may contribute to a greener olive farming, permitting agri-environmental and climate measures to be implemented on a wider scale.

Specific policies are needed to promote farmers' cooperation. These policies should have explicit financial aids to promote the creation of farmers' networking and social capital in addition to cover the running costs of cooperation.

5.1.9. ACKNOWLEDGEMENTS

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5.2. COST ANALYSIS OF PARCEL FRAGMENTATION IN AGRICULTURE: THE CASE OF TRADITIONAL OLIVE CULTIVATION*

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5.2.1. ABSTRACT

Land fragmentation and dispersion hampers the optimisation of agricultural management. In this study, a methodology is proposed to quantify the extra costs to farmers caused by the spatial dispersion among agricultural parcels in their farms. The methodology proposed measures the length of the trips between parcels in the same farm, adds the inoperative periods due to the travel and then estimates the additional costs for fuel and labour. The study focuses on traditional olive cultivation in the province of Jaen for being a major crop with a highly fragmented and scattered structure. Thus, the profitability of this crop is seriously reduced so lower production costs become necessary to prevent crop abandonment. The results indicate that the dispersion of the olive parcels has a significant impact on production costs, with cases in which the expense of travel between parcels represents more than one fourth than the overall farming costs. The significant impact of the spatial dispersion of the parcels on production costs evidences the need for policies either to enlarge the farm size or to foment shared cultivation to offset the spatial scattering of olive parcels.

Keywords:

Land fragmentation, spatial dispersion, GIS, olive orchard, production costs

5.2.2. INTRODUCTION

The fragmented structure of the land ownership affects many countries, especially those where the pressure of the population on the agricultural land has been most intense over history. Land fragmentation is due primarily to diverse geographic factors and to the inheritance system (Bentley, 1987). In this sense, there is a dichotomy between the countries of Europe and those established by European colonization (the colonial period), where the parcel system was the result of artificial land allocation, based on vast parcels that ensured the future viability of the colonists. For example, the average surface area of farms in countries such as Brazil, Canada, and the United States is 582.5 ha, 273 ha, and 178.35 ha, respectively. On the other hand, smallholdings constitutes a model of agriculture still predominant in the EU (European Parliament, 2014). This is particularly true in the Central and Eastern European (Petrescu-Mag et al., 2017; Jürgenson, 2016; European

Parliament, 2015; Hartvigsen, 2014, 2016), and in Mediterranean countries (e.g. Falah, 1992; Karouzis, 1971), although comparable situations occur in other countries around the world (e.g. Kjelland et al., 2007; Van Hung et al., 2007; Verry, 2001; Wan & Cheng, 2001; Blaikie & Sadeque, 2000). In the EU, farms covering less than 2 ha occupy more than 25% of agricultural land, and as a whole 69% of the farms cover less than 5 ha while only 2.7% are larger than 100 ha (European Commission, 2013).

Land fragmentation is a complex phenomenon caused by the number, shapes, and spatial distribution of parcels that are separated and individually cultivated (McPherson, 1982; King & Burton, 1982). Normally land fragmentation has been considered harmful because it increases production costs (Delord et al., 2015), reducing work efficiency along the edges (Janus et al., 2016; Colombo & Perujo, 2017a), and raising a greater potential for conflicts between adjacent owners (López Iglesias, 1996). However, studies have indicated certain benefits of fragmentation in the sense that cultivation on different parcels tends to divide up the risks, allows the sharing seasonal labour, and foments diversification (Van Hung et al., 2007).

Farm management is affected in two basic ways by the spatial dispersion caused by parcel fragmentation. First, it directly affects production costs by the travel needed to reach different parcels which are far apart. Each trip involves down time, which raises labour costs. Thus, greater fragmentation requires a higher number of trips per parcel and thus greater management costs and complications (Tan et al., 2010; Vilar et al., 2011). Secondly, a high degree of fragmentation directly affects decision making, causing the more distant parcels to be managed differently with respect to ones nearby. For example, labour may be reduced to a minimum in the more distant parcels, diminishing their productive potential.

In the literature, the spatial dispersion of agricultural parcels has been analysed from different perspectives that can be divided into two main groups: studies based on index analyses (relative values), such as the Simpson Diversification Index (Van Hung, 2007; Igbozurike, 1974; Simmons, 1964); and those focusing on cartographic analyses of distances between the centroid and barycentre of the farm and its parcels. In the latter case, some studies have considered dispersion as the distance of the centroid with the nearest parcel (Latruffe & Piet, 2014), while others measure the maximum distance of the parcels to the centre of the farm, using different normalization methods (Marie, 2009), or the measurement of areas of parcel concentration from the main centre of the municipality (González et al., 2007). Alternatively, the real location of the economic centre of the farm instead of the centre of gravity could be used (Deininger et al., 2014).

These analyses present several drawbacks. First, analyses that make the calculation through indices give neither the distance between the parcels nor the irregularity of the parcel structure (Janus & Markuszewskab, 2017; Latruffe & Piet, 2014; González et al., 2007) This irregularity between parcels of the same farm bears special importance in practice that no previous methodologies have taken into account, as will be discussed below. Second, methods that provide the calculation of dispersion with respect to the centroid of the farm can offer unrealistic values, taken as the real distance between the parcels, as this is an abstract point on the land that cannot coincide with the edges of the property. For example, the centroid method can offer equal values for farms with very different parcels, where some parcels are concentrated in groups while others remain isolated.

No studies available analysing spatial dispersion enable the direct relation with production costs and with possible farm-management methods. Studies have, however, quantified a certain cost of distance, but considering exclusively the distance from a parcel to the town centre or to a certain olive mill (Lorente-Sánchez et al., 2016) and other studies relate the reduction in land fragmentation to yield, pre-tax profit, and total technical efficiency (Latruffe & Piet, 2014). However, these analyses are made at the municipality level and not at the farm level. The analysis of costs due to the dispersion at the farm level requires a description of the parcel dispersion as the distance that the farmer has to travel between parcels to perform farm work. The number of trips required in certain periods needs to be determined and translated into labour and fuel costs, together with variables involved in the trips made.

In this study, a methodology is proposed to measure the parcels spatial dispersion by firstly considering the distance and later translating it into the time lost by the farmer both to travel between parcels of the same farm as well as preparation time for each trip.

Specifically, by an iterative process based on the overlap between areas of influence of each parcel, an estimate is made of the distance that the farmer must travel between parcels of the same farm, assuming that travel is from one parcel to the next nearest one each time a trip is undertaken. The method proposed offers an absolute value for distances separating the parcels of each farm. The method is meant to be exhaustive (the initial point of the measurement is the edge of the property, not the centroid), real (travel is calculated to the nearest parcel, not to an abstract point), and easily applied to any context (other agricultural or forestry, applications, etc.). In addition, it indicates the parcel structure of the farm -i.e. the distribution of the parcels over the land in relation to the others- in order to identify the farms with structures that are bipolar (those composed of two groups of parcels that are far apart), irregular (made up of parcels close together and another far away), or regular (parcels are more or less equidistant from each other). This information, unavailable in the literature, is critical in decision making by the farmer, as the high costs of fragmentation can lead to a different management approach for the more isolated parcels. The purpose of this paper is threefold: First, to propose a methodology to quantify the spatial structure of the fragmented farms; second to quantify the economic costs generated by the parcel fragmentation; and third, to propose public and private actions to be implemented to enhance farming profitability.

The analysis focuses on the traditional cultivation of olive orchards, for being an example of highly fragmented agriculture. In fact, in Spain, Italy, and Greece, the main European olive growers, the average surface area for olive orchards farms is only 5.8 ha in Spain, 1.8 ha in Greece, and 1.5 ha in Italy (Eurostat, 2015), which are typically scattered among several small parcels. Furthermore, the low profitability of traditional olive growing (Rocamora-Montiel et al., 2014; Colombo et al., 2015a) requires measures that reduce production costs and enlarge the net profit margin. In this sphere, the direct costs generated by the property system and especially those that are spatially dispersed should be quantified in an exhaustive way to weigh their impact on the profit of the producers and foment public action to minimize the situation. On numerous occasions, given the low profits of the sector, cooperation between producers of similar characteristics can substantially boost profitability (Colombo & Perujo-Villanueva, 2017b).

This study is organized as follows: first, the study area (Jaen province, Spain) is characterized, and then the methodology used to calculate the spatial dispersion and its translation into costs is detailed. Next, the results are presented, these subdivided into three: territorial dispersion of the farms, analysis of the irregular dispersion, and conversion of the dispersion into agricultural costs. The impact of the results in the olive sector together with the design of public policies intended to reduce dispersion is then discussed. Finally, the conclusions are presented.

5.2.3. CASE STUDY

The present work focuses on the traditional olive orchard in the province of Jaen (Figure 10), in the region of Andalusia (Spain). This region is the world's leading olive-oil producer, with a surface area of 1.5 million ha, constituting 17% of the surface area occupied by olive orchards in the world and 30% in Europe (International Olive Council, 2015). In the province of Jaen, olive cultivation accounts for 83% of the farmed surface area, covering 571,423 ha and representing 37.4% of the total surface area of olive orchards in Andalusia. Indeed, the olive-oil production of the province of Jaen alone is greater than the production of Italy, the second country in world production. The production structure of the Jaen province is characterized by small agricultural holdings with an extraordinary parcel fragmentation in the territory for several historical reasons. The royal divisions (by the Catholic Monarchs) marked the beginning of the fragmentation process of land in the early 16th century. The division criteria were founded on social class, whereby properties of small went to small farmers while large parcels were left in the hands of the nobility and the church. Later, a transition period ended with large tracts of the land owned by absentee landowners. Then, in the 19th century the influence of economic liberalism and confiscation (Alía-Miranda & Valle-Calzado, 2004) started a new process of fragmentation, leading again to land division. Finally, in the 20th century, an incipient process of containment of land fragmentation began, especially based on the legal limitations of land provision, but with little success (Perujo-Villanueva & Colombo, 2017c).

Source: Authors' elaboration.

Figure 10: Location of the study region.

As a result, 62.9% of the parcels have a surface area of less than 1 ha, while 94.1% do not exceed 5 ha (Colombo & Perujo-Villanueva, 2017b). Figure 11 represents an example of parcel distribution from a real case in the study area. The analyses concentrate on the traditional mechanizable olive orchard, which is the most common situation in the study area, occupying 78.8% of the overall surface area of olive orchards.

Source: Authors' elaboration.

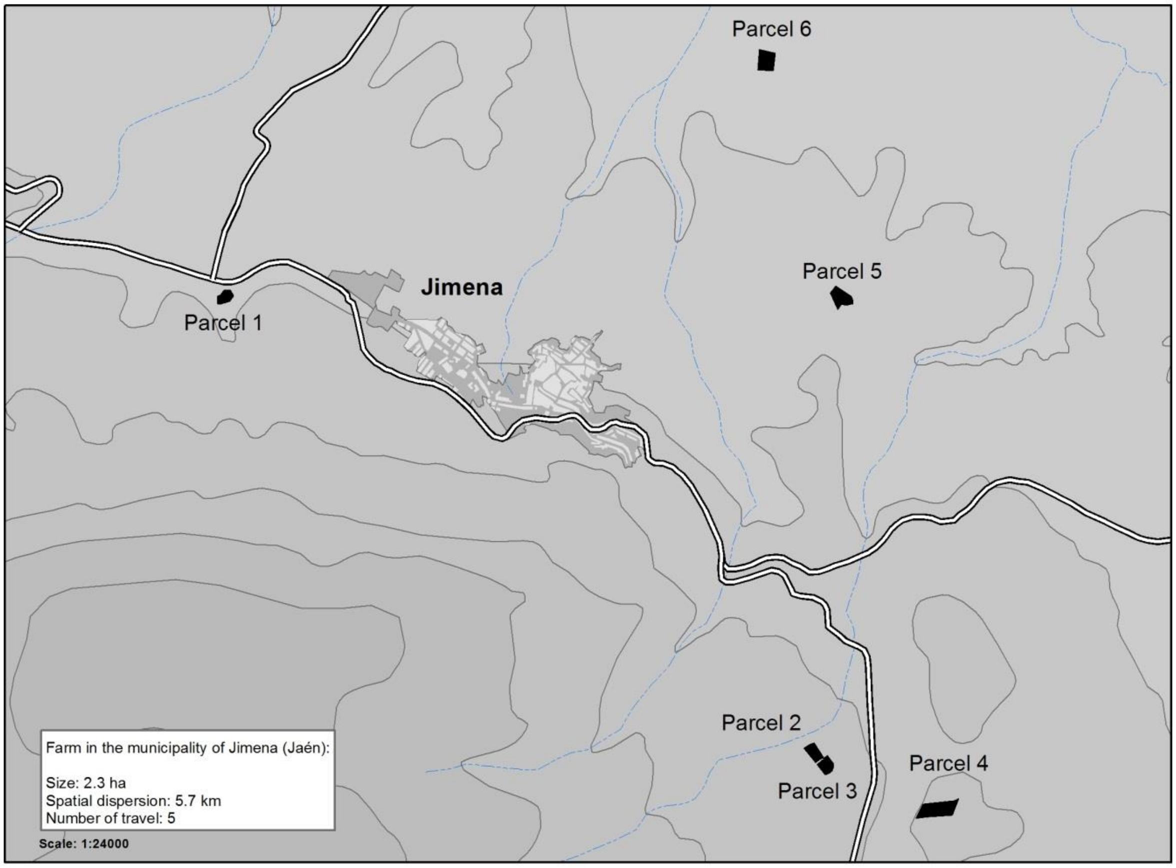

Figure 11: Example of parcel distribution from a real case in the study area. The represented 3 ha farm is composed by 6 parcels with a spatial dispersion of 5.7 km.

5.2.4. METHODOLOGY

To measure the cost due to the dispersion of farm parcels is a complex task that requires starting information on the georeferenced location of the parcels of each farm and the calculation of the trips that the olive farmer makes over the year to manage the parcels comprising that farm. The starting information on the distribution of the olive-orchard parcels was taken from the characterization by Colombo & Perujo-Villanueva (2017b). That work characterizes the location of all the olive-orchard parcels, using UTM (Universal Transversal Mercator) Huso 30 coordinates and the ETRS1989. In addition, each parcel was associated with its owner. The file is of the polygonal type and contains structural information for each parcel such as slope, planting density, surface area, and perimeter. A total of 261,450 parcels were included from 84,788 farms. In the study area, the number of parcels per farm varied from 1 to 101.

The calculation of the distance between parcels involved assumptions necessary to offset the limitations of the starting data and the lack of information on the route followed by the farmer when travelling to the different parcels. Firstly, there was no cartographic source of sufficient quality displaying the totality of the roads existing in the farming area. The roads are owned primarily by the town halls and very few inventories have been made. Therefore, the study cannot rely on maps of the existing roads. Furthermore, the spatial analysis tools only offered routines for calculating the distance between the closest parcels or between all the parcels of a farm, both having limited practical use. In the first case, the distance was omitted between all the parcels that were not closest, and thus longer distances within the parcels were not counted. In the second case, a huge volume of information was compiled, enormously complicating its subsequent analysis. For example, a farm with *n* parcels would produce a symmetrical matrix of size n * n, where in each cell the distance of the parcel *i* and parcel *j* would be represented. Each matrix would need to be analysed to determine the path followed by the owner, once the route followed by the farmer was assumed. Finally, the itineraries that each farmer followed to pursue the farming tasks were unknown, since, among other factors, it was not possible to know the starting point of each farmer.

Source: Authors' elaboration.

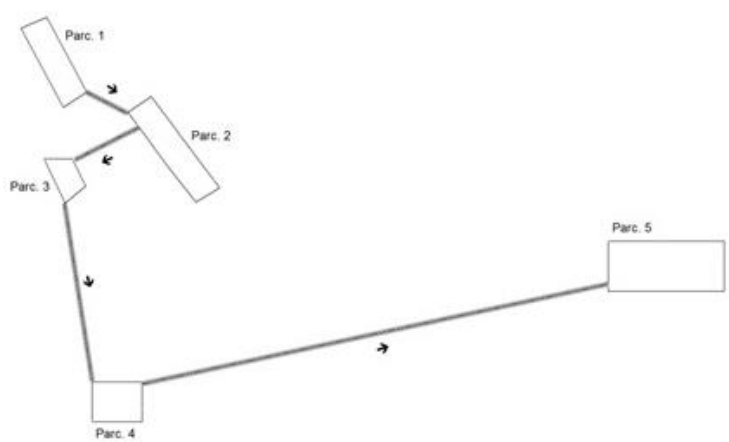

Figure 12: Example of route followed by the farmer.

For all the reasons given above, in this work, the first dispersion variable was measured by calculating the distance in a straight line from one parcel to another, assuming that the farmer travelled from one parcel to the next closest one (Figure 12). This calculation is conservative, as it assumes that the farmer moved along the optimal route between parcels.

To avoid the limitations of the analysis programs described above, the procedure followed included a neighbourhood analysis based on geometric figures, specifically through areas of influence with the aim of finding the spatial adjacency between parcels (minimum distance needed to bring about on overlap between the areas of influence of two or more parcels). For an exhaustive analysis, the procedure was undertaken iteratively with different radii[11] of the areas of influence, so that the distance could be measured with the desired precision. For example, in the case of the 5 parcels (*n*=5) described in Figure 12, in the first iteration (*i*=1) the process drew an area of influence of 5 m in radius (*r*=5) from the edges of each parcel and analysed whether they overlapped. As can be seen in Figure 13a, the areas of influence of three parcels overlapped, indicating that their edges were at a distance of less than 10 m (*r**2). The procedure proposed combines three areas of influence and begins another iteration with a larger radius (10 m in the example drawn in Fig. 13b). By repeating the process until the radius in which all the areas of influence overlap (r=25 in Fig. 13c), it was possible to calculate the distance that separated the parcels of the farm, using the equation:

$$D = \sum_{i=1}^{I}(n_i - n_{i+1}) * 2r_i \qquad [1]$$

where D is the distance separating all the parcels of the farm; *i* is the iteration index; *I* is the maximum number of iterations desired; n_i is the number of parcels with areas of influence that are not combined in the iteration *i*; and r_i is the radius of the areas of influence in the iteration *i*.

The above procedure has advantages and disadvantages. Among the latter it is important that the measurement provided is not exact but rather approximates the real

[11] Specifically, the procedure was followed with radii of the areas of influence of 5, 10, 25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2750, 3000, 3250, 3500, 3750, 4000, 4250, 4500, 4750, and 5000 metres.

distance. The exactness of the measurement depends on the length of the radii of the areas of influence, being more exact the measurements the shorter the radii. However, there are no limits in the definition of the number of radii, and by reducing the differences between the radii of each iteration the desired precision can be reached at the cost of greater calculation times. Also, the procedure assumes that the farmer follows the most efficient path for each trip between parcels, following straight lines. It can be assumed that the farmer will follow the most efficient route possible, but the distance calculated represents a conservative estimate. In this respect, it bears mentioning that the distance between parcels is calculated from the edge of the parcel and not from its centroid. This point is important, considering that the surface areas of the parcels in the province vary from 0.1 ha to 350 ha and thus that the error committed from calculating the distance from the centroids may be quite high. Also, the method estimates the travel distance without needing to know the route followed by the farmer. For example, in Figure 13, it is indifferent whether the farmer follows the path between plots 1, 2, 3, 4, or 5, between 2, 1, 3, 4, 5, or between 3, 1, 2, 4, 5. Finally, computationally the procedure is very fast and simple to perform with any program that processes cartographic data.

Source: Authors' elaboration.

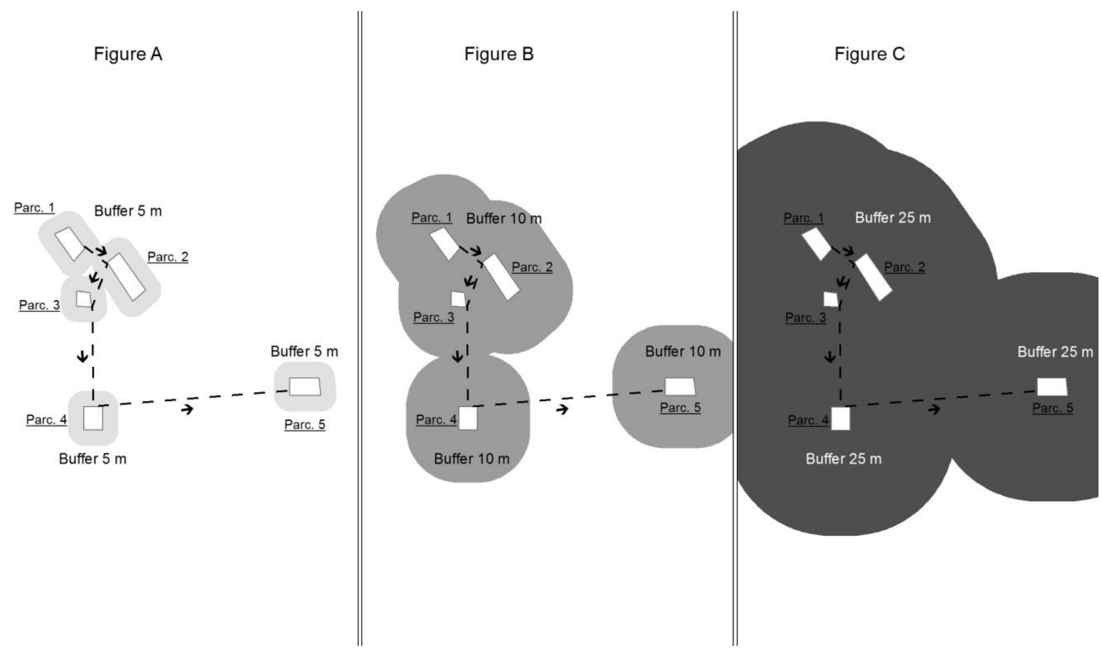

Figure 13: Example of the procedure for radii of 5, 10, and 25 m.

For the calculation of the costs due to the dispersion of the parcels, the distances were transformed into time and these were assigned an economic value. The transformation was made because the impact of the dispersion on production costs involves not only travel time itself, but also inoperative time needed for tasks related to collecting tools and materials to be transported between parcels. For this, given the different types of work that the olive orchard requires, and according to the surface area of each farm, the distances were converted into labour costs, both agricultural as well as tractor related, as well as the costs of fuel.

In the calculation of the fuel expenses, it was considered that the farms of medium and large sizes (>10 ha) use a tractor and a 4WD (Wheel Drive) in the trips, according to the work to be done, while the small farms (<10 ha) used a 4WD but had no access to a tractor, except for management work which required hiring a tractor from an outside service. For the calculation, it was assumed that a tractor of 120 CV -Caballo de Vapor- (88.2 KW – Kilovatio-) would cost 5.44 €/h (Márquez, 2007) and would have an average velocity of 15 km/h, together with the 4WD, costing 3€/h and an average speed of 25 km/h (2.5 l/h was estimated, at 1.2 €/l). With respect to the tasks included in the calculation, it was assumed that the farmer would follow a system of minimum tillage, as was common in the study area (Esyrce, 2012). Under this system, the olive orchard requires the work shown in the first column of Table 5, which is carried out a number of times and with the machinery listed in columns 2, 3, 4 and with the number of workers detailed in columns 5 and 6 of the same table. For example, in the farms of less than 10 ha, fertilizer is spread once per year, using two people who are transported between parcels in a 4WD.

Source: Authors' elaboration.

		Farms < 10 ha						**Farms > 10 ha**					
		Machinery and workers involved in the travel				**Inefficiency periods**		**Machinery and workers involved in the travel**				**Inefficiency periods**	
Treatments	**N**	**4WD**	**Tractor**	**Worker**	**Tractor driver**	**Worker**	**Tractor driver**	**4WD**	**Tractor**	**Worker**	**Tractor driver**	**Worker**	**Tractor driver**
Fertilizer	1	X		2		6 min			X		1		3 min.
Pesticides	3	X		2		18 min			X		1		9 min.
Tillage	2		X		2		6 min		X		1		6 min.
Harrowing	1		X		1		3 min		X		1		3 min.
Sucker removal	1	X		1		3 min		X		2		6 min.	
Herbicides	1	X		1		3 min			X		1		3 min.
Pruning	1	X		1		3 min		X		2		6 min.	
Harvest	1	X		8		40 min		X		7	1	35 .	3 min

Table 5: Number of trips, persons transported, and inefficiency periods on the farms of less than 10 ha and more than 10 ha.

The expenses assigned to hand labour was calculated based on the Field Agreement of the Province of Jaen (Convenio del Campo de la Provincia de Jaén, 2015-2016), for which the hour of tractor work costs 9.85 €/h and the field worker earns 9.30 €/h, in both cases including the costs of social security. Columns 7 and 8 reflect the time of inefficiency and down time from the end of the work until the transport begins to the next parcel to collect the tools, load them into the vehicle, open and close the gates of the parcels, etc. These times were calculated through interviews with experts in olive management and 60 surveys made with farmers. Three minutes per task and person were counted, except for tool collection, which was quantified as 5 min per person. Columns 9-14 list the data assumed for the farms of more than 10 ha.

Finally, it was necessary to consider that the dispersion translated not only in absolute terms of distance and costs. Two farms of the same characteristics and with the same dispersion could be managed differently due to different structures of the dispersion. Typically, the most isolated parcels received less attention and supervision than did the closer ones, reducing the profitability of the distant ones. For example, Figure 14 represents two farms composed of 3 parcels and total dispersion of 5 km. However, farm A proved to have a distance between parcels of 2.5 km, while farm B had a distance between parcels 1 and 2 of 10 m and a distance between parcels 2 and 3 of 4.9 km. The iterative procedure explained above permits the analysis of the irregularity of the dispersion, where irregularity is considered the presence of parcels isolated from other parcels or groups of parcels. Therefore, it registers in each iteration the number of parcels or groups of parcels that are not combined. In the example illustrated in Figure 14, there are five parcels that are not combined in the first iteration (n_i=5 in Eq. [1]), three uncombined parcels in the second iteration (n_{i+1}=3), and a single one in the third iteration. Relating the dispersion radius (r_i) to the number of uncombined parcels (n_i - n_{i+1}) makes it possible to identify whether there are parcels isolated from others.

Source: Authors' elaboration.

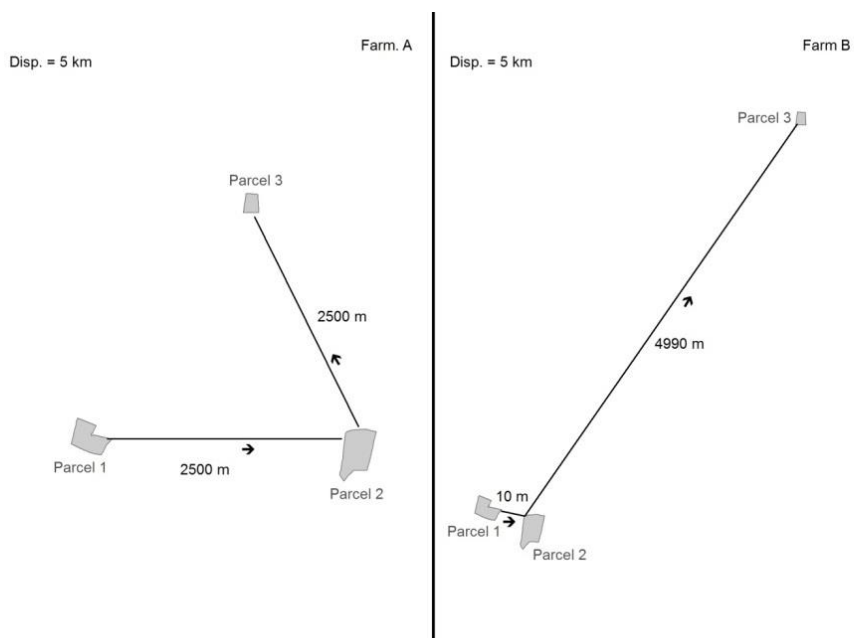

Figure 14: Dispersion structure for 3 parcels and 5 km of dispersion.

5.2.5. RESULTS

According to the results of the parcel analysis (Colombo & Perujo-Villanueva., 2017b) 62.9% of the parcels had a surface area of less than 1 ha, and 94.1% less than 5 ha. The farms of the province (Table 6) presented an average surface area of 5.3 ha and 3.1 parcels. Regarding farm size, 89.1% of the farms could be considered small, being less than 10 ha. However, the average size of these farms was only 2.3 ha, this representing only 39.6% of the total surface area of olive orchard. On average, the small farms were composed of 2.5 parcels. On the other hand, the farms of more than 10 ha made up 10.9% of the total and covered 60.4% of the surface area. The average surface area of each farm was 29.3 ha with an average of 7.6 parcels.

Source: Authors' elaboration.

Size (ha)	**Average number of parcels**	**Farms**		**Accumulated surface area**	
		N.	**%**	**ha.**	**%**
0 – 1	1.3	25484	30.0	14113	3.1
1,01 – 5	2.7	40336	47.5	96103	21.4
5,01 – 10	4.9	9727	11.4	67555.8	15.0
10,01 – 15	6.1	3486	4.1	42454.7	9.4
15,01 – 20	7.2	1693	1.9	29209.1	6.5
20,01 – 50	8.2	2895	3.4	87908.3	19.6
50,01 – 100	9.9	837	0.9	57129.4	12.7
>100	13.2	330	0.3	54357.5	12.1
Total	3.1	84788	100	448831.6	100

Table 6: Structure of olive-orchard farms in Jaen province (Spain).

<u>Territorial dispersion of the farms</u>

Table 7 presents the parcel dispersion of the 84,788 farms analysed. The first result of interest is that of the total number of the farms, 36.5% have a single parcel with no dispersion. Thus, the farms with less dispersion are those of a single parcel but separated by a road, or natural feature such as a river or ravine. According to the methodology used, these farms were assigned a dispersion of 10 m[12]. This constituted 3% of the sample. For the small farms (Sup. < 10 ha), the average dispersion was 3.2 km and the maximum 46.5 km. For farms with a surface area of more than 10 ha, the average dispersion was 10.0 km and the maximum 73.6 km. At the provincial level, the mean dispersion was 40 km. Nevertheless, when only farms with dispersion were considered, i.e. those with more than one parcel, the average dispersion proved substantially greater, reaching 6.3 km, a value reflecting the high degree of spatial dispersion of the farms.

Source: Authors' elaboration.

Dispersion (km)	**Representation**		**Average surface area**	**Average number of parcels**
	Absolute	**%**		
0	30945	36.5	1.7	1
0.1-3	19974	23.6	5.7	2.6
3.1-6	12484	14.7	4.7	3.5
6.1-9	8386	9.9	6.1	4.4
9.1-12	5216	6.2	8.6	5.5
12.1-15	3046	3.6	11.0	6.7
15.1-18	1829	2.2	13.4	7.8
18.1-21	1169	1.4	15.3	8.3
21.1-24	642	0.8	21.6	10.6
24.1-27	447	0.5	22.5	11.5
27.1-30	246	0.3	27.3	12.1
30.1-33	136	0.2	36.0	15.7
>33	268	0.3	38.8	16.8

Table 7: Parcel dispersion by interval.

The dispersion corresponds to the number of parcels and the surface area of the farms. Figure 15 indicates the fit between the parcel dispersion measured in km, the average surface area of the farms, and the number of parcels. In both cases, the fit is very strong and it was found that the greater number of parcels and the larger size of the farms,

[12] The minimum radius of the areas of influence was 5 m. Thus, for all the distances between parcels of less than 10 m, there was an overlap of the areas of influence and this was attributed a dispersion value of 10 m. This value was chosen considering that country roads are usually 6 to 10 m wide.

the greater the dispersion[13]. However, given that the number of parcels was not always available in agrarian censuses, and thus this variable could not always be used for predictive purposes, it is preferable to use the regression between the surface of the farm and its dispersion. According to this relation, the farms with a surface area of 5 ha had an average dispersion of 2.4 km, while those of 20 ha had an average dispersion of 7.1 km.

Source: Authors' elaboration.

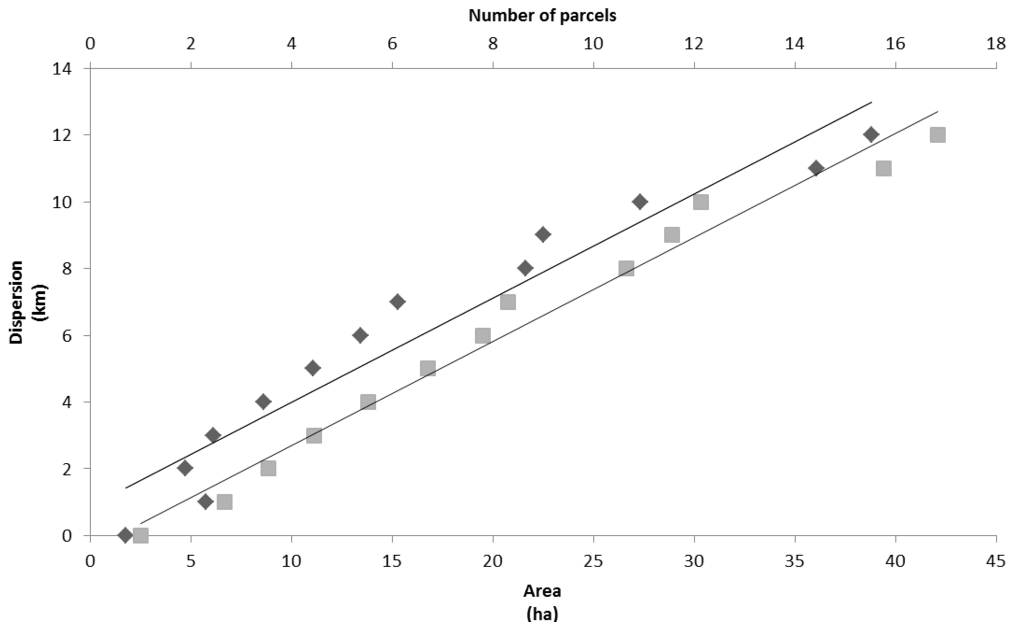

Figure 15: Relation between dispersion (Y) and number of parcels (X),[squares in the figure Y= - .422 + .780 X; R^2=.978]; and between dispersion (Y) and surface area (Z), [Rhomboids in the figure ; Y= - .878 + .312 Z; R^2=.932].

Conversion of dispersion into agricultural costs

Table 8 lists the time derived from the dispersion values according to farm size. The time refers to the hypothesis of analysis where the trips are computed for the workers moving between the parcels over the year. In the second, third, and fourth columns appear the average values for surface area, dispersion, and number of trips that had to be made in

[13] In analyses not described in this study, a multivariant fit was made using the number of parcels and the surface area of the farms as the independent variables. The results show that both variables are highly significant despite that the results do not differ significantly from those described in the present work.

the farms with a size specified in column 1. The following columns list the average travel time and inefficiency resulting from the management chores described in Table 5.

For farms of 0.1 to 2 ha, the time lost due to spatial dispersion reaches 1834.9 min (30.6 h), distributed in the following way: 93.2% of the time corresponds to the travel of the persons associated with the farm, primarily workers (92.6%) and only a minority for the tractor driver (7.4%). The impact of the inoperative periods is low, representing 6.8% of the total time. For farms of greater dimensions (> a 50 ha), 5061 min (84.3 h) extra of management were required, of which 85.6% corresponded to travel time and 14.4% to periods of inefficiency.

Table 8 lists the costs related to dispersion according to farm size. The distribution of the expense is uneven. Travel (sum of the expense of the fuel and the workers transported) represents almost all the expenses on all the farms. The relative weight of the costs related to the inefficiency periods is very limited. With regard to the cost breakdown per trip, the expenses are mainly labour (>97%), as the fuel is economically almost negligible.

Source: Authors' elaboration.

	Travel cost				**Inefficiency cost (€)**	**Total dispersion cost (€)**	**€ ha^{-1}**
Type of exp. (ha)	Fuel cost (€)		Labour cost (€)				
	4X4	Tractor	Worker	Tractor driver			
0.1-2	4.2	7.6	245.6	20.5	19.5	297.4	247.8
2-5	7.2	13.0	422.3	35.3	35.3	513.0	160.3
5-10	10.1	18.3	596.3	49.8	55.7	730.3	105.8
10-50	5.2	9.4	591.2	512.3	74.7	1292.9	66.4
>50	5.3	9.6	600.5	520.4	115.3	1251.1	13.0

Table 8: Annual cost of dispersion.

The average cost assumed for the farms of between 0.1 and 2 ha was 247 € ha^{-1}, which represents roughly 10% of the total production costs (Colombo et al., 2016). The costs of spatial dispersion continue to be significant for the farms of up to 10 ha, this becoming minimized for the middle- and large-sized farms.

At the provincial level, a total of 338,123 km of travel were computed, covering a total surface area of 448,831 ha. The total expense per year in fuel was 0.9 million euros and in labour 28.2 million euros. The average cost per ha was 79.5 € ha^{-1}, distributed as follows: 2.4 € ha^{-1} in fuel, 71.6 € ha^{-1} for worker transport, and 5.5 € ha^{-1} costs for inefficiency.

Analysis of irregular dispersion

The analysis of the distribution of the parcels in the territory reveals that 22% of the farms had one parcel or more separated from the others by more than 4 km, whereas almost 5000 farms (5.8%) had parcels separated by more than 8 km. These data differed in the small farms with respect to the large ones, isolation of the parcels being more significant in the latter case. In particular, regarding small farms, some 19% had less than one parcel at more than 4 km and 4% more than 8 km. In the case of the farms of more than 10 ha, these percentages increased to 43% and 19%, respectively. It bears emphasizing that for this group, a significant number of farms had at least one parcel at more than 8 km, a distance that, by a conservative estimate, implies more than 32 min of travel for a tractor. A more precise idea of the differential impact of the irregular dispersion can be given, for example, by detailing the costs of dispersion for a representative farm with a high degree of dispersion. That is, a farm of 3 ha[14] with a total dispersion of 8 km, composed of 3 parcels of equal dimensions of which one lies 7.9 km from the other two, which are separated by a road. This farm would have a total annual travel cost of 745.4 €, of which 99.7% would be due to the access to the parcel farthest away. Under the assumption that each parcel has a surface area of 1 ha, the expense of travel to manage the farthest parcel would be 744.6 € ha^{-1}, some 33% of the total management cost. Clearly, these high costs of travel dissuade farmers from tending the parcels and can change the management of the isolated parcels, even resulting in abandonment or semi-abandonment.

[14] Three ha were selected as the surface area because this size represents the median distribution of farm size.

5.2.6. DISCUSSION AND CONCLUSIONS

In the official statistics of agricultural properties the information available on land fragmentation is scarce. For example, as mentioned above, Eurostat (2015) reveals that the average farm size in the three main European olive-oil producers, Spain, Italy, and Greece is just 5.8, 1.8, and 1.5 ha, respectively, but does not provide any information concerning the production structure within the farms, such as the parcel numbers, size, shape, or their spatial distribution.

To know the morphology of the system of farm property (surface area, shape of the parcels, number of parcels, distance between them) enables the quantification of the impact of fragmentation on the production costs and therefore helps in a more precise diagnosis of the farm sector and in designing strategies to improve farm profitability. In the present work, a methodology is proposed to measure parcel dispersion and its costs in the olive orchard. However, the method is applicable in any context providing georeferenced locations of farm parcels and where the cultivation procedure is known in advance[15].

The calculation used was very conservative and therefore the results should be taken with caution. Firstly, because the domicile of the farmer was unknown, the travel time of the farmer from home to any of the parcels was omitted. Despite that other studies assign the domicile to the closest municipality (González et al., 2007), it was considered in the present work that this trip was not due to the spatial dispersion of the parcels and therefore its inclusion would distort the calculation of parcel dispersion. Secondly, the distances between parcels were estimated with straight lines. The lack of cartographic sources showing the rural roads hampered the measurement of the routes taken by the farmers. Despite that the distances calculated were shorter than the real ones, the procedure proposed allowed the assignment of a dispersion value in the cases (the majority in the rural setting) where there was no cartographic information on country roads. In addition, it permitted the estimation of the distances regardless of the home address of the farmer and the road followed to the orchards. Thirdly, the calculation is conservative since the indirect

[15] The application of the proposed methodology requires knowing the number of trips between the parcels and the labor requirements for each farming task. As such, the methodology is not suitable when a mixture of crops is cultivated in the different parcels.

expenses associated with dispersion were not calculated, as in the case of extra costs due to the maintenance and amortization of the vehicles used for travel. Nor were social costs computed, such as repairs and maintenance of the roads, and environmental costs such as CO_2 emissions to the atmosphere. For example, under the assumption of a 4WD (in the case of a tractor, it would be even higher), the CO_2 emissions due to the dispersion would be more than 70 ton/CO_2 year. Finally, the calculation is conservative because it considers only the spatial dispersion of the parcel, omitting other effects of fragmentation such as the shape and size of the parcels that also affect production costs (Janus et al., 2016; Colombo & Perujo-Villanueva, 2017a). All these aspects should be investigated in future studies to provide a more accurate estimation of the economic impact of land fragmentation on production costs.

The procedure proposed makes it possible to compute not only the dispersion as an absolute value but also the distribution in the territory of the parcels of each farm. This offers a more detailed radiography of the land fragmentation, enabling the identification of the farms where, for their irregular parcel structure and high costs of dispersion associated with some parcels, it is very probable that the farmers reduce or abandon the work on the isolated parcels.

The spatial dispersion generates periods of inefficiency that translate as extra costs for the farmer. This is particularly relevant in the small farms, which in turn have the highest production costs, for the low level of technology and mechanization as well as for the lack of economies of scale in production (Colombo et al., 2016). In these farms, the costs due to the spatial dispersion represent a highly significant percentage of the total production costs. The transmission of this information to the farmers provides a new horizon for the olive-growing sector, which favours a shift in attitude towards the implementation of new management mechanisms, such as those based on cooperation between neighbouring owners for more efficient farm management. In this context, the adoption of assisted or shared cultivation systems[16], in which farmers offer management

16 Shared cultivation can be defined as the activity of a group of farmers who cooperate in the care of their orchards using means in common. Meanwhile, assisted cultivation is the system by which owners turn over the management of their olive orchards to an entity with the sufficient human, technological, and

services to other farmers or share production input such as machineries is a valid option to consider, especially in the farms with irregular dispersion and isolated parcels (Vilar et al. 2011; Colombo & Perujo-Villanueva, 2017b). Future research should analyse the farmers' willingness to cooperate and determine their demands towards these cooperation systems.

In light of these results, it is considered necessary for institutions to firmly foment public policies of reducing fragmentation. These policies should stimulate farmers' cooperation by means of financial aid to producers or group of producers who manage the land cooperatively. This would be an alternative solution to parcel fragmentation relative to land consolidation programmes that have proven to be expensive and often a controversial option that may generate conflict between farmers (Lisec et al., 2014; Prosen & Cerjak, 2001). This is particularly true in olive cultivation, a perennial crop where many issues external to economic factors affect the farmers' subjective value of their lands, such as the available infrastructures, farm buildings and facilities or even intangible values such as the existence of social network, inheritance concerns and environmental issues. Proof of this is the failed attempt at land consolidation in the study area promoted by the government in 1988[17], where less than 1.6% of olive surface area was involved. In parallel, policies aimed at giving fiscal incentives to land contracts that allow joining small parcels should also be implemented. Finally, they should impede a further fragmentation of the land, by setting a minimum unit of cropping and by forbidding the sale of any land which would generate parcels whose dimensions are smaller than the established threshold (Perujo-Villanueva & Colombo, 2017c). All these aspects should also be investigated in future research.

In conclusion, it is important to underscore that the reduction of land fragmentation through cooperation systems, as opposed to the absorption of small farms by larger ones, prevents land grabbing (Petrescu-Mag et al., 2017). As such, it maintains the small land-holder network of properties and thus does not affect either the distribution of agricultural income or the permanence of the population in these settings, aspects of fundamental importance in current and forthcoming agricultural policies.

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mechanical resources for professional farming. Both systems make use of middle-scale production economies while significantly lowering the production costs.

[17] Ministerio de Agricultura Pesca y Alimentación. Gobierno de España (1988).

5.2.7. ACKNOWLEDGEMENTS

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5.3. LOS EFECTOS DE LA UMC EN LAS TIERRAS AGRÍCOLAS DE BAJA RENTABILIDAD: EL CASO DEL OLIVAR*

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5.3.1. RESUMEN

El concepto de la UMC fue instituido para evitar la excesiva fragmentación de la tierra y asegurar la calidad de vida de las familias rurales. La UMC ha sido estudiada por multitud de autores desde un ámbito jurídico siendo muy escasos, si no ausentes, los estudios que han investigado los factores socioeconómicos y productivos que son necesarios para la correcta definición y aplicación de la misma. En este estudio, se analiza y critica el concepto de UMC, en particular el determinado en la Comunidad Autónoma de Andalucía, para proponer una redefinición del mismo en aras de conseguir su objetivo: lograr que las explotaciones tengan una dimensión suficiente para garantizar un rendimiento satisfactorio. Los resultados ponen de manifiesto que, en el caso de un cultivo emblemático como el olivar tradicional andaluz, la definición actual no cumple con su objetivo ya que instaura una UMC muy inferior a la necesaria para obtener un rendimiento satisfactorio. Por tanto, es necesario, por un lado, adaptar los límites de la UMC a los rendimientos de los diferentes cultivos frenando así la excesiva fragmentación de la tierra y por el otro, establecer mecanismos públicos o privados que garanticen una propiedad con una superficie mínima que permita gestionar sus recursos de forma adecuada y rentable. Entre ellos, la consolidación de la tierra, junto a medidas fiscales como la exención de tributos por la compraventa de terrenos colindantes o la cooperación entre agricultores pueden constituir alternativas a considerar.

Palabras clave: Minifundismo, rentabilidad, SIG, Olivar.

5.3.2. ABSTRACT

The effects of MCU (Minimun Crop Unit) in the low profitability agricultural lands: the case of olive grove. The concept of MCU was created to avoid the excess of land fragmentation and to ensure the quality of life for rural families. Previous research analyzed the MCU in a juridical point of view, being almost inexistent studies about the socioeconomic and productive factors for the correct definition and application of the MCU. In this study, the concept of MUC of the autonomous community of Andalusia is analyzed and discussed to propose a redefinition of it, in order to achieve its aim: farms must have a sufficient size that guarantees a satisfactory income. Results show that, in the

case of a symbolic farming system such as traditional olives farms, the current definition of MCU in the Andalusian region doesn t fulfill its aim, because it establishes a MUC much smaller than the necessary to obtain satisfactory income. Therefore, on the one hand, it is necessary to adapt the MCU limits to the different crops, stopping the excess of land fragmentation, and on the other to establish public or private mechanisms to guarantee a property system that allows managing farms in an adequate and profitable way. Amongst them, fee exemption in the land transmission where neighboring plot are transmitted, land consolidation projects or the cooperation of farmers are suitable alternatives to consider.

Keywords: Small farming, profitability, GIS, olive orchard.

5.3.3. INTRODUCCIÓN

La fragmentación de la tierra es un proceso que afecta a numerosos países del mundo, a pesar de que ha estado asociada normalmente a Europa y los países mediterráneos (Falah, 1992; Karouzis, 1971). A consecuencia de ello, se ha implantado un mosaico territorial vinculado a una explotación de carácter familiar con escasa aptitud competitiva (Mata Olmo, 1987), dando lugar a un gran número de explotaciones de dimensiones reducidas y un escaso número de explotaciones de grandes dimensiones (Naranjo Ramírez, 2003).

En España, ante la sucesiva fragmentación de las parcelas agrarias y el consecuente impacto negativo en los ratios de eficiencia de las mismas (Akkaya Aslan et al., 2007; Chukwukere Austin et al., 2012), la administración pública ha intervenido en la reordenación del espacio agrario principalmente a través de dos procedimientos: de un lado de forma activa, mediante la obligación a los propietarios de participar en procesos de concentración de la tierra y ordenación rural (Maceda Rubio, 2014) o bien de forma pasiva, mediante la limitación de determinados actos al propietario, como es la prohibición de enajenar si las fincas resultantes son inferiores a una determinada área.

El segundo procedimiento contempla el análisis del régimen de la UMC que ha sido estudiado por multitud de autores desde una esfera legal, es decir, del tráfico jurídico de la propiedad rústica (Millán Salas, 2016; Cosialls Ubach, 2008), siendo muy escasos los estudios que se centran en una perspectiva socioeconómica del instituto jurídico. La UMC se define en la actualidad como la superficie suficiente que debe tener una finca rústica para que las labores fundamentales de su cultivo, utilizando los medios normales y técnicos de producción, puedan llevarse a cabo con un rendimiento satisfactorio, teniendo en cuenta las características socioeconómicas de la agricultura en la comarca o zona (BOE, 1995). Su finalidad es evitar la excesiva fragmentación de la tierra y asegurar la calidad de vida de las familias rurales (Macía Arce et al., 2004). Su fundamento radica en la idea de que la diseminación parcelaria es inadmisible desde una perspectiva técnica y económica.

Por tanto, es la Ley 19/1995 LMEA la que define el régimen de las UMC, habilitando a las diferentes CCAA (Comunidad Autónoma) para que resuelvan la dimensión de las mismas (BOJA, 1996). Actualmente el Anteproyecto de Ley de Agricultura y Ganadería para Andalucía (Junta de Andalucía, 2016) propone nuevamente la necesidad de definir reglamentariamente las unidades de producción mínimas que permitan asegurar la viabilidad de la explotación, en función de su ubicación y del tipo de actividad agraria desarrollada en ella y utilizando los medios normales y técnicos de producción (art. 21.2).

En la resolución autonómica que delimita la UMC para el caso de la Comunidad Autónoma de Andalucía, se reconoce que la configuración de las UMC es una tarea compleja que requiere tiempo para su estudio, tanto en el ámbito regional, provincial y comarcal como en la negociación con los sectores implicados. Sin embargo, se considera necesario establecer una delimitación provisional. La resolución andaluza define las UMC en función del régimen de cultivo (regadío o secano) y del municipio donde se asienta, sin considerar la variabilidad de rendimiento en función del cultivo y/o gestión del mismo. No obstante, existen grandes diferencias de magnitud entre los ingresos medios por explotación que perciben las diferentes tipologías de olivar (Sanz Cañada et al., 2014; AEMO, 2012). Una hectárea de olivar super-intensivo puede llegar a equivaler a 50 hectáreas de olivar marginal (Sánchez Martínez et al., 2015).

Dos notas esenciales se extraen de dicha resolución: su carácter provisional, aunque pasados ya más de veinte años es pertinente preguntarse sobre la intención original de provisionalidad, y el mantenimiento de una UMC para todos los municipios de Andalucía en el régimen de regadío de 0,25 ha[18]. En el régimen de secano, según provincias, los valores oscilan entre 2,50 y 3,50 ha.

La dificultad que entraña la excesiva fragmentación de la tierra para una gestión eficiente se acrecienta en cultivos de baja rentabilidad como es el cultivo del olivar, en el que se están incorporando países sin ninguna tradición olivarera con densidades mayores de plantaciones y costes de producción muy bajos (Vilar y Cárdenas, 2016). La situación de bajos niveles de precios supone, a todas luces, una remuneración de los aceites a los productores que no cubre los costes de un gran número de explotaciones de la geografía oleícola española (García Brenes y Sanz Cañada, 2012). La finca rústica ha de tener una extensión suficiente para que el agricultor pueda estar ocupado durante todo el año y como consecuencia obtenga una renta equiparable a la que otro trabajador hubiera obtenido trabajando el mismo tiempo en un sector que no sea agrario (Millán Salas, 2001). No obstante, los olivares de bajos rendimientos han sido considerados como una fuente secundaria de renta y no como una fuente principal (García Brenes, 2005). Por tanto, la superficie debe ser al menos de la dimensión suficiente para obtener un rendimiento complementario a la actividad principal.

La estrecha relación entre el minifundismo y el olivar tradicional (Cejudo García y Maroto Martos, 1999) hace que la UMC adquiera especial relevancia para este cultivo, y que por tanto, sea el olivar el cultivo elegido para los análisis en este trabajo. La situación económica de las pequeñas explotaciones agrarias, específicamente en el olivar, se ha deteriorado a lo largo de los últimos años (Colombo y Camacho Castillo, 2014). Colombo et al. (2016a) realizan un análisis comparativo de tres parcelas agrarias con diferente superficie (1 ha, 5 ha y 10 ha) y demuestran como a menor superficie corresponden mayores costes de producción. Por todo ello, el objetivo de esta publicación es diseñar una metodología que permita definir una UMC acorde a la rentabilidad del cultivo.

Los autores no tienen conocimiento de que existan estudios que justifiquen una determinada UMC en función de la rentabilidad real de cada cultivo. Tampoco existen estudios que cuantifiquen ésta en función de la ligazón entre el agricultor y su economía (agricultura marginal, complementaria o profesional). Por ello, analizar el concepto desde

[18] A excepción de la Provincia de Granada donde en el régimen de regadío extensivo es de 0,50 ha.

el área de la economía agraria, y no exclusivamente de los efectos jurídicos de la misma, aportará el conocimiento suficiente para ajustar la rentabilidad del cultivo a los requerimientos mínimos de subsistencia de un propietario y el hogar medio. El nuevo marco normativo que establece el Anteproyecto de Ley de Agricultura y Ganadería de Andalucía se presenta como una oportunidad única para proponer una nueva UMC atendiendo a las cualidades de cada cultivo.

5.3.4. MATERIAL Y MÉTODOS

5.3.4.1. CASO DE ESTUDIO

El olivar es uno de los principales cultivos de Andalucía, tanto por su superficie (1,5 millones de ha) como por su incidencia en la producción de la rama agraria, 21,7% (BOJA, 2015). Este estudio se centra en el OTM[19] de la provincia de Jaén por ser el sistema de cultivo predominante y encontrarse en una situación de incertidumbre. Esta provincia representa el cultivo del olivar en su máxima expresión, el 83% de la superficie agraria útil (PerujoVillanueva et al., 2015). Además, el mismo adolece de un excesivo minifundismo que se traduce en parcelas de pequeña dimensión que a su vez son gestionadas de forma familiar. En cuanto a la evolución histórica del sistema de propiedad, las dos principales notas en la provincia de Jaén que afectan a la definición de la UMC son, por un lado, la sucesiva fragmentación de la tierra y, por otro, el crecimiento vertiginoso del regadío. En el año 1980 existía una importante pequeña propiedad siendo las explotaciones menores de 20 ha un 85,2% del total, junto a una reducida gran propiedad mayor de 100 ha que representaba un 7,0% (Quirós Romero, 1984). Ya en 2009, la pequeña propiedad significaba en las explotaciones de menos de 20 ha un 91,5% mientras que la gran propiedad mayor de 100 ha solo un 0,3% (INE, 2009). En 1984, los regadíos sumaron en toda la provincia 66.249 ha (Quirós Romero, 1984), valor que se incrementó rápidamente en los años 90 hasta alcanzar actual mente las 260.000 ha, que suponen un 35,4% de la superficie total olivarera en la provincia (Sánchez Martínez et al., 2015).

[19] Por olivar tradicional se entiende el olivar de carácter extensivo o semi-extensivo, con dos o tres pies por árbol, marco de plantación amplio y rendimientos productivos medios-bajos. Además su pendiente permite el uso de tractor para determinados trabajos.

5.3.4.2. UMC

La definición de la UMC en olivar requiere, desde el punto de vista metodológico, diferenciar dos procedimientos: de un lado es necesario caracterizar el olivar para disponer de una radiografía de las parcelas agrarias en el área de estudio en función del régimen de cultivo, además de establecer una clasificación del tipo de olivar atendiendo a su productividad y manejo; de otro, estimar la rentabilidad media del cultivo del olivar tradicional para la obtención de la superficie mínima que asegure un rendimiento satisfactorio.

5.3.4.3. CARACTERIZACIÓN DEL OLIVAR DE LA PROVINCIA DE JAÉN

La metodología seguida, basada en el uso de herramientas SIG, se ha nutrido de la base de datos espacial del SIGPAC y las declaraciones de cultivo correspondientes a 2013 (SIGPAC 2013). A partir de ellas, se ha generado el mapa de recintos de olivar de la provincia de Jaén, como base cartográfica, sobre el que se ha realizado un análisis de caracterización y selección del olivar objeto del estudio, seguido de análisis espaciales a nivel de parcelas agrarias para su tipificación. Los recintos de olivar se han caracterizado atendiendo a las tres variables normalmente consideradas para definir las características estructurales y agronómicas del olivar: 1) la densidad de plantación (número de olivos por ha); 2) el régimen de cultivo, ya sea de secano o de regadío; y 3) la pendiente media. La información relativa a la densidad de plantación se ha extraído de la base de datos del SIGPAC de la edición de 2009, última en la que consta dicho atributo. En los recintos de los que no se disponía de la misma, se ha atribuido el valor a través de interpolación por el vecino más próximo. La discriminación entre olivar de secano y de regadío se ha realizado por compilación de la capa creada por la Confederación Hidrográfica del Guadalquivir para el año 2008 y el SIGPAC 2013. En cuanto a la pendiente media, se ha utilizado el valor contenido en el SIGPAC 2013. Ello nos permitirá definir los diferentes tipos de olivar en función de su productividad.

A partir del mapa de recintos, que es la información que facilita SIGPAC, se ha generado el mapa de parcelas agrarias (recintos de olivar adyacentes y pertenecientes un mismo propietario) que es el objeto de estudio de la LMEA. Con la información creada se ha podido analizar la superficie que presentaba cada parcela y si eran potencialmente segregables (por tener una superficie al menos del doble de la UMC requerida).

5.3.4.4. CÁLCULO DEL RENDIMIENTO SATISFACTORIO PARA EL OTM

Para cuantificar el concepto "rendimiento satisfactorio" de una parcela de olivar tradicional se requiere en primer lugar conocer los costes de producción, a continuación los ingresos por la venta de aceite y en último lugar, el umbral de rendimiento que debe imputarse a una parcela para que sea satisfactorio.

La estimación de los costes de producción se ha llevado a cabo empleando un software específico (Programa de Gestión de Olivar (GESTOLI V.1)). En este software el analista inserta todos los parámetros de producción (maquinarias, sistema de manejo, insumos, etc.), para obtener el coste de producción de un kg de aceite. La principal innovación introducida se centra en que la estimación de los costes se realiza en función del tamaño de la parcela. Además, se han introducido en el cálculo de los costes los "tiempos muertos" en la producción necesarios para la preparación, carga, descarga y desplazamiento del tractor y de los aperos. Por último, se considera el coste de oportunidad de la tierra y se permite calcular el impacto del autoempleo en los costes de producción. La estimación de costes obtenida por este software se ha calibrado empleando 60 encuestas a olivicultores de la provincia de Jaén. También, se ha corroborado que la estimación no difiere de los valores medios publicados en la literatura (CES, 2011; AEMO, 2012)[20] para los casos concretos descritos en estos estudios. Para incorporar en el cálculo de los costes el concepto que utiliza la LMEA "utilizando los medios normales y técnicos de producción", asumimos que los agricultores disponen de la tecnología y maquinaria comúnmente empleada[21] en cada

[20] Por razones de espacio no es posible una descripción completa del diseño y funcionamiento del software GESTOLI V.1. El lector interesado puede encontrar más información en Colombo et al. (en prensa) y Colombo et al. (2017).

[21] Debido a la reducida dimensión de las parcelas en la provincia de Jaén, se asume que el titular de la explotación no tiene un tractor y los aperos que necesitan la tracción del mismo. Por otro lado, dispone de un todoterreno, un remolque, una cuba para tratamientos fitosanitarios y herbicidas, una motosierra, un vibrador de rama, una sopladora y varios aperos (hachas, fardos etc.) necesarios en las operaciones de cultivo. El titular de la explotación se encarga de todas las tareas, requiere de la ayuda de una persona en los

sistema de manejo y que operan bajo el sistema de mínimo laboreo caracterizado por las siguientes operaciones anuales: un abonado de suelo, tres tratamientos fitosanitarios, dos pases de cultivador y uno de rastra, eliminación de rebrotes (desvareto), un pase de herbicida en otoño y recolección manual. Además, una poda bianual. Este sistema ha sido utilizado para calcular el coste de una ha de olivar tradicional, tanto en régimen de secano como de regadío con una producción de 3.500 kg y 6.000 kg respectivamente y un 21% de rendimiento grasos en ambos casos. Se ha asumido un modelo de explotación basado en la mano de obra familiar donde la mayor parte del trabajo agrario es realizado directamente por el titular y su familia, contratando solo de manera excepcional (y por lo general, de modo estacional) trabajo asalariado (Moyano Estrada, 2014). Es decir, se computa el coste de mano de obra como renta de la parcela. Los ingresos han sido calculados asumiendo un precio de venta del aceite de 2,29 €/kg.[22], y una subvención media por ha de 550 € en el régimen de secano y 650 € en regadío. Los ingresos por ha se cifran en 2.233 €/ha y 3.535 €/ha para el caso del olivar de secano y regadío respectivamente.

En cuanto al umbral de rendimiento que debe imputarse a una parcela se ha considerado que el rendimiento mínimo es satisfactorio, es decir asegura la calidad de vida de las familias rurales, si permite ingresar al menos el SMI (Salario Mínimo Interprofesional) al titular de la parcela. También para establecer un supuesto paralelo de comparación se ha utilizado el URP (Umbral Riesgo de Pobreza), que siguiendo los criterios de Eurostat, se fija en el 60% de la mediana de los ingresos por unidad de consumo de las personas. El SMI para el año 2017 es de 9.906 € y el URP se sitúa en 8.011 €. Finalmente se exponen los datos atendiendo a los hogares compuestos por dos adultos y dos menores de catorce años, cuyo URP se sitúa en 16.823 €.

Además, se ha tenido en cuenta la idiosincrasia del propio cultivo del olivar y el perfil del olivicultor planteando cuatro escenarios posibles en función de la vinculación

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tratamientos fitosanitarios y fertilización y en la recogida trabajan tres familiares. Se externaliza el picado de ramón (35 €/ha), el manejo del suelo con rastra (15 €/ha) y cultivador (18 €/ha). El cálculo del coste de oportunidad se ha llevado a cabo asumiendo una tasa de interés de un 1% al precio de la tierra según reflejado en las encuestas sobre los precios de las tierras en Andalucía de la Consejería de Agricultura Pesca y Desarrollo Rural de 2014.

[22] Según datos de Poolred (Sistema de Información de Precios en Origen), el precio medio de venta del aceite, ponderado por la cantidades producidas y los respectivos precios en el periodo 2000-2015, es de 2,29 €/kg

económica de éste y el propio fundo agrario (importancia de los ingresos del olivar en su renta anual). Así, para el olivicultor tipo A se asume que no dispone de otros ingresos y vive exclusivamente del olivar (100% de la renta); para el caso B, se describe una situación en el que aunque el agricultor tiene otra fuente de ingresos, ésta es secundaria respecto a la que percibe por el olivar (75% olivar, 25% otras fuentes) y para los últimos dos tipos de olivicultores, los su - puestos C y D, se asume que se posee otra profesión principal y los ingresos procedentes del olivar son de igual cuantía y/o secundarios (50% y 25%[23]). Un esquema de la metodología seguida se muestra en la figura 16.

[23] Según el Plan Director del Olivar en Andalucía, el 41% de los titulares llevan a cabo otras actividades. Para el 88% esta otra actividad es la principal.

Fuente: Elaboración propia.

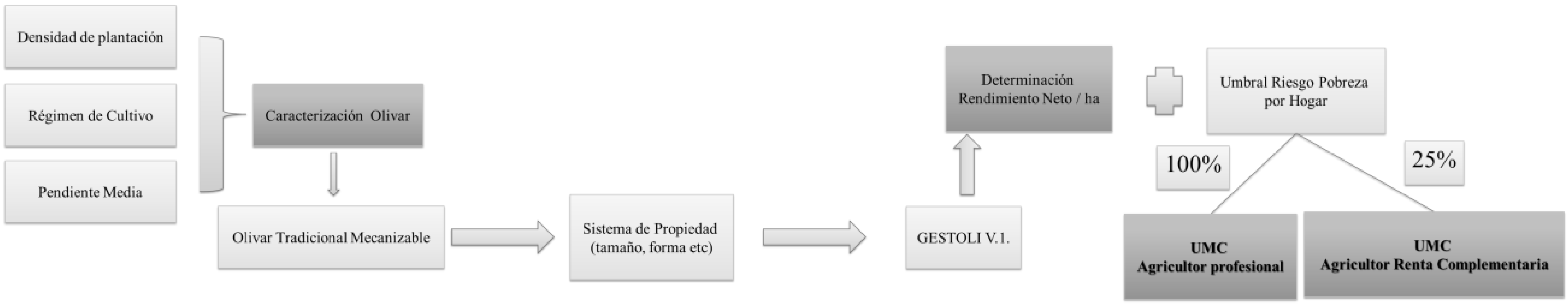


Figura 16: Descripción de la metodología empleada.

El número de ha necesarias para que cada parcela de olivar tradicional sea rentable (UMC) se calcula mediante la siguiente fórmula:

$$RSF = (RSha \times Nha) - (Bap \times \alpha)$$

Sujeto a: $RSF > 0;\quad Nha > \frac{(bap\times\alpha)}{RSha}$

donde:

RSF es el Rendimiento Satisfactorio Final; RSha el Rendimiento Satisfactorio neto por ha; Nha es el Número de hectáreas necesarias para que el RSF sea mayor que 0 (UMC); Bap es el Beneficio anual personal, que define el umbral de ingresos anuales que debe percibir una persona para no estar en una situación de vulnerabilidad; α es una constante que tiene en cuenta el peso que tiene el olivar en la renta anual del olivicultor.

Según LMEA, el objeto de la UMC es la parcela agraria. No obstante, la propia norma en su artículo 2 define la explotación agraria como una unidad técnico-económica. Por ello es necesario considerar los siguientes análisis con respecto a tres escenarios diferentes: en primer lugar, se estudian las explotaciones que están constituidas por una única parcela (coincide el término explotación con el de parcela agraria y por tanto con el objeto de la ley); en segundo lugar, se analizan los datos para las explotaciones constituidas por más de una parcela, situación real de numerosas explotaciones, y por último, se asume el caso hipotético de que todas las parcelas de cada propietario se aunaran en una unidad (escenario óptimo atendiendo a la superficie de cada propietario), es decir, un escenario que aboga por definir la UMC de la explotaciones en lugar de las parcelas, hecho que disminuirá la UMC requerida para el rendimiento satisfactorio al configurarse un escenario con mejores condiciones para la gestión. Este hecho ha sido sugerido por varios autores en la literatura, que consideran el tamaño de la explotación como prioritario (Cosialls Ubach y Muñiz Espada, 2015; Téllez de Peralta, 2000).

5.3.5. RESULTADOS

5.3.5.1. ANÁLISIS CARTOGRÁFICO DEL TIPO DE OLIVAR EN FUNCIÓN DE SU RENDIMIENTO

El análisis del mapa de recintos del SIGPAC revela que hay 488.028 recintos de olivar que representan una superficie de 569.903 ha. Con respecto al régimen de cultivo, los recintos en regadío alcanzan el 30,4% de la muestra (173.140) y una superficie del 45,7% (260.312 ha). La superficie media de este tipo de recinto es de 1,5 ha. Los recintos de secano tienen una superficie media inferior (0,9 ha) y suponen el 69,6% de la muestra cubriendo una superficie de 309.591 ha.

El tamaño medio de parcela es de 1,7 ha, con una elevada proporción de parcelas agrarias de dimensiones reducidas: el 62,9% de las parcelas presentan una superficie inferior a 1 ha (17,8% del suelo olivarero), y el 94,6% inferior a 5 ha. En la tabla 9 se representa la superficie susceptible de segregación en la provincia de Jaén, es decir aquellas parcelas potencialmente divisibles al disponer de una superficie de, al menos, el doble de la UMC. Se distingue entre el regadío y el secano para dirimir los dos regímenes establecidos por la normativa actual. Además, los datos se muestran segregados por comarcas, dado que los tamaños de las parcelas en la zona de estudio difieren en función de las zonas, especialmente en el caso del regadío. Los resultados son muy diferentes entre las parcelas olivareras en régimen de secano y en régimen de regadío. En secano el umbral de divisibilidad establecido en la UMC hace que el número de parcelas divisibles sea mínimo. Tan solo el 3,9% de las parcelas agrarias son divisibles (5.433). En cambio, en el olivar regado la superficie segregable es mucho mayor, concretamente el 62,8% en términos medios. Estos valores varían de forma significativa entre comarcas. En comarcas como Condado, Sierra Morena, Campiña del Norte y Campiña del Sur se concentran los mayores índices de segregación, con valores superiores al 70%.

Fuente: Elaboración propia.

Comarca	**Regadío**		**Secano**	
	Parcelas segregables	**%**	**Parcelas segregables**	**%**
Sierra de Segura	8157	61.0	332	1.9
El Condado	11993	70.4	402	2.8
Sierra Morena	6302	80.7	268	7.3
La Loma	36811	56.1	159	3.2
Campiña del Norte	17100	76.7	1437	6.6
Sierra de Cazorla	12838	68.4	1809	5.2
Campiña del Sur	12991	71.1	216	4.0
Mágina	14944	53.1	247	6.5
Sierra Sur	8334	55.9	563	1.7

Tabla 9**:** Parcelas y superficie segregables por comarcas en la provincia de Jaén.

5.3.5.2 ANÁLISIS DEL RENDIMIENTO SATISFACTORIO PARA EL OTM

Explotaciones de una parcela

En la provincia de Jaén, las explotaciones de OTM conformadas por una parcela suponen el 36% (30.816) del total de las explotaciones. Entre ellas, 18.389 son olivar de secano con una superficie media de 1,6 ha. Asumiendo la actual delimitación de la UMC, las parcelas divisibles para el secano representan el 2,9%. En cuanto al regadío, de las 12.427, con una media de 2,0 ha, 8.360 disponen de una superficie suficiente para su divisibilidad (27,1%).

El beneficio neto por ha se ha calculado para la parcela media tanto para el regadío como para el secano. Así, para una parcela media en régimen de secano (1,6 ha) es de 1.261 €/ha, mientras que para el regadío (2,0 ha) es de 1.629 €/ha. Estos valores son el producto de minorar a los ingresos, donde se incluye la subvención y el producto de la venta del aceite en origen, los gastos y otras partidas como la maquila, tratamiento de suelos, riego, etc.

Asumiendo los dos valores referidos anteriormente para dirimir el rendimiento satisfactorio (SMI y URP), para este conjunto de la muestra, la UMC debería establecerse tal y como muestra la siguiente tabla 10.

Fuente: Elaboración propia.

	UMC conforme al Salario Mínimo interprofesional (ha)		**UMC conforme Umbral Riesgo de Pobreza (ha)**	
	Secano	**Regadío**	**Secano**	**Regadío**
Olivicultor Tipo A	7.8	6.0	6.3	4.9
Olivicultor Tipo B	5.9	4.5	4.8	3.7
Olivicultor Tipo C	3.9	3.0	3.2	2.5
Olivicultor Tipo D	1.9	1.5	1.6	1.2

Tabla 10: UMC establecida para el OTM de secano y regadío.

Los datos señalan cómo, en cualquiera de los contextos planteados, la vigente UMC establecida para Andalucía es muy inferior a la que se requiere para alcanzar el rendimiento satisfactorio de la parcela. Para el olivicultor A, agricultor a tiempo completo, según los datos expuestos en la tabla 10 se considera que para alcanzar el SMI en una explotación de secano se requiere de una superficie de 7,8 ha. Tan solo 456 propietarios (1,5%) disponen de tal dimensión. Si analizamos los datos en base al URP, se requieren al menos 6,3 ha para que la parcela olivarera alcance dicho umbral; tan solo 624 propietarios (2,0%) alcanzaría esa superficie suficiente. Si se computan los datos para el régimen de regadío, del conjunto de explotaciones analizado tan solo alcanzaría el SMI el 2,3% y el URP el 2,9%.

Si se consideran los ingresos URP por hogar en lugar de por individuo, se requieren 13,4 ha en secano para el sustento de una familia de cuatro miembros y 10,3 ha si el régimen es de regadío. Este análisis manifiesta que el olivar tradicional no puede ser considerado como actividad única para alcanzar un umbral mínimo de ingresos dada su fragmentación actual, a excepción de que existan ayudas sociales que permitan fijar a la población en los territorios.

Para el olivarero D, es decir, aquel que percibe una renta principal no procedente del olivar, se estiman unas superficies inferiores a las del caso anterior, gracias a la renta complementaria procedente de otra actividad. Para alcanzar el SMI se necesitan al menos

1,9 ha en secano y 1,5 ha en regadío, mientras que para alcanzar el URP se requieren 1,6 para el secano y 1,2 ha para el regadío. Actualmente tan solo alcanzarían la superficie suficiente el 10,5% de las explotaciones en régimen de secano, mientras que en régimen de regadío la cifra asciende a 11,1%. Por tanto, en torno al 90% de estas explotaciones no registran ingresos suficientes para alcanzar un rendimiento satisfactorio. Considerando la magnitud del ingreso por hogar para el caso del olivarero D, donde se considera rendimiento satisfactorio aquél que proporciona 4.205 € procedentes del olivar y 12.617 € por otra actividad principal, se requieren 3,3 ha en régimen de secano y 2,6 ha en régimen de regadío.

Estos umbrales solo se cumplen para el 5,2% de las explotaciones en secano y el 6,3% en el regadío. Si los beneficios son inexistentes para la mayoría de los agricultores a título principal, los datos no son más halagüeños para el propietario que dispone de otra renta. En estos casos, tan solo en torno al 6% de las explotaciones presenta la superficie suficiente para alcanzar el rendimiento satisfactorio.

Explotaciones constituidas por más de una parcela

En este apartado se analizan las explotaciones constituidas por más de una parcela, el 64% del total. En este caso, la superficie media considerada para el cálculo del rendimiento por ha es la suma de la superficie del conjunto de parcelas de cada explotación. Los resultados mostrados son conservadores, ya que no computan los costes de dispersión (Perujo-Villanueva y Colombo, 2017), ni de fragmentación (Colombo y Perujo-Villanueva, 2017a) que pueden encarecer los costes de producción en torno a un 15%.

De un total de 230.634 parcelas, 81.890 se encuentran en régimen de secano, con una superficie media de 1,5 ha, de las que, según legislación vigente, 3.717 (1,6%) son segregables por disponer al menos del doble de la UMC; en el caso del regadío, existen 148.744 parcelas con una superficie media de 1,9 ha. De ellas, el 41,1% (94.848) son susceptibles de segregación. Este análisis preliminar permite ofrecer una situación muy diferente entre el olivar en secano y en regadío ya que, debido a la baja superficie de la UMC para el regadío, este último puede seguir subdividiéndose y aumentando aún más el grave problema de la excesiva fragmentación de la tierra y la consiguiente baja o nula rentabilidad del fundo.

Para el caso del olivarero A, en el caso del secano solo en torno al 1% de las parcelas alcanza la rentabilidad establecida en función de UMC, mientras que para el caso del regadío ésta se sitúa en torno al 5%. Para el olivarero tipo D, en régimen de secano, según se emplee el SMI o el URP, el 1,9% o 7,5% de las parcelas alcanzarían la rentabilidad satisfactoria, mientras que para el regadío esta cifra la lograrían en torno al 16,0% (SMI) o 19,8% (URP) de las parcelas agrarias.

El valor ofrece, bajo la actual definición de la UMC, una perspectiva definitoria del cultivo: su carácter deficitario desde el punto de vista económico, incluso considerando sus ingresos como renta marginal del agricultor y su gestión a través de la mano de obra familiar.

UMC en función de la superficie de la explotación

En tercer lugar, se presentan los resultados bajo el supuesto de que la UMC fuese definida a nivel de explotación. En este caso, la muestra analizada está constituida por el total de propietarios de olivar tradicional de la provincia de Jaén, 84.788 propietarios, de los cuales 41.003 poseen la totalidad de sus parcelas en secano (48,4%), con una media de 3,6 ha, mientras que las explotaciones constituidas íntegramente por regadío suponen el 28,8%, con una superficie media de 4,1 ha. El resto de las explotaciones están constituidas por un régimen mixto y suponen el 22,9%.

La tabla 11 muestra la UMC a nivel de explotación agraria. Al computarse el conjunto de hectáreas de cada agricultor el beneficio neto por ha aumenta (mayor eficiencia en las labores), lo que repercute directamente en la superficie necesaria para alcanzar el rendimiento satisfactorio. Sin embargo, en el caso del secano, para el tipo olivicultor A, el rendimiento satisfactorio sigue sin alcanzar el 15% (en función del parámetro utilizado entre el 11,2% y 14,5%), lo que vuelve a demostrar el escaso nivel de rentabilidad del cultivo, que hace inviable su consideración como única actividad para el propietario. Si se considera como cultivo complementario, es decir el caso del olivicultor D, la superficie aumenta considerablemente, llegando a umbrales notables (46,4%-53,9%). Estas cifras manifiestan que incluso considerando la totalidad de las tierras de un propietario y que la renta proveniente del olivar suponga solo una cuarta parte del SMI o URP, gran parte de las explotaciones de la provincia no proporcionan una renta suficiente. El caso del regadío es muy parecido al del secano, y las reducidas diferencias no justifican el establecimiento de una superficie muy reducida como UMC en este sistema. Es por tanto necesario plantear nuevos escenarios que permitan aumentar la superficie de las explotaciones.

Fuente: Elaboración propia.

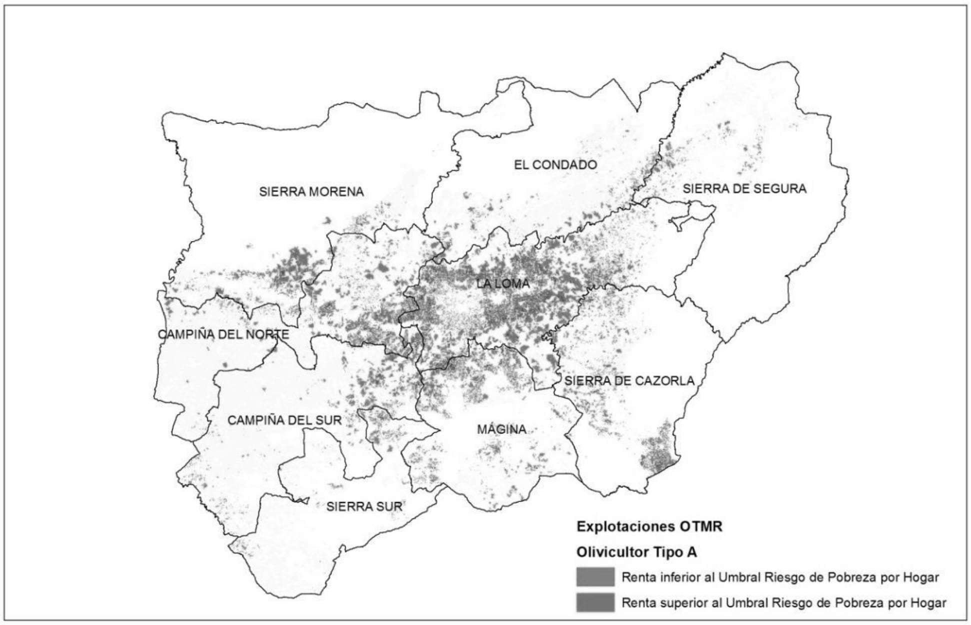
	UMC de Cultivo conforme al Salario Mínimo interprofesional (ha)		**UMC conforme Umbral Riesgo de Pobreza (ha)**	
	Secano	**Regadío**	**Secano**	**Regadío**
Olivicultor Tipo A	6.8	6.0	5.5	4.8
Olivicultor Tipo B	5.1	4.5	4.2	3.6
Olivicultor Tipo C	3.4	3.0	2.8	2.4
Olivicultor Tipo D	1.7	1.5	1.4	1.2

Tabla 11: UMC según tamaño de explotaciones.

No obstante, la consideración de la totalidad de la superficie de la explotaciones arroja resultados mejores que los planteados en el primer supuesto, donde los porcentajes de rendimiento satisfactorio solo lo alcanzaban el 3,0% en el tipo A e inferiores al 11% para el tipo D; también son mejores que los resultados alcanzados en el segundo supuesto, aquellas explotaciones con más de una parcela donde los porcentajes más halagüeños no superan el 5% para el tipo A o el 20% para el tipo D.

La figura 17 representa la distribución del OTM en la provincia de Jaén. Con base en el URP por hogar se muestra la distribución del mismo que consigue alcanzar un rendimiento satisfactorio en régimen de regadío. En el mapa superior se representa en color verde la superficie de olivar que alcanza esta renta considerando que la totalidad de los ingresos del propietario se deben a este cultivo. En tonos rojos aparecen reflejados aquellos olivares que no alcanzan los ingresos necesarios estimados para el hogar, 16.823 €. En el mapa inferior, se presenta la distribución de olivar regado para el caso del olivicultor D, es decir, un propietario que percibe el 75% en base a una actividad principal y el 25% del olivar. En ambos casos el escenario se analiza bajo el supuesto de la consolidación de la totalidad de las tierras de cada propietario. Los datos son concluyentes en ambas hipótesis: el olivar no alcanza la rentabilidad en la mayor parte de las explotaciones existentes. En el mapa superior se presenta un espacio donde tan solo el 7,6% de los propietarios obtienen rendimientos satisfactorios (53% de la superficie); mientras que en el mapa inferior, el porcentaje de propietarios con rendimientos satisfactorios asciende al 32,6% (82,7% de la superficie).

Fuente: Elaboración propia.



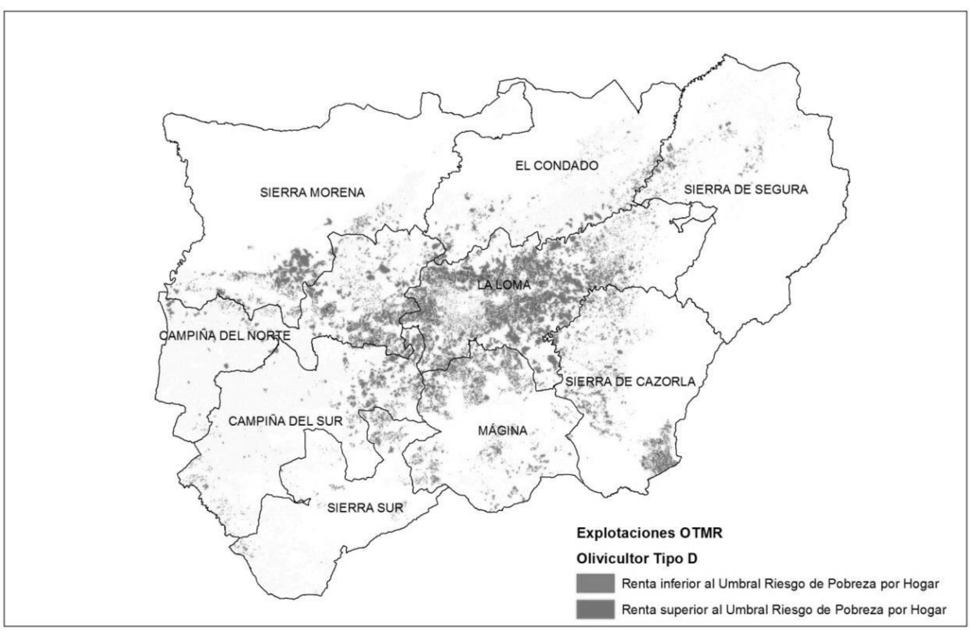


Figura 17: Distribución del OTM en función de su rendimiento satisfactorio por hogar.

5.3.6. DISCUSIÓN

La excesiva fragmentación de la tierra rústica, junto con la baja rentabilidad del cultivo del olivar, hace necesario replantear el futuro de las pequeñas explotaciones agrarias. Entre otros factores, la escasa dimensión económica de las explotaciones es uno de los elementos que reducen la rentabilidad y por ende favorece el abandono de las mismas, especialmente por los jóvenes agricultores (Langreo Navarro y García Azcárate, 2017). Así, la administración debe apostar por establecer mecanismos públicos o privados que garanticen una propiedad con una superficie mínima que permita gestionar sus recursos de forma adecuada y rentable.

A estos efectos, la UMC impide futuras divisiones de los fundos agrarios por debajo de una superficie mínima con el objetivo de mantener su viabilidad. No obstante, esta figura no soluciona el problema actual del excesivo minifundismo en el espacio agrario, entre otros motivos por no haberse fijado de forma correcta en cuanto a su objeto, la parcela agraria, y por determinar valores demasiado bajos que impiden alcanzar un rendimiento satisfactorio. Por tanto, se define como una figura de prevención, pero de es caso valor en territorios donde la fragmentación es ya una realidad como es el caso de muchos cultivos en el ámbito mediterráneo. En el supuesto del olivar, lamentablemente la UMC es una medida que llega tarde, especialmente para el régimen de secano, ya que actualmente casi la totalidad de las parcelas se encuentran por debajo de la superficie mínima establecida (98,1%). En cambio, en el olivar regado, las parcelas segregables ascienden al 62,8% de la muestra; ello se debe especialmente a la baja dimensión que se requiere en la actualidad, que por otro lado no garantiza en absoluto un rendimiento mínimo satisfactorio. Por ello es de vital importancia incrementar la UMC para este tipo de cultivo estableciendo una dimensión suficiente que frene la paulatina fragmentación y a la vez asegure un rendimiento satisfactorio.

Consciente del problema que supone el minifundismo en el medio rural y de que la actual UMC no ha sido definida en función de criterios reales, la administración está considerando modificarla. El Anteproyecto de Ley de Agricultura y Ganadería de Andalucía propone la necesidad de definir nuevamente la UMC de forma reglamentada, que permita asegurar la viabilidad de la explotación en función de su ubicación y del tipo de actividad agraria utilizando los medios normales y técnicos de producción. Además, señala que no fomentará iniciativas o proyectos que sobre la base de un fraccionamiento o disminución de la dimensión física de la tierra originen explotaciones con tamaños no competitivos.

En la revisión de la UMC, en primer lugar, se debería considerar la tipología de cultivo o grupos de cultivos en base a su rentabilidad. En segundo lugar, siguiendo leyes pioneras como la Ley 1/2014, de 19 de marzo, Agraria de Castilla y León, se debería abogar por establecer una Unidad Mínima de Explotación en lugar de parcela, dado que su fundamento radica en asegurar la calidad de vida de las familias rurales. Para ello es necesario establecer la unidad mínima computando el total de las parcelas agrarias de un propietario. Además, en el cálculo de la rentabilidad de la explotación se debe tener en cuenta aspectos estructurales de interés como la pendiente de las parcelas, el número de las mismas, su dispersión en el territorio y otros aspectos edafoclimáticos que intervienen en los costes o en la potencialidad productiva. Ello nos permitirá delimitar una Unidad Mínima de Explotación en igualdad de condiciones entre explotaciones. En este contexto, el proceso metodológico empleado para la definición de las regiones productivas en la última revisión de la PAC puede representar un punto de partida.

En el caso del olivar tradicional, el actual nivel de fragmentación de la propiedad rústica no logra alcanzar una UMC satisfactoria. Una posible razón de su existencia, en particular para el 59% de olivicultores que ejercen su actividad a tiempo completo, es la presencia de ayudas sociales que permiten mejorar la precaria situación del agricultor, especialmente del que no tiene otra actividad complementaria y no dispone de una dimensión suficiente. En todos los casos, el mantenimiento de ayudas vinculadas al mundo rural permite de forma indirecta proteger un espacio agrario cada vez más fragmentado y menos competitivo en un contexto global. Por ejemplo, considerando solo el subsidio agrario para una persona de entre 52 a 59 años la superficie necesaria para alcanzar el rendimiento satisfactorio serían 4,5 ha en secano y 3,5 ha en regadío, que suponen superficies más cercanas a la realidad observada en la zona de estudio, especialmente a nivel de explotación (5,3 ha).

Por otro lado, es necesario apostar por acciones que contribuyan al aumento del tamaño de las explotaciones y, a la vez, la reducción de la fragmentación. Incrementar la movilidad en el mercado de la tierra, tanto en propiedad como en arrendamiento, así como fomentar la compraventa de fincas colindantes mediante exenciones fiscales, puede contribuir a la mejora de la dimensión de las parcelas agrarias y por tanto a la calidad de vida en el medio rural. Asimismo, la reducción de la fragmentación intra-explotación, es decir la disminución del número de parcelas no colindantes de un propietario, puede incrementar la rentabilidad de las explotaciones agrarias (Colombo y Perujo-Villanueva, 2017a). Esta reducción se podría conseguir a través de procesos de consolidación de las propiedades. No obstante, hay que decir que, en un intento anterior de concentración, tan solo participaron 1.609 propietarios (Maceda Rubio, 2014) por lo que sus efectos fueron insignificantes en la práctica. Las posibles razones pueden deberse al alto coste del proceso y a la dificultad de obtener consenso entre los propietarios o una actitud positiva. Otra posible alternativa para aprovechar las economías de escala que se originan mediante el aumento del tamaño de las explotaciones agrarias es la gestión en común de las explotaciones. Estas acciones pueden desarrollarse en función de las condiciones de partida (cercanía o no a explotaciones de grandes dimensiones y mecanizadas), a través de cultivos asistidos y/o compartidos (Colombo y PerujoVillanueva, 2017b).

5.3.7. CONCLUSIONES

El futuro del espacio agrario depende del mantenimiento de la población local, pero el excesivo minifundismo reduce la rentabilidad de las explotaciones haciéndolas poco atractivas para la inversión en su mejora y modernización. En este sentido, es necesario no solo frenar la atomización y fragmentación de la tierra, sino asumir mecanismos que permitan aumentar la superficie y abaratar los costes de producción. La concentración parcelaria no permite por sí sola revertir la situación actual, ya que la superficie media por propietario, incluso consideradas bajo una misma linde, no es suficiente para alcanzar un salario justo. De ahí que aumentar la superficie gestionada de forma unitaria, bien a través de la adquisición de tierras colindantes o la gestión en común del olivar entre varios propietarios, pueda ser una de las soluciones para la reducción de costes de las pequeñas explotaciones.

A pesar de que los resultados tienen que ser leídos con cautela ya que dependen de los parámetros empleados en la definición del rendimiento satisfactorio que establece la LMEA, en este trabajo se demuestra que las explotaciones de olivar tradicional no tienen una superficie que asegure la rentabilidad en la mayor parte de las explotaciones, incluso cuando se asume que el cultivo solo representa una renta complementaria. Es más, dichos resultados han sido obtenidos bajo un enfoque muy conservador en el establecimiento de los umbrales de rentabilidad satisfactorios, que solo permiten la subsistencia en el medio rural. Así, es gracias al soporte de la PAC, el subsidio agrario, la gestión mediante mano de obra familiar y la búsqueda de rentas complementarias que los olivicultores titulares de pequeñas explotaciones agrarias subsisten en el medio rural.

Por ello, la administración debe apostar decididamente por medidas específicas para el pequeño propietario que incentiven un incremento del tamaño de las explotaciones, especialmente cuando el agricultor ejerce la actividad agrícola a título principal. Medidas fiscales en las transmisiones patrimoniales de las parcelas diseñadas para pequeñas explotaciones representan una válida opción a elegir. Paralelamente, otras medidas que permitan incrementar la rentabilidad del cultivo y favorecer una renta satisfactoria en explotaciones de pequeñas dimensiones, como por ejemplo la intensificación del cultivo, la gestión en común o acciones que aumenten el valor añadido del producto vía calidad y diferenciación, deberían también ser promovidas.

5.3.8. AGRADECIMIENTOS

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5.4. IMPACT OF PARCEL FRAGMENTATION ON THE CALCULATION OF THE REAL ESTATE VALUE OF LAND BELONGING TO FARMS*

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5.4.1. ABSTRACT

Agricultural parcels are often the subject of land valuation studies. This approach implicitly assumes that real estate value of the land belonging to a farm is the sum of the values of the individual parcels that make up the farm. Nonetheless, the value of a whole can be very different from the sum of its parts. This study proposes a methodology for calculating the real estate value of the land belonging to a farm, not only on the basis of production factors such as surface area, type of crop and intensity, but also by implementing parameters relating to the fragmentation of the land. Fragmentation increases production costs and reduces farmers' incomes and by extension the real estate value of the farm. In our study area, the province of Jaén in Spain, figures for its most emblematic crop, the olive, show that the fragmentation of the land reduces its value by between 56.4% for a 10 ha farm and 12.3% for a 30 ha farm as compared to the values set out in the bibliography. The reorganization of the ownership system or the promotion of systems for the common management of land are instruments that could increase the profitability and therefore the value of land according to the 'income capitalization' approach.

Keywords:

Farm value, Fragmentation, income capitalization, GIS

List of abbreviations:

AEMO: Asociación de los municipios de olivar (Associations of the Olive Grove Municipalities).

BOE: Boletín Oficial del Estado (Official State Bulletin).

BOJA: Boletín Oficial de la Junta de Andalucía (Official Bulletin of the Regional Government of Andalusia).

CES: Consejo Económico Social (Social and Economic Council).

GIS: Sistemas de Información Geográfica (Geografical Information System).

MAPAMA: Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente (Spanish Ministry of Agriculture Fishery Food and Environment).

SIGPAC: Sistema de Información Geográfica de Identificación de Parcelas Agrícolas (Geographical Information System for the identification of Agricultural Parcels).
ATLLUR: Texto Refundido de la Ley del Suelo y Rehabilitación Urbana (Amended Text of the Law on Land and Urban Redevelopment).

5.4.2. INTRODUCTION

The object of land valuation is to calculate the price of land on the basis of a series of selected criteria. Agricultural land is valued for a range of purposes be they private (loans, division of estates, mortgages, property sales, agrarian insurance policies, etc.) or public, especially in administrative proceedings (expropriation, organization of farms, consolidation of farm land, assessment of damage caused by the Administration), and for tax reasons (property tax, tax on the sale or transfer of real estate and documented legal acts, etc.). Accurate calculation of the value of land is therefore vital to guarantee legal certainty for the owner and the protection of his or her rights (López de Luis, 2010). A fair land valuation method is therefore essential.

In the procedure aiming at determining the real estate value of rural land agricultural parcels are the subject of land valuation reports, being very scarce the studies which evaluated the real estate value of the "whole" land belonging to a farm. Nonetheless, the value of a whole can be very different from the sum of its parts. Thus, calculating the value of the land belonging to a farm as a whole rather than as just the sum of its separate parts could be particularly important in processes for the wholesale transformation of agrarian structures, in that it would allow valuations to be made without creating large inequalities, taking into account all the factors that influence the real estate value. One clear example is the plan for the reorganization of farms, an initiative that offers grants for the improvement of agrarian structures in areas in which there is a predominance of small and medium-sized holdings in which a land consolidation process is due to be performed (Maceda Rubio, 2014). In these processes the methodologies normally used are based on the individual valuation of each small part, and create a discriminatory situation in which the land is valued on the basis of the configuration of the land contributed by each owner.

Additionally, the common approach followed did not include in the analysis the spatial fragmentation and dispersion of the parcels that make up the farm when accounting the value. For instance, the studies which employed the hedonic methods, only considered a set of variables related to the farm size and production structure (irrigation, quality of land, type of crop, location, etc.) as explanatory variables, ignoring completely the existence of land fragmentation (Boisvert et al., 1997; Calatrava and Cañero, 2000; Maddison, 2000). However, land fragmention may impact severely the land profitability (Lu et al., 2018; Colombo and Perujo Villanueva, 2017a; Perujo-Villanueva and Colombo, 2017; Latruffe and Piet, 2014;) and thus the real estate value of the land.

Various methods have traditionally been used to estimate the real estate value of agricultural land (Wahlen et al., 2013). These methodologies produce highly varying results (Jeanneaux et al., 2017), and different methods are used depending on the objective of the valuation, the type of ownership or the land use (Wyatt, 1997). One widely used classical method is the comparative method (Pagourtzi et al., 2003). For it to produce a reliable result, this method requires enormous amounts of information with regard to the transactions involving similar estates or properties. In the end this led to the method being abandoned for the valuation of agricultural land in countries like Spain in which there are fewer transactions and the market is less transparent than for urban land and land with planning permission (BOE, 2015). For this reason, for those procedures in which the public administration is involved, the use of the 'income capitalization' method has become mandatory. This method values land on the basis of its suitability for production, in an unlimited scenario which assumes that for the foreseeable future the land will continue to be used for agricultural purposes with the same crop. In this way by calculating the difference between farm revenue and costs, it is possible to calculate the annual return on each parcel being valued. By applying a specific interest rate the real estate value of the land can also be obtained.

In order to be able to apply this method correctly, it is necessary to know the income or profit generated by the farm. The most commonly used variable for measuring agrarian income is the area of the farm (Cañas et al., 1994; Caballer & Guadalajara, 2005). The analysis of the income from farms also normally involves the valuation of external variables such as production, the quality of the land or the risk of frost (Aznar & Guijarro, 2004; García et al., 2017), which although they influence the profitability of the land are not the only factors affecting it. Other factors which have a direct influence on the profitability and therefore on the real estate value of the land are often ignored. For example, Eves (2007) showed that the technical, financial and environmental management of the farm had a direct influence on its value, creating differences in the real estate value of up to 20%. In the same way the fragmentation and dispersion of parcels of land has a direct impact on the value of the farm in that in certain situations the farmer cannot work the land so efficiently and therefore makes a smaller return (Coelho et al., 2001; Delord et al., 2015; Coruhlu & Yildiz, 2017). Farms of the same size have very different costs and therefore profit levels, depending on the number, and the shape of the plots of land of which they are composed and the distance between them (Tan et al., 2010; Vilar et al., 2011). These variables often go unnoticed in cost studies used as a reference for calculating the annual income.

Therefore, in such fragmented land ownership situations as those applying in the European agrarian system (Akkaya Aslan et al., 2002; European Parliament, 2014), in which there is a predominance of smallholdings[24], in any calculations of the profitability of farms and the real estate value of the land, it is necessary to take these variables into account and to calculate the differences in income due to the less efficient management produced by the unfavourable fragmented structure of the farm. Small farms have higher costs, which reduce their annual income (Colombo & Perujo-Villanueva, 2017a), in some cases leading to negative yields, which put the viability of the 'income capitalization' method into doubt.

In this paper we will be focusing on calculating the impact of the structural aspects of the farms, namely farm size and parcel fragmentation, on the real estate value of the land at farm level, a question that has yet to be broached in the literature. Our objective is to demonstrate that any public or private action aimed at increasing the income from agricultural holdings not only has a positive short-term effect on the economic viability of

[24] 69% of the farms have areas of less than 5 ha and only 2.7% have more than 100 ha (European Commission, 2013).

farms ((Vilar Hernández et al., 2010)), but also increases their real estate value and in turn the overall wealth of rural communities. The maintenance of this kind of farms provides an essential complement to the family budget (Fernández-Zamudio & De Miguel, 2006).

The paper is structured as follows: we begin by defining the rules and laws governing the methods used for the valuation of rural property in Spain; we then describe the study area and set out the methodology we propose for quantifying the value of farms. In the results and discussion section we summarize the main effects and comment on the different comparative scenarios for the valuation of rural properties. We conclude by making clear that the real estate value of the farm can vary considerably according to the impact of the spatial distribution and the shape of the parcels. Small atomized farms have much lower values than their larger, more concentrated counterparts.

5.4.3. THE VALUATION OF AGRICULTURAL LAND IN SPAIN

Nowadays the Amended Text of the Law on Land and Urban Redevelopment (BOE, 2011), hereinafter ATLLUR, provides a general framework for the valuation of land for administrative purposes (Falcón Pérez, 2015), advocating the use of the 'income capitalisation' method for calculating the value of agricultural land (Art. 36). This method takes into account the capacity of the land for generating value and determines income on the basis of the productivity of the estate, focusing particularly on its location, and on the type of crop and the normal technological equipment used in its production (Cañero León & Calatrava Requena, 2000) including subsidies of a stable nature and subtracting the costs incurred. The income calculation is based primarily on the consideration of land as a production factor. Specifically, the method is based on calculating the annual income (total revenue minus the necessary costs) and projecting it onto an unlimited scenario based on the useful life of the crop. This means that the value of the agricultural land is affected by the type of crop and by the efficiency with which it is managed. The final value could be adjusted upwards on the basis of different location factors. In addition, for the income capitalisation approach, we will be using an interest rate which, according to the provisions of Additional Clause 7 of the ATLLUR, is determined by a general interest rate multiplied by a corrective coefficient which is published for each type of crop. At the time of writing this article the rate for olive groves is 1.25%.

The bibliography most critical of this method highlights various aspects: firstly the difficulty of defining the income from each farm, on many occasions resulting in income being calculated as a percentage of final production (Gutiérrez Flores, 2010); secondly the limited availability of cost studies that reflect the real situation of the farm being considered; thirdly, the conditionality involved in using a predetermined interest-rate given that the variability in this rate can have a considerable effect on the real estate value of the property[25]. Fourthly and finally the fact that sociological factors, which at times are more important than the income from the crop, are not taken into account (Jeanneaux et al., 2017).

None of the studies cited above refer to the need to calculate the value of the farm, defined as the group of parcels that make up the land owned by an olive farmer on which he/she carries out his/her farming activities, primarily aimed at the market and which constitutes a technical economic unit in itself. In other words, in these studies the object being valued is the single agrarian parcel or plot without considering or proposing the need to value the farm as a whole. Farming research has shown that agrarian systems must be considered as a complex fabric and not as a mere collection of agricultural parcels that influence their configuration (De Juan Valero et al., 2003) and therefore their production methods and efficiency. In addition, if the management of the different parcels is performed with the same machinery and human resources and within a common agronomic, technical organization, the farm must be considered as a basic technical unit and not as various base units, in other words, various farms (Ballestero, 2000).

One clear example of the need to make valuations at farm level is proposed in the Preliminary Draft of the Andalusia Agriculture and Livestock Act. Article 29 of this Act states the need to promote farm organization plans in order to establish farms of sufficient size and characteristics in terms of their structure, capitalization, business organisation and environmental integration. This procedure is used to consolidate land ownership in specific districts or areas, for which purposes it is necessary to calculate the value of the set of plots

[25] The impact of this variability has been resolved in part by using as the capitalization rate the average value (from the annual data published by the Bank of Spain) for the return on 30-year Government Bonds, for the three years prior to the date to which the valuation is understood to refer (BOE, 2015).

contributed by each farmer, in order to create more concentrated farms with a similar value to that of the land contributed.

5.4.4. STUDY AREA

The olive tree is undoubtedly the most emblematic crop in the province of Jaen (southern Spain), extending over 551,191 ha or 83.3% of its total agrarian area. This represents 26% of the total area planted with olive trees in Spain as a whole and 46% of the olive groves in Andalusia (CES, 2011). Our research focuses on the traditional machine-workable olive grove in this province (gradients of less than 25% accessible to tractors), which covers 78.5% of the useful agrarian area. In general terms, the agrarian structure of the province, a concept that includes parameters such as property and forms of farming and landholding, is characterized by its heterogeneity and/or polarization: there are a large number of small farms and relatively few large ones (Naranjo Ramírez, 2003). As regards fragmentation, the figures indicate that the average farm has 5.3 ha, although 77.6% of them have 5 ha or less (Colombo & Perujo-Villanueva, 2017a). There are a total of 261,450 plots making an average of 3.1 plots per farm. The most fragmented farm has 101 parcels, though farms with more than 10 parcels make up just 3.4% of the total. As regards the geographical dispersion of the plots, the average value is 4 km. The minimum value is 0 km for 36% of the farms and the maximum is 73.6 km (Perujo-Villanueva & Colombo, 2017). Figure 1 show a real image of typical olive farm structures in the studied area.

The traditional olive grove is showing worrying signs in terms of the return on this crop, especially due to the high fragmentation of ownership, the relatively limited professionalization and modernization of the farms and their high production costs. Traditional olive-growing is generally considered an agro-system with low returns, such that many olive farmers are dependent on subsidies from the CAP and on family labour (Colombo et al., 2016). The current situation is likely to get worse given the age of the agrarian population in which 74.6% are over 44 years old and 25.3% are over 64 years old (BOJA, 2015) and due to the gradual reduction of the support from the CAP. The fact that few members of the younger generation seem interested in farming (Langreo Navarro, 2002), the uncertainties of the Common Agricultural Policy and the low income from olive farming make for an unattractive scenario for the dynamization of rural Jaen. In this situation, it is expected that the sale or transfer of properties between private individuals will increase and there will therefore be increasing interest in valuations.

Source: Authors' elaboration.

Figure 18**:** Examples of the parcel composition and dispersion of typical olive farms in the studied area.

5.4.5. MATERIAL AND METHODS

Using the 'income capitalization' method, the real estate value of the set of agricultural plots belonging to a farm (*J*) is calculated using the following formula:

$$\sum_{j}^{J} PV_j = \frac{RIP_{1j}}{(1+r_2)^1} + \frac{RIP_{2j}}{(1+r_2)^2} + \cdots + \frac{RIP_{nj}}{(1+r_2)^n} \quad =$$

Where PV_j is the capitalization value of the parcel *j* (€/ha); RIP_1, $RIP_2 \ldots RIP_n$ is the real or potential annual income[26] from the parcel *j*, from the first year until the end of the unlimited duration of the useful life *n* (€/ha); r_2 is the capitalization rate obtained by multiplying the general capitalization rate r_1 (At the time of writing this article the rate for olive groves is 1.25%. Is obtained by multiplying the general rate (2.9%) by the correction coefficient of 0.43, which is defined by the Regulation of the Land Law in Annexe 1)[27].

With this methodology, it is possible to calculate the value of each parcel and later, assuming that the objective is to calculate the value of a whole farm, add together the values of all the different parcels, using the profitability per hectare[28] as a reference without considering parameters that affect the overall management of the farm, such as the journeys that have to be made to reach all the various parcels or the inefficiencies due to their shape and size. For demonstration purposes, this fact is shown in Figure 2, which shows three kinds of farm with the same surface area (1 ha). The farm in Table A does not show inefficiencies due to fragmentation and dispersion, while those in squares B and C have excess costs due to these factors, which reduce their income and by extension their real estate value.

[26] Real income will be understood as that resulting from the farming of rural land according to its state and activity at the time of valuation, be it the duly accredited existing income, or the attributable income according to the particular crops and other farming uses. Potential income will be understood as the income attributable to the farming of rural land in accordance with the most likely uses and activities that are feasible using the normal technical resources for its production.

[27] is calculated according to Royal Decree Law 7/2015, which establishes: "1. For the capitalisation of the real or potential annual income of a farm, as referred to in Section 1 of Art. 363, the capitalisation rate to be used shall be the average value of the annual data published by the Bank of Spain about the profitability of Government Bonds at 30 years, which corresponds to the 3 years prior to the date to which the valuation is understood to refer." Available at: https://www.bde.es/webbde/es/estadis/infoest/si_1_2.pdf

[28] As a reference it uses the cost and profitability studies carried out by the public administration as well as the surveys on the price of land (MAPAMA, 2016) and the Olive Grove Master Plan (BOJA, 2015). These studies do not consider the economies of scale in production or the spatial distribution of the parcels.

Source: Authors' elaboration.

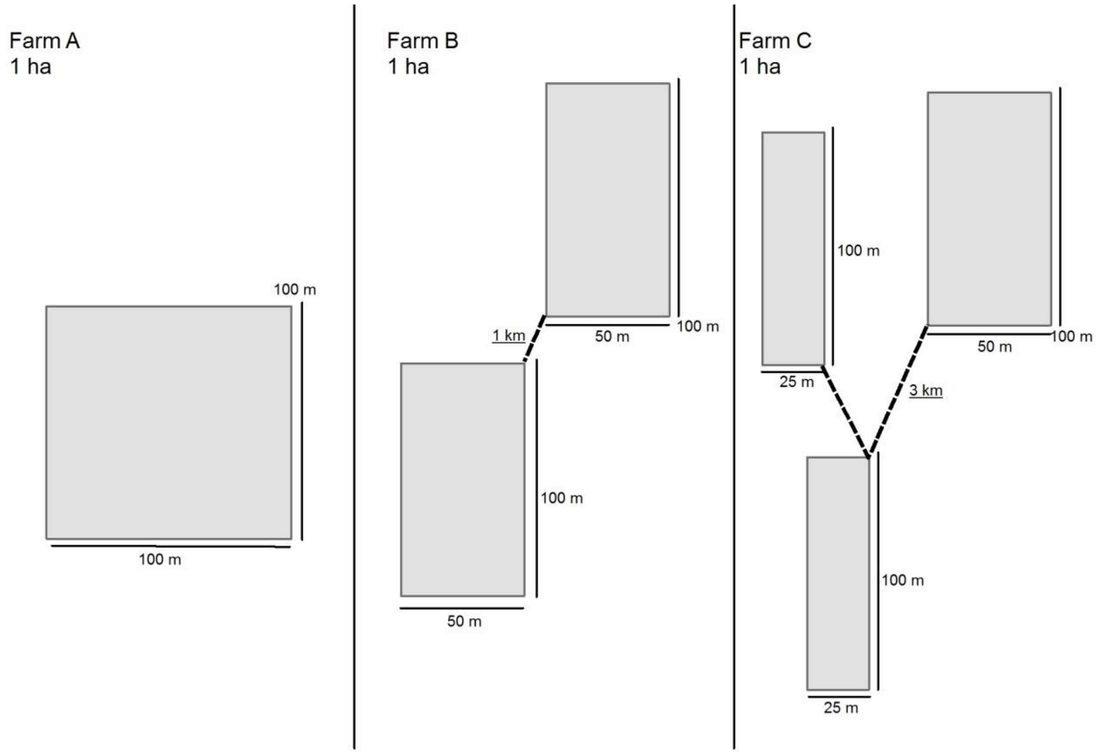

Figure 19: Different fragmentation structures in a typical 1 ha olive farm.

In this paper, in order to include the effect of structural factors on farm income we have calculated the excess cost resulting from the fragmentation and dispersion of agricultural parcels, so as to subtract it from the total revenue entering the farm. The cost due to fragmentation, defined as the number, shapes and sizes of the parcels, has been calculated according to the methodology described in Colombo and Perujo-Villanueva (2017a). The cost due to dispersion has been estimated using the methodology proposed by Perujo-Villanueva and Colombo (2017)[29].

The real estate value of the set of agricultural plots belonging to a farm can be calculated as follows:

[29] Colombo and Perujo Villanueva (2017a) demonstrate that the number and shapes of the parcels create inefficiencies in the various tasks involved in olive farming. This leads to an average increase in production costs of between 4.4% and 6.5%. These costs are higher in farms with small and elongated parcels. In addition, Perujo-Villanueva & Colombo (Perujo-Villanueva & Colombo, 2017) estimated that the increase in production costs due to parcel dispersion, in other words, the time wasted by the farmer in covering the distance between his/her different parcels is between 1% and 10% and is more significant in small farms than in large ones.

$$FV = \frac{TRIF_1}{(1+r_2)^1} + \frac{TRIF_2}{(1+r_2)^2} + \cdots + \frac{TRIF_n}{(1+r_2)^n} = \sum_{i=1}^{n\to\infty} \frac{TRIF_i}{(1+r_2)^i}$$

$$TRIF_i = \sum_{j}^{J} RIP_{ji} - (IF_i + ID_i)$$

Where FV is the real estate value of the set of agricultural plots that make up a farm; TRIF, is the sum of the income from all the parcels, including the costs resulting from fragmentation and dispersion. IF is the cost due to inefficiencies caused by fragmentation and ID is the cost due to inefficiencies caused by dispersion.

Clearly, the value for inefficiencies due to fragmentation and dispersion varies from one farm to the next due to their spatial structure and dimensions. In this paper the impact of fragmentation and dispersion is calculated by applying the average levels of fragmentation and dispersion for all the traditional olive farms in Jaén with more than one parcel, according to different sizes. The following size ranges: 0.1-1 ha, 1.1-5 ha, 5.1-10 ha, 10.1-50 ha and over 50 ha were chosen because they are the most commonly used in the bibliography for the olive sector. Lastly, as set out in Annex 1 of the ATLLUR, the final value of the land must take into account the specific location of the piece of land and apply, when applicable, a global correction factor.

$$FLV = FV * LF$$

Where FVL is the final value of the land in euros and LF is the global location factor defined as the product between the following factors: accessibility to the town or village, accessibility to economic hubs and location in places of high environmental and landscape value[30].

[30] The location factor value is not considered in this paper because it is specific to each parcel and/or farm and there are no data available to quantify it. The maximum value can be no more than 2 according to the rules for land valuation set out in the Land Act Hay (BOE, 2011).

5.4.6. RESULTS

The machine-workable traditional olive grove in the Province of Jaén covers an area of 448,831 ha. This land is distributed amongst 84,788 farms or smallholdings. The largest olive farm measures 849.99 ha and the smallest just 0.04 ha.

Table 12 shows the frequency of farms in terms of their size. It is clear that the olive production structure is highly fragmented. In the province of Jaén, the size range with most members is less than 1 hectare with (30.1%). 77.6% of the farms we analysed have less than 5 ha, and occupy only 26% of the total area of olive grove.

Source: Authors' elaboration.

Area	Number	%	Aver. Area	Total Area	Nº Plots
0.1 – 1 ha	25484	30.1	0.5	15223.5	1.4
1.01 – 2 ha	18515	21.8	1.4	26906.1	2.3
2.01 – 5 ha	21821	25.7	3.2	65380.0	3.5
5.01 – 10 ha	9727	11.5	6.9	60631.4	5.2
10.01 – 50 ha	8074	9.5	19.5	136588.5	7.4
>50 ha	1167	1.4	95.0	94339.6	11.1

Table 12: Farms by surface area. Characterization of farms on the basis of their size/area and the average number of plots that make them up.

The costs resulting from the inefficiencies due to parcel fragmentation and dispersion on farms with more than one plot (N=53972) are described in Table 13[31]. On these farms, the average inefficiency due to fragmentation for the province of Jaén is 14.7%, which results in an average cost of 100.8 €/ha, while the effect of dispersion is 190.1 €/ha.

[31] Obviously in the farms with just one parcel there are no fragmentation or dispersion costs.

Source: Authors' elaboration.

Area	Inefficiency due to fragmentation (%)	Average Dispersion (km)	Cost due to fragmentation (€/ha)	Cost due to dispersion (€/ha)	Total cost (€/ha)
0.1 – 1 ha	20.1	2.6	137.1	225.1	467.9
1.01 – 2 ha	16.8	4.0	114.9	227.9	342.8
2.01 – 5 ha	14.8	6.0	101.3	163.2	264.5
5.01 – 10 ha	12.6	8.5	86.5	106.6	193.0
10.01 – 50 ha	9.6	10.8	66.1	70.3	136.4
>50 ha	5.8	11.0	39.9	16.0	55.9

Table 13: Average cost of parcel fragmentation and dispersion in the province of Jaén (Spain). Determination of the penalization costs (fragmentation and geographic dispersion) according to the size of the farm.

The costs indicated in Table 13 refer to the average costs that the farms with more than one plot have to bear due to the fragmentation and dispersion of the plots, and depending on the size of the farm, the variable used in the process of valuation of rural estates. Figure 20 shows the regression between the area of the farm and the costs of fragmentation and dispersion (penalization costs). This ratio is exponential so illustrating that the impact of fragmentation and dispersion on the profitability of small farms is much greater than on medium-sized and large farms, where these problems are insignificant.

Source: Authors' elaboration.

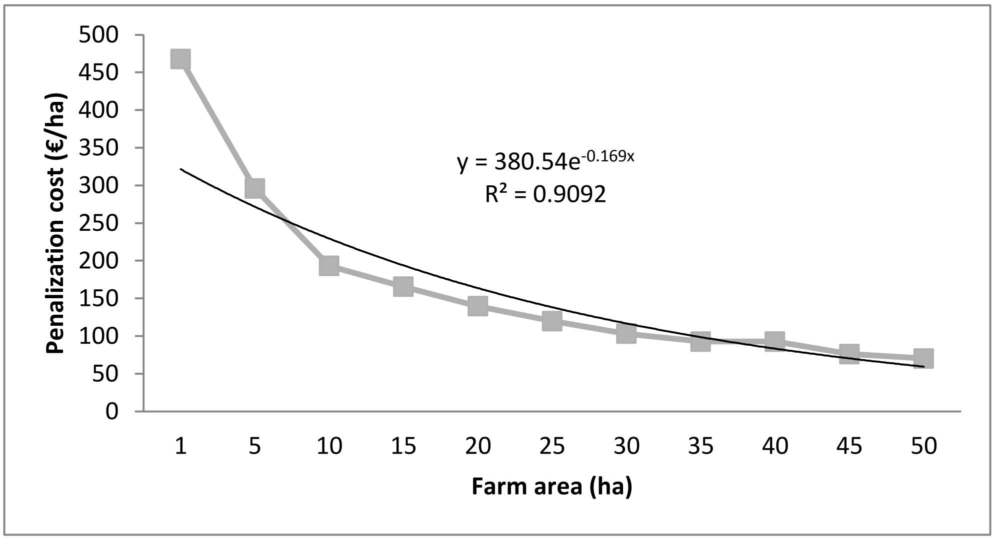

Figure 20: Correlation between the area of the farm and the penalization costs. Average values for the different size ranges.

The equation resulting from the regression can be used to calculate the reduction in income due to fragmentation and dispersion simply by knowing the size of the farm. However, each farm has different costs on the basis of its specific degree of fragmentation and dispersion. The exact figure for these costs can be defined using the methodology proposed by Colombo & Perujo-Villanueva (2017a) and Perujo-Villanueva & Colombo (2017). This is impossible without detailed information about each of the parcels that make up the farm, such as the shape and the geo-referenced location. Unfortunately, this information is often unavailable, or the calculation process is too complicated for the value interested in determining the income from the farm. In order to make a more accurate attribution of inefficiency costs, it is necessary to consider the average fragmentation and dispersion values for all the farms and assign costs on the basis of the degree of fragmentation and dispersion of each farm. In order to calculate the threshold marking whether the fragmentation and dispersion is high or low, we used the median of the number of plots in the case of fragmentation and of the distance between the plots in the case of dispersion. Taking the whole sample, for the 0.1 – 2 ha range, the median for the variable fragmentation is 2 plots while the median for dispersion is 2.8 km. This means that simply by observing the number of plots and the average distance, the valuer can attribute different inefficiencies due to structure. The results are those set out in Table 14. As an example, as in the previous example, for farms in the 0.1 – 2 ha range, with a low fragmentation, the penalization costs due to fragmentation are 74.4 €/ha and 102.4 €/ha as a result of dispersion. At the opposite end of the scale, if fragmentation is high, the costs are as high as 172.3 €/ha and 435.4 €/ha. In large farms however, the penalization costs are less significant and more homogeneous. The penalization cost of a slightly fragmented farm of over 50 ha is only 30 €/ha, while the same farm with high levels of fragmentation and dispersion would have penalization costs of 81.9 €/ha.

Source: Authors' elaboration.

Area (ha)	**Low fragmentation (€/ha)**	**High fragmentation (€/ha)**	**Low Dispersion (€/ha)**	**High Dispersion (€/ha)**
0.1 – 2	74.4	173.3	102.4	435.4
2.1 – 5	67.5	135.7	71.6	258.6
5.1 – 10	57.9	114.9	47.6	167.1
10.1 – 50	42.3	90.7	26.9	114.6
>50	26.2	53.7	3.8	28.2

Table 14: Penalization costs due to different levels of parcel fragmentation and dispersion by area range. Penalization costs increase in line with the increase in fragmentation and dispersion. In this table we can see that these costs are higher on smaller farms.

In order to calculate the income, it is necessary to know both the production costs and the revenue. The costs can be obtained from previous papers for the area ranges under consideration, such as the paper by Colombo et al., (2016) for farms of between 1 and 10 ha and the cost study by AEMO (Cubero & Penco, 2012) for 30 ha farms. In both cases the data obtained refer to rainfed land[32]. Revenue is estimated using average values for the area for production, prices and subsidies over the last 10 years[33].

[32] The study by Colombo et al. (2016) only presents the production costs for unirrigated olive groves.
[33] We considered a typical farm producing 3500 kg of olives per hectare with a 21% yield, a subsidy of 550 €/ha and a sale price of 2.4 €/kg. The total revenue would be 2,314 € per hectare.

For the sake of example, Table 15 shows the income from and real estate value of the agricultural plots that make up a typical farm in the study area. For 1 ha farms, the income is negative if certain tasks are outsourced and these farms are only profitable if the farmer resorts to family labour. This negative income means that the ‘income capitalization’ method is not the most suitable approach for valuing agrarian spaces with low or no profitability, given that the real estate value of land cannot be less than zero in any expropriation or land consolidation process. Secondly, for 10 ha farms, the value per hectare of 3,467.9 € is far below the market value. If the same piece of land were valued without considering the fragmentation parameters, the real estate value would be 7,951.2€ (a difference between the two valuations of 56.4%). If we analyse the data for 30 ha farms, the real estate value of the agricultural plots that make up the farm considering both the economies of scale and the penalization costs would come to 18,202.3 €, while today according to the methodology applied, the value we would theoretically obtain would be 20,748.2 €. This means that there is a difference of 12.3% between the two values.

Fuente: Source: Authors’ elaboration.

Area	**Cost €/ha**	**Cost fragmentation (€/ha)**	**Cost Dispersion (€/ha)**	**Total penalization cost (€/ha)**	**Annual income (€/ha)**	**Real estate value (ha)**
1 ha	2,457	124.6	276.4	400.9	-543.9	-14,086
10 ha	2,007	79.2	93.9	173.1	133.9	3,467
30 ha	1,512.9	56.1	42.1	98.3	702.8	18,202

Table 15**:** Calculation of the real estate value of the farm according to its size. This table shows the real estate values of farms according to their area and estimating the costs of fragmentation and dispersion.

5.4.7. DISCUSSION AND CONCLUSIONS

The valuation of farmland in Spain is conducted using the ‘income capitalization’ method for administrative procedures, which values the land according to its capacity to produce revenue. A realistic, accurate valuation is essential from a legal point of view as it has a wide variety of effects. For example for tax purposes (tax payable), expropriations (for calculating the amount of compensation payable to the owner), mortgages (the land must be valued before a mortgage can be approved) and even for sentence enforcement purposes (judicial sales). The success of the valuation lies in obtaining a value as close as possible to the real market price. The current configuration of the method analysed does not give real answers especially when valuing farms with more than one plot. For example, if we follow the current methodology, a 6 hectare farm made up of 3 two-hectare plots and a dispersion of 15 km would have the same value as a 6 hectare farm made up of 2 three-hectare farms with just a track running between them[34]. The market operates in a different way setting higher prices for more concentrated, less fragmented farms.

For a fair valuation of farmland, it is necessary to consider all the costs involved in the management of a farm without forgetting aspects which on certain occasions create large differences in farm accounts and therefore in the income to be used as the base value. In this paper we have noted the impact of structural variables on the farms (such as the size, fragmentation and dispersion of the plots that make up the farm) have on the real estate value of farmland, especially on small farms. The results show that economies of scale in production not only affect the profitability of the farm but also its real estate value. They also show that this effect is augmented by the fragmentation and dispersion of plots.

In order to maintain the real estate value of land it is essential to increase the size of the farms and reduce fragmentation into smaller and smaller plots. Various solutions include the reorganization of farms, the concentration of plots and even the implementation of measures that facilitate the purchase of adjacent plots so as to reduce fragmentation. These changes in the land ownership system would increase income from the land and therefore the capitalization of agricultural land and would boost the wealth of country areas. Another option would be shared management of the land, either through shared or assisted cultivation (Colombo & Perujo-Villanueva, 2017b). These options would also increase the

[34] The value could change if some of the parcels had different correction factors due to location. However this seems unlikely with the values established in the valuation rules set out in the Land Act (Ley del Suelo RD 1492-2011).

value of agricultural land. This means that public policies that encourage changes of this kind would also improve the capitalization of rural areas.

The objective of this research is to create a tool to enable the public administration and land valuers to adjust the real estate value of farms according to the degree of fragmentation, on the basis of simple variables such as the surface area, the number of plots and the distance between them. The methodology we propose is applied to the traditional olive grove but could also be used with other crops.

The information we have generated could be very useful for the public administration and for the owners of rural land in the processes of reorganization of territory in areas with very fragmented land ownership dominated by smallholdings. On the one hand the consideration of structural variables in the formation of income enables a fairer, more equitable valuation of the farmland in a particular area for those affected by processes of this kind. This could potentially increase the degree of confidence of those affected by processes of reorganization of land ownership and by extension their participation in these processes (Kupidura et al., 2014). Secondly the reduction in the real estate value of the fragmented farms could encourage owners of land to join their different plots together, so boosting the market for rural properties, which tends to be very static.

The information produced in our research could also be very useful in the design of future laws for the reorganization of farms, such as for example the forthcoming Andalusia Agriculture and Livestock Act[35]. The practical application of future laws must include penalization coefficients due to fragmentation and dispersion in different crops, which must be applied in land valuation processes in which at least two plots belonging to the same owner are involved. In situations in which the public administration is reorganizing the layout and ownership of farmland, the method for valuing the income produces a number of unknowns which must be resolved in the case of crops with a very low or zero rate of return such as the traditional olive grove. When the return is zero or negative the 'income capitalization' approach does not provide a quantity for the calculation of the real estate value of the land and this is normally calculated using a pre-established formula, capitalizing a theoretical income equivalent to one third of the minimum income of the land

[35] Preliminary Draft of the Andalusia Agriculture and Livestock Act of 11th October 2016.

in that particular area[36]. However, it is important to bear in mind that these agrarian systems provide society with a whole series of non-commercial goods and services (Gómez-Limón & Arriaza, 2011), which if properly valued would significantly increase their income and by extension their real estate value. For example, from a social point of view, if the impact of self-employment were to be taken into account in the formation of income, we would obtain very different results in our income calculation (Colombo et al. 2016). In this way crops with almost no real estate value from a professional perspective would have some value from a social perspective. Likewise, environmental considerations could be included in the estimation of income from traditional extensive farming after monetising the environmental externalities they originate (Villanueva et al. 2014; Arriaza et al., 2008; Colombo et al. 2006). Recent studies show that in the case of marginal systems such as the olive grove, the production of environmental goods could be prioritised to the detriment of commercial products, making the "environmental income" the main income for these systems (Villanueva et al., 2017). These aspects are an excellent basis for future research.

Future research must also analyze the impact of the subsidy from the Common Agricultural Policy on the income used in the 'income capitalization' method. These subsidies have a huge impact on the profitability of farms and on their real estate value. However, the uneven distribution of subsidies between farms causes large disparities in the valuation of the land regardless of their production capacity. Likewise, the gradual reduction of subsidies from the Common Agricultural Policy has led to a fall in rural wealth without a corresponding reduction in the production capacity.

This research has various limitations which must be considered when interpreting the results. Firstly, the complexity of applying the location factors proposed in the ATLLUR when the focus of the analysis is at a farm level rather than at a parcel level and given that different parcels may have different location factors. One possible solution could be to use the centroid of the farm as the point of reference (Latruffe & Piet, 2014) or to take as a reference the average distance from all the plots or from the plot with the largest area, establishing various standardization criteria (Marie, 2009). The impact of different farm

[36] Article 16 of the Valuation Regulations from the Land Act (Ley del Suelo RD 1492-2011).

location factors on the real estate value of these farms could be an interesting subject for future research.

Another limitation can be observed in the concentration, reorganization or expropriation processes affecting some but not all of the plots belonging to the farm. In these cases, the object being valued must be the group of plots affected by the particular procedure and not the whole farm. Finally, we would like to make clear that the maintenance of rural heritage is key for the future of Europe (food safety, environmental protection, supervision and care of rural territories, etc.). To this end public policies must plan tools that promote a system of agrarian ownership and management that increases the real estate value of farms and by extension the general welfare of rural areas.

5.4.8. ACKNOWLEDGMENTS

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5.5. FULLY CONNECTED PARCELS WITH THE SAME VALUE. A PRACTICAL METHOD FOR THE EX-ANTE EVALUATION OF LAND CONSOLIDATION INITIATIVES*

*Este artículo es copia literal del publicado en: Fully connected parcels with the same value. A practical method for the ex-ante evaluation of land consolidation initiatives. Land Use Policy, 81, 463-471.

5.5.1. ABSTRACT

Land consolidation is an important instrument open to public authorities seeking to achieve sustainable rural development, especially in countries where rural property is highly fragmented. As land consolidation projects are complex and costly, researchers have tried to better understand the concepts and improve the methodologies involved so as to ensure their success. In this paper, we propose a methodology for assessing *ex-ante* the most suitable areas in which land consolidation initiatives could be carried out. The land in these areas must have a similar per hectare value and must be fully connected, criteria that make land consolidation projects much easier to implement. The case study focuses on olive groves in the Andalusia region. Olives are a perennial crop with a very fragmented, static property structure. Previous land consolidation projects have often had poor results mainly because of the reluctance of the affected landowners to get involved, due to difficulties in ensuring that the land allocated to them in the consolidation process had the same value as the land they owned prior to it. Our results indicate that a land consolidation procedure in the areas identified would bring about a noticeable improvement in the property structure and production cost savings of between 5.8% and 15.3% depending on whether the farm is worked by the family or by hired employees.

5.5.2. INTRODUCTION

Land fragmentation is a problem affecting many rural areas in which farms are made up of many undersized, randomly scattered plots of land often considerable distances apart (Burton and King, 1982; McPherson, 1982). Although this is a generalized phenomenon throughout the world (Kesavan and Swaminathan, 2008), it has developed above all in those areas in which population pressure on agricultural land has been most intense throughout the course of history (Perujo-Villanueva and Colombo, 2017) as has happened in Europe (Petrescu-Mag et al., 2017; Jürgenson, 2016; Hartvigsen, 2016).

The division of farmland into several property units can have a negative influence on rural development leading to economic, social and environmental losses such as reduced agricultural productivity, rural depopulation, soil erosion and water mismanagement (Niroula and Thapa, 2005). In economic terms, it increases production costs by obstructing mechanization and causing inefficiencies in production (Tan et al., 2008; Hiironen and y Riekkinen, 2016; Colombo and Perujo-Villanueva, 2017a; Perujo-Villanueva and Colombo, 2017). Small-scale fragmented farms are often unprofitable, causing people to abandon rural areas which can then fall into decline. Other undesirable effects include a fall in the proportion of full-time, professional farmers, their increasing average age and their reluctance to invest in and modernize their farms (Burton, 1988). From an environmental perspective, the fragmentation of the natural system has been related to biodiversity reduction and soil erosion (Lisec and Pintar, 2005).

To counteract these effects, land consolidation (LC) measures have been proposed and extensively implemented over the last centuries in Europe (Vitikainen, 2004) and the rest of the world (Wang 1997, Niroula and Thapa, 2005, Lou and Timothy, 2017)[37]. It is one of Europe's core objectives in the global framework and has been an essential part of its agricultural policy (Lisec et al., 2014). Today, it is a useful instrument for improving and supporting rural productivity, livelihoods, quality of life and local ecology (Long, 2014).

Generally speaking, LC can be defined as the reallocation and exchange of privately-owned land combining adjacent plots owned by different farmers to form new holdings containing a single, or as few as possible, plot(s) with the same or similar value as the original areas (Oldenburg, 1990). There are four main approaches to land consolidation: comprehensive land consolidation, simplified consolidation, voluntary group consolidation and individual consolidation initiatives (FAO, 2003). The objectives, methodologies and procedures for applying these different approaches can also vary significantly between countries and cultures (Luo, W.B., Xu, F., Timothy, D.J., 2017). Generally speaking, LC can be defined as the reallocation and exchange of privately-owned land combining adjacent plots owned by different farmers to form new holdings containing a single, or as few as possible, plot(s) with the same or similar value as the original areas (Oldenburg, 1990). Under the comprehensive land consolidation approach, the reallocation of land is generally combined with a wide range of other post-consolidation initiatives to promote

[37] While in the European continent and Asia the tendency has been towards land consolidation, in many parts of Africa and South America, where most of the agricultural land was concentrated in the hands of a few rich landowners, the opposite has taken place. Governments have implemented land reforms in which large tracts of land are expropriated from the wealthy and redistributed to the rural poor.

rural development such as new infrastructure (roads, drainage systems, village renewal) and socio-environmental measures (support for community-based programs, erosion control schemes, designation of nature reserves etc.). For their part, simplified land consolidation projects arise from the need to reduce the economic and administrative burden required in a comprehensive land consolidation scheme (Muchová et al. 2017). In this case, LC seeks to combine a small number of adjacent plots. Minor improvements to local infrastructures and facilities are sometimes also made. The voluntary group consolidation initiative differs from the previous LC scheme in that participation is completely voluntary, with no element of compulsion by the public authorities, which can however offer incentives to encourage farmers to take part. These LC initiatives are typically carried out in small-scale projects involving about 30-100 participants (FAO, 2003). Finally, individual consolidation schemes take place informally between individuals. These kinds of initiatives are privately promoted and are usually based on the shared use of resources and facilities rather than on re-arranging the property structure (Colombo and Perujo-Villanueva, 2017b). Although there is no direct public involvement in these schemes, public authorities may encourage them with a range of incentives (FAO 2003) o encourage joint acquisition of machinery, joint service contracting and so on.

Regardless of how they are accomplished, LC projects are costly rural development actions whose performance must be evaluated (Lu et al., 2018). Evaluation can take place at different stages of the project; before (*ex-ante* evaluation), during the execution (ongoing evaluation) or after completion (*ex-post* evaluation). Recent research has tended to focus on the *ex-post* evaluation of LC projects (Hiironen and Riekkinen, 2016; Janus and Markuszewka, 2017; Muchová et al. 2017) to determine whether the resulting benefits exceed the costs incurred. Results show that LC has been successful in most cases, even when only purely economic outcomes are considered[38]. Fewer studies have focused however on *ex-ante* analysis of LC projects (Lu et al; 2014; Zhou et al. 2017), despite the fact that this stage is essential for ensuring the success of the LC process (Sklenicka, 2006).

[38] Hiironen and Reikkinen (2016) point out that indirect and environmental impacts are not included in the analysis although they are expected to be positive and to increase the benefits of the LC project.

With this in mind, in this paper we carry out an ex-ante evaluation of the LC process in the Andalusia region of southern Spain, focusing particularly on the olive-farming sector as a case study. Despite the highly fragmented system of ownership in this sector in Andalusia, previous land consolidation projects have proved unsuccessful. Given that the most complex stage in the land consolidation process and the one that raises most concerns is the reallocation of the land as fairly as possible (Lisec et al., 2014; Muchová et al., 2017), the main objective of this research is to propose a methodology for identifying homogeneous areas where land consolidation initiatives could be carried out, limiting as far as possible the need for any monetary transactions. To achieve this goal it is necessary firstly to take into account the point of view of the landowners affected by it and secondly to ensure that the land consolidation process only reallocates "very similar" plots. With this in mind, we began by carrying out a survey of landowners in the study area in order to find out what they considered to be the main obstacles that might discourage them from taking part in a land consolidation initiative. We then turned our attention to identifying fully connected areas with the same value (FCASV). These areas are typically composed of the same kind of olive groves in terms of value (e.g. land with the same morphological, edaphic and structural conditions that lead to the same productivity per ha) and must be free of any spatial obstacles that might obstruct the LC process (e.g. streams, roads, ravines, etc.). If these conditions apply, adjacent fragmented olive groves could easily be combined and managed as a homogeneous single unit. In areas of this kind the reallocation phase should therefore pose fewer problems and raise less controversy amongst affected landowners. Therefore, this paper aims to contribute to the existing literature in two ways: firstly, by providing methodological insights into the use of the ex-ante evaluation approach as a tool for identifying suitable areas from the landowners' perspective in which to carry out land consolidation processes; and secondly, by providing evidence of the benefits to be gained from carrying out land consolidation initiatives in the olive groves, despite the failure of previous attempts. To achieve these objectives, we offer data from a survey of landowners' opinions regarding the main hurdles that might prevent them from participating in a land consolidation project and carry out cartographic analysis to map the most suitable areas.

The identification of FCASV offers several advantages to guarantee the success of farmland consolidation projects. First, there is no, or only very limited, need for post-consolidation measures. Post-consolidation development has often involved higher costs than re-parcelling (Janus and Markuszewska, 2017) and thus should be avoided when possible, especially within a policy framework characterised by continuous cuts in government spending on agriculture. A second advantage is that as the plots subject to consolidation all have a similar value, their exchange in the reallocation phase is unlikely to lead to objections by affected farmers. This is paramount in the case of perennial crops such as olives, in which different agricultural systems (traditional in sloping areas, traditional, intensive and super-intensive, each either rainfed or irrigated) are often spatially intertwined. Parcels from different systems are difficult to exchange not only because the land value is very different but also because the farming methods and the machinery needed vary greatly. Farmers would therefore be highly unlikely to accept the exchange for example of modern, intensive olive groves (high density and younger trees) for more traditional, less productive ones (low density and very old trees). Thirdly, the success of LC depends largely on the satisfaction (Yaslioglu et al., 2009; Kupidura et al., 2014) and active participation of farmers (Lisec et al., 2014). FCASV initiatives are better positioned in this context in that they are easier for farmers to understand and to accept, given that the parcels involved have similar value and conditions. Fourthly, because in the case of olive groves there is evidence that just by reducing parcel fragmentation and dispersion (i.e. without any other post-consolidation measures), very significant economic gains can be achieved, especially by smaller farms (Colombo and Perujo-Villanueva, 2017a; Perujo-Villanueva and Colombo, 2017). Finally, the complete connection of the parcels avoids the creation of isolated plots or "debris" after the consolidation.

One drawback of the use of FCASV is that it restricts LC projects to smaller areas, given the spatial and structural constraints used to define them. Thus, FCASV is more suitable for simplified consolidation projects and voluntary group consolidation initiatives. However, these "small" actions have spill-over effects that can increase the positive effects of land consolidation. They become "pilot" areas where the results of land consolidation can be demonstrated and explained to a broader audience. This may help to improve the acceptance of larger land consolidation projects where comprehensive initiatives can encompass several FCASV. They also increase farmers' awareness of the negative economic and social impacts of land fragmentation, which can trigger positive changes for the social economy (Burton, 1988) by encouraging farmers to cooperate via individual cooperation schemes that may further contribute to increase the competitiveness of small farming (Colombo and Perujo-Villanueva, 2017b).

The article is structured as follows: we begin with a brief introduction to the institutional framework and the current situation of land consolidation projects in Spain. We then describe the study area in order to demonstrate why land consolidation schemes are required there. After that we move on to describe the methodology. In the final section we present the results and discuss them in order to obtain a set of practical conclusions that could enable us to increase the competitiveness of olive groves in an area in which their very survival is at risk, due to the high degree of spatial fragmentation.

5.5.3. LAND CONSOLIDATION IN SPAIN

In Spain land consolidation is considered as a form of agrarian reform aimed particularly at the modernization of farms and their structure. Although parcel fragmentation is an age-old problem, the first decisive, land consolidation processes did not take place until the mid-twentieth century with the Land Consolidation Act (*Ley de Concentración Parcelaria*) of 1952. This was much later than in other countries in which the public authorities have been implementing land consolidation processes since the 18th and 19th centuries (Liss, 1987).

This law was intended to be provisional and experimental, based on the assumption that the changes it involved would be unpopular in rural areas, and that consolidation projects should therefore be accompanied by propaganda and information campaigns aimed at reducing mistrust and resistance to change (García de Oteyza, 1953).

The results of the land consolidation processes in Spain have varied a great deal in different parts of the country. The consolidation projects executed between the 1950s and the mid-1980s[39] highlight that there are regions in the north and centre of Spain such as Castilla León and Castilla La Mancha, in which very significant swathes of land have been

[39] In the mid-1980s, powers and responsibilities in agriculture were devolved to the Regional Governments. The resulting dispersion of information makes it very difficult to make reliable comparisons of the data on land consolidation.

consolidated (3.6 and 1.3 million ha respectively). In other regions, however, land consolidation has been merely symbolic. This is what has happened in Andalusia (southern Spain) which in spite of being Spain's largest region has only consolidated 40,000 ha (0.7% of the total area consolidated in Spain). These regional disparities may be due to the predominance of annual crops in the centre and north of Spain in which the exchange of agricultural parcels is easier compared to areas with complex topography or farming systems, as is the case of the perennial crops (olives, almonds etc.) typical of the Mediterranean regions (Fernández García, 1992). The devolution of the powers over agrarian management and reform to the regional governments did not bring about significant changes in the trend of land consolidation processes in Andalusia, in which projects for the reorganization of agrarian land ownership have been almost non-existent since 1984.

Nowadays, in Andalusia, land consolidation projects are subject to the rules set out in the Agrarian Reform Act of 1984 (Ley 8/1984, de 3 de Julio, de Reforma Agraria). This regional law encourages the concentration of land ownership, enabling land consolidation projects to be initiated at the behest of either the public administration or the landowners involved[40]. We must therefore conclude that the relative insignificance of these processes in Andalusia is not due to legal or institutional problems but to the very conditions of the crops themselves (perennial crops are difficult to farm and only offer returns in the medium to long-term) the orography of the territory (hilly and mountainous) and the possible resistance of the rural population (Maceda Rubio, 2014).

5.5.4. STUDIED AREA

Our study centres on the traditional olive grove in the province of Jaén, one of the world's most important olive-producing areas. The olive grove is the most typical agro-system in Andalusia and is considered by the public authorities as a strategic sector. There are approximately 1,500,000 ha of olive groves in Andalusia, 60% of the total area in Spain and 30% in Europe as a whole (CAPDR, 2015).

[40] The procedure for consolidation on the basis of the public utility of farms can be initiated at the request of any number of landowners to whom the majority of the parcels subject to the consolidation process belong (art. 48).

There are 551,191 ha of olive groves in our study area, representing 94% of its total agricultural area. Traditional olive groves occupy 448,831 ha (83%) and typically have a very high fragmentation of ownership in which 63% of the parcels cover less than 1 ha and 94% less than 5 ha (Colombo & Perujo-Villanueva, 2017a). The average farm has an area of around 5 ha and typically has more than three parcels and a geographical dispersion between them of 6.3 km (Perujo-Villanueva & Colombo, 2017). 54.3% of the olive groves in the study area are rainfed and are concentrated in the steepest-sloping areas in the west of the province. Irrigation is more common in more fertile, flatter land (above all in the valleys) occupying a slightly lower percentage than rain-fed. The average tree density in this province is 116 olive trees/ha.

In spite of its high significance in quantity terms, the traditional olive grove is immersed in a deep crisis due to high production costs and severe high fragmentation and atomization of ownership. These high production costs put the continuity of this crop at risk, especially on small farms (Colombo & Camacho Castillo, 2014). Possible solutions for increasing the return from these farms include cooperation and land consolidation (Colombo & Perujo-Villanueva, 2017b).

5.5.5. METHODOLOGY

We interviewed 72 landowners in the study in order to assess their views and attitudes towards land consolidation projects. The interviewees were asked whether they regarded land fragmentation as a problem and to offer their opinions about land consolidation as a method for improving or solving it. They were then asked about the main hurdles that would discourage them from taking part in a land consolidation initiative and about what could be done to reduce the uncertainty and doubts they might have. A binary logit model was used to determine which socioeconomic and/or structural factors were most influential in the landowners' decision to take part in a land consolidation initiative.

The information on which we based the definition of the FCASV was taken from a previous paper on the characterization of the olive grove in the province of Jaén (Colombo & Perujo-Villanueva, 2015). This article characterized the different olive production systems according to the three variables most commonly used to calculate the value of the land: 1) tree density (per ha), currently used to differentiate between the traditional, intensive and super-intensive forms of plantation; 2) crop regime, whether rainfed or irrigated; and 3) average slope, currently used to differentiate between olive groves that can be mechanized and those that cannot.

The above classification enables us to identify olive groves of similar value in which the implementation of land consolidation initiatives would create less controversy amongst the affected farmers. Within these areas, we focused on traditional olive groves (rainfed or irrigated) in which machinery can be used because we believe they are the most suitable for land consolidation projects. There are many reasons for this choice. First of all, the importance of this type of olive grove for rural development and in the economy of the province. The traditional olive grove generates almost 90% of final agricultural production. From a social point of view, the province of Jaen creates most employment in the olive sector with a total of 6.7 million days' work, 35.2% of the total number of days worked in the olive sector in Andalusia (CAPDR, 2015). Secondly, the high degree of fragmentation of ownership such that the average parcel covers only 1.7 ha (Perujo-Villanueva & Colombo, 2018a). Thirdly, the high costs of fragmentation and dispersion (Colombo & Perujo-Villanueva, 2017a; Perujo-Villanueva & Colombo 2017), which reduce the profitability of these farms and put their survival at risk particularly in the current context of reductions in EU grants and subsidies and the younger generation's apparent lack of interest in farming (Colombo & Perujo-Villanueva, 2015).

In addition to having the same value, it is also important for the selected area to be completed connected, such that there are no natural or artificial barriers (rivers, roads, ravines) that might obstruct the reorganization of the space in a hypothetical process of land consolidation due to the refusal by those involved to accept more fragmented land than that already owned. Figure 1 illustrates the process we followed. In the first step we identified a homogeneous portion of the territory in which there are no structural impediments to agricultural use, i.e. a continuous piece of land (Area A in Figure 21). Within this area, we categorized the subareas made up of the same kind of traditional olive orchards (subarea 1 and subarea 2 irrigated orchards and subarea 3 rainfed), each one composed of several parcels and a range of owners. These subareas are FCASV and thus "ideal" for land consolidation initiatives.

Source: Authors' elaboration.

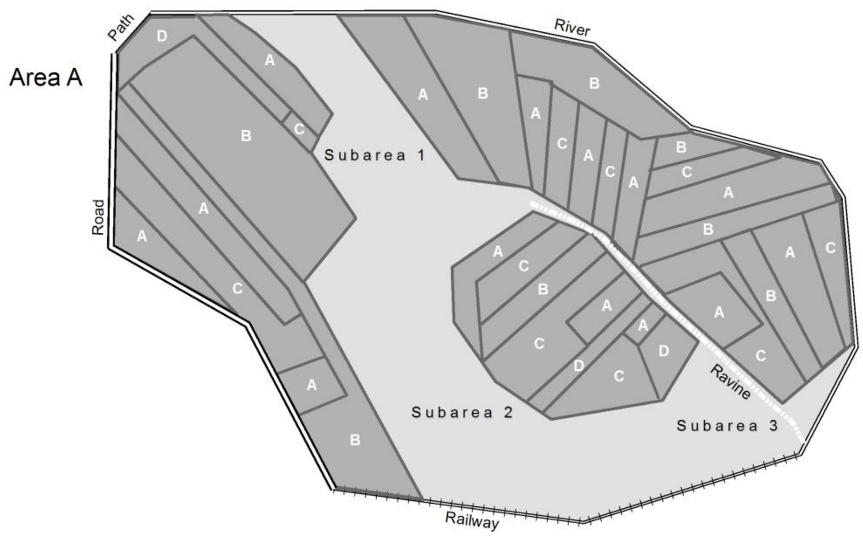

Figura 21: Zona delimitada por infraestructuras e hitos naturales donde existen tres subgrupos continuos.

In each homogeneous area we calculated the number of plots, the number of owners affected and the possible benefits from the land consolidation process, such as the reduction in fragmentation, the increase in plot size and the savings in operating costs. These savings are quantified by applying the methodology proposed by Colombo and Perujo-Villanueva (2017) for calculating the costs due to inefficiency in production (perimeter/area ratio) and by Perujo-Villanueva and Colombo (2017) for the inefficiency due to parcel dispersion (distance between fields). Figure 22 presents the ex-ante (Figure 2.a) and ex-post (Figure 2.b) situation of a typical FCASV.

Source: Authors' elaboration.

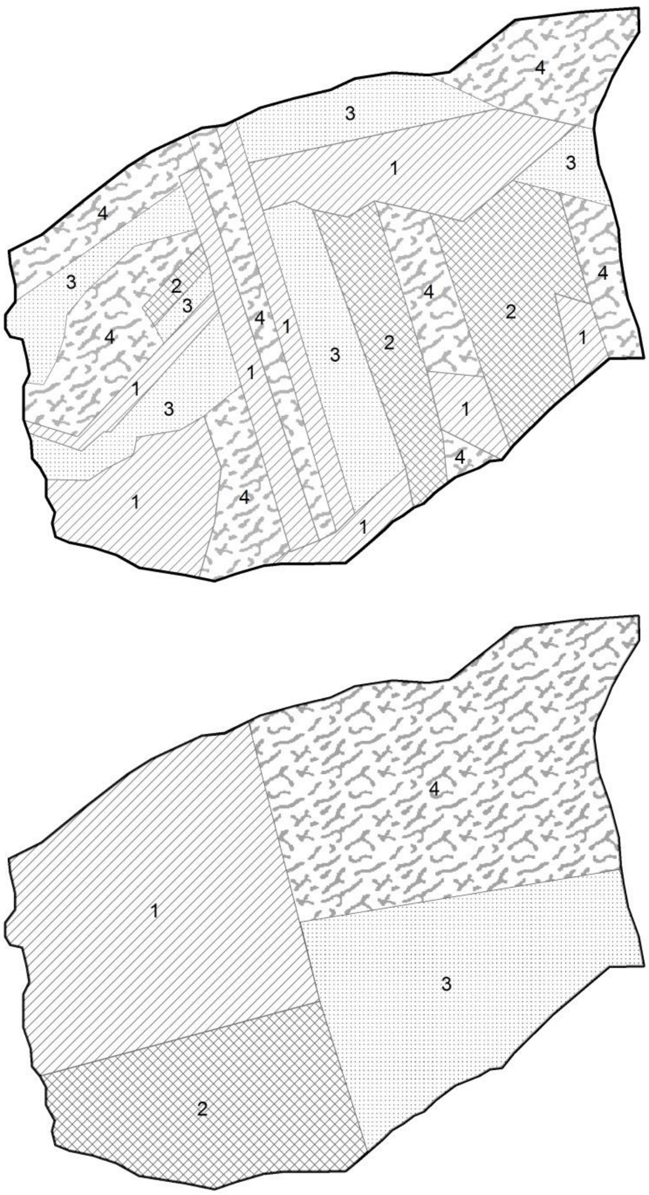

Figure 22: Ex-ante and ex-post parcels distribution in a real FCASV.

In this example the number of parcels would reduce from 8 to 1 for farmers 1 and 4, from 6 to 1 for farmer 3 and from 3 to 1 for farmer 2. At the end of the process, all the farmers have the same area as at the beginning. The reduction of fragmentation creates obvious production cost savings due to improved efficiency in carrying out typical farm jobs such as ploughing, spraying, harvesting etc. on one large plot rather than 6 or 8 small ones and the savings in time and money resulting from not having to travel between separate, often distant fields.

In order to avoid the selection of very small areas in which a limited number of farmers are involved in the re-parcelling, we further constrained the identification of FCASV to areas in which the parcels were owned by at least 20 farmers. Additionally, we focused on highly fragmented areas in which the reallocation process would bring about a minimum reduction of 50% in the number of parcels. These values were chosen by the authors according to previous work on farmers' cooperation in the study area. In particular, Colombo and Perujo-Villanueva (2017) suggest that when few landowners are involved, fully private initiatives such as assisted cooperation or shared cooperation schemes should be applied to reduce the negative effects of land fragmentation. In contrast, when cooperation projects must involve large numbers of farmers, other instruments managed by the administration (such as land consolidation projects) are preferable. The criterion of a 50% reduction in the number of parcels is to identify the areas where LC initiatives can provide important benefits. These thresholds can be modified easily by analysts according to the specific situation in each FCASV, such as the number of parcels and farmers involved, the number of farmers willing to participate in the process or the available budget for post-consolidation measures.

5.5.6. RESULTS

The results of the survey reveal that the vast majority of landowners (72.2%) consider land fragmentation as a problem. When asked whether they would participate in a land consolidation initiative, 75% of the interviewees declared that they would. However, 81% of these stated that their participation would depend on the conditions of the plots exchanged. The results of the binary logit model (which classified 71% of the responses correctly) showed that the main criteria underlying the decision to take part in a land consolidation initiative were "opinion about land fragmentation" and "importance of agricultural income in total income". Thus, the landowners most likely to participate are those who feel that land fragmentation is the most important problem for efficient land management and those whose income depends above all on agriculture. Other socioeconomic (age, sex, education, etc.) and structural variables (farm size) had no significant influence on the decision to take part in initiatives of this kind. The main hurdle to participation was their concern that the new plots would be of poorer quality than those they had previously owned in terms of value and location.

It is interesting that 30% of the respondents who declared that currently they would not participate in a LC initiative stated that they might be prepared to do so in the future. The majority of respondents also expected to achieve significant savings from the LC process. Specifically, less than 10% of the sample stated that they did not expect any savings, whilst 71% thought that production costs would be reduced by between 10% and 20% and the rest by more than 20%. These results demonstrate the excessively conservative stance of the traditional olive sector regarding innovation and change in the land ownership structure, even when these changes are expected to benefit the economy. Olive growers tend to put off "structural changes", perhaps waiting for others to embark on processes of this kind before getting involved themselves (Parra-López et al. 2007). This confirms the respondents' opinion that the best way to remove any doubts regarding the benefits of the land consolidation initiative would be for successful pilot projects to be conducted in the area.

The cartographic analysis initially identified 3544 FCASVs covering 42,704 ha of traditional olive grove. The mean area of each FCASV was 12.0 ha and, on average, each one had 9.3 parcels and 7.3 owners. After the application of the constraints for the number of owners (min. 20) and the reduction in the number of parcels (min. 50%), the number of FCASVs fell sharply to just 28, although the area involved fell less dramatically to 14,076 ha. These FCASVs had an average total size of 502 ha and contained 329.3 parcels and 192.2 owners. Within this group, there were some very small FCASVs (25% had less than 50 ha) in which simpler cooperation measures could be used to reduce land fragmentation, as proposed by Colombo and Perujo-Villanueva (2017b). In the rest, land consolidation initiatives could be used to reorganize farm plots more efficiently. It is worth pointing out that given that the parcels in these areas are fully connected and have the same value, parcel re-allotment should be straightforward, with only minimal, administrative costs for the public sector6. In the same way, the complete connection between the plots and the absence of any obstacles mean that no parcel "debris" is produced in the reallocation, so that each owner will receive the same area of land as they owned prior to consolidation. Finally, they respond to the main concerns raised by landowners regarding possible obstacles that would discourage them from taking part in a land consolidation initiative.

Table 16 summarizes the main features of the 28 FCASVs we identified. In all of these situations, a land consolidation procedure would bring significant benefits in terms of both the reduction in the number of parcels and an increase in the average parcel size. On average, the number of parcels is reduced by 84.3% (column 5) while the average size of the parcels increases by 73.9% (column 8). The better spatial distribution of the land reduces production costs by between 82 €/ha and 174 €/ha (average 119 €/ha), which represent savings of between 5.8% and 15.3% for the average farm size in the study area, depending on whether the farm is worked by the family or using externally contracted labour[41]. Most of these savings result from improved efficiency from working fields with fewer borders (81%), given that the parcel dispersion within the FCASV is low (9%). The savings from reduced parcel dispersion are most significant in the largest areas. It is important to emphasize that even owners with just one parcel in the area benefit from the land consolidation procedure, as their new olive grove will be squarer, so improving the perimeter/area ratio and reducing the costs arising from the border effect (Colombo and Perujo-Villanueva,2017a)

[41] According to Colombo et al., (2016), the production costs of a family-run 5 ha olive grove come to 778 €, while when run as a business with employed labour they amount to 2,054 €.

Source: Authors' elaboration.

N	Area (ha)	N parc Ex ante	N parc Ex post	Reduct N parcels (%)	Mean parcel size Ex ante (Ha)	Mean Parcel size Ex post (Ha)	Parcel Size Increase(%)	Savings for Border effects (€/ha)	Savings for parcel dispersion (€/ha)	Total savings (€/ha)
1	3684	2137	1189	79.7	1.7	3.1	88.4	98	32	130
2	2630	1242	781	59.0	2.1	3.4	61.9	66	30	96
3	1352	929	566	64.1	1.5	2.4	60.0	141	33	174
4	1288	1018	553	84.1	1.3	2.4	84.6	100	29	129
5	967.2	903	529	70.7	1.1	1.8	63.6	105	37	141
6	709.5	439	258	70.2	1.6	2.7	68.7	89	20	109
7	569.4	570	369	54.5	1.0	1.5	50.0	110	12	123
8	534.1	203	106	91.5	2.6	5.0	92.3	96	4	100
9	510.3	458	261	75.5	1.1	2.0	81.8	100	28	128
10	464.6	115	66	74.2	4.0	7.0	75.0	79	3	82
11	207.3	141	65	116.9	1.5	3.2	113.3	104	8	112
12	138.0	85	51	66.7	1.6	2.7	68.7	90	1	91
13	115.7	78	47	65.9	1.5	2.5	66.7	97	2	99
14	109.1	106	66	60.6	1.0	1.7	70.0	82	4	87
15	105.6	63	33	90.9	1.7	3.2	88.2	160	1	160
16	105.0	122	75	62.6	0.9	1.4	55.6	119	8	127
17	94.6	49	25	96.0	1.9	3.8	100	93	2	95
18	87.0	68	43	58.1	1.3	2.0	53.8	97	3	100
19	77.8	50	33	51.5	1.6	2.4	50.0	105	1	107
20	64.5	92	54	70.4	0.7	1.2	71.4	117	7	124
21	58.9	77	40	92.5	0.8	1.5	87.5	140	7	148
22	43.4	42	26	61.5	1.0	1.7	70.0	101	1	103
23	31.5	33	21	57.1	1.0	1.5	50.0	107	2	109
24	28.8	34	20	70.0	0.8	1.4	75.0	133	7	140
25	28.8	37	23	60.9	0.8	1.3	62.5	112	3	115
26	27.8	56	35	60.0	0.5	0.8	60.0	134	12	146
27	22.3	36	23	56.5	0.6	1.0	66.7	143	3	146
28	20.4	37	24	54.2	0.6	0.8	33.4	125	4	129

Table 16: Description of the HIVVCA.

Up until now, we have only considered "pure" FCASV in the sense that we limited our target group to fully connected areas containing parcels with the same "type" of olive grove. These constraints are necessary to ensure that the land has the same value so as to avoid the landowners having to compensate each other, something which often gives rise to disputes. However, if we assume that either financial compensation or post-consolidation measures can be used to make up for the difference in the value of the parcels exchanged, it would be possible to relax some of the constraints and create larger FCASV. For example, if we assume that the land consolidation process also includes post-consolidation work for the restructuring of the irrigation system, in such a way that after the consolidation process all the parcels are irrigated, it would then be possible to consider largely irrigated areas that contain a few rainfed parcels as FCASV[42]. The higher the percentage of rainfed parcels permitted, the larger the number of areas that can be classified as FCASV in which land consolidation processes can take place, although this would logically involve greater costs in post-consolidation due to the need to convert rainfed land into irrigated land. For illustrative purposes, Figure 23 shows the results of the relaxation of the same value criterion, so permitting the presence of 10% of rainfed olive groves in an irrigated FCASV. Figures 3a and 3b show the resulting FCASVs when 0% and 10%, respectively, of rainfed parcels are allowed in the irrigated FCASVs. The area covered by olive groves in the province of Jaén appears in grey, while the FCASV are shown in black.

[42] Under the initial FCASV classification system, the presence of a single plot of rainfed land within a set of plots of irrigated land breaches the same value criterion and divides up the FCASVs. According to data published by the Ministry of Agriculture and Fishing of the Regional Government of Andalusia (CAPDR, 2015) the price per hectare of irrigated olive grove is approximately double that of rainfed.

Source: Authors’ elaboration.

Figure 3a

Figure 3b

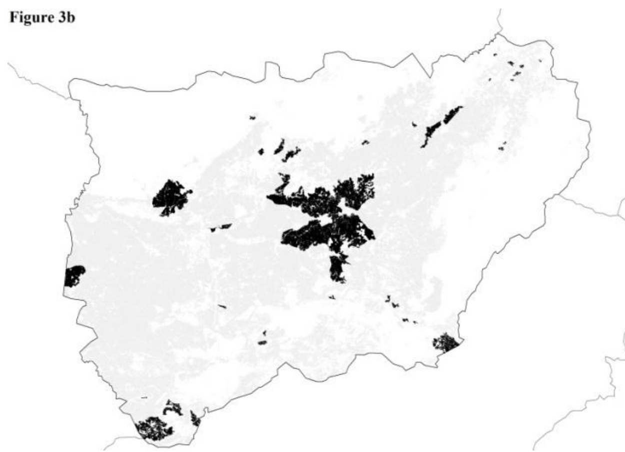

Figure 3c

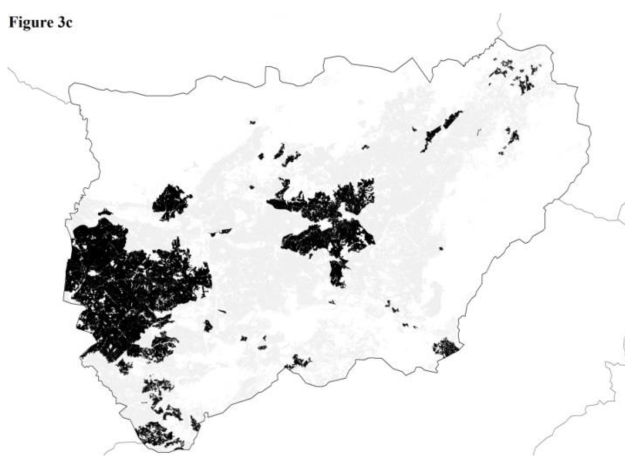

***Figure 23*:** HIVVCA areas accordig to different defree of homogeneity in value.

The surface area included in the FCASV increases significantly if we accept the presence of up to 10% of rainfed parcels in irrigated FCASVs. In this scenario the area of the FCASV increases to 59644 ha (323%) as does the size, number of parcels and number of owners. On average the FCASVs have a surface area of 1192 ha and are made up of 798 parcels and 361 owners. The average size of the plots ex-antes is 1.8 ha while ex-post it is 3.3 ha, an increase of 83.3%. This could also apply in the opposite situation i.e. in the FCASVs with a majority of rainfed fields and a small number of irrigated plots. In spite of being theoretically equivalent to the previous hypothesis, this hypothesis is less likely to be put into practice given the fact that it would probably be rejected by a large number of farmers. Those who have rainfed fields would have no objections about taking part in a land consolidation process in which they could be allocated irrigated fields, but those who have irrigated land would not be prepared to exchange it for rainfed fields, even if they were to receive some kind of payment in compensation[43]. However, assuming that the administration were to carry out a consolidation process in these areas, paying compensation to those landowners who exchange irrigated plots for rainfed ones, the area of the FCASV would be significantly increased. Figure 23c shows the resulting FCASV if this hypothesis were also to be included. The total area increases considerably to 168,025 ha (37.4% of the total surface area of machine workable traditional olive grove). In this case the average reduction in the number of parcels would be 132.2%, increasing the average size of the parcel from 1.8 ha to 3.2 ha (77.8%).

Due to the substantial increase in the size of the plots and the reduction in their number, the savings in terms of production costs are more significant when the conditions are relaxed in these areas, even though they have to be set against the post-consolidation costs incurred in converting rainfed into irrigated land. The calculation of these costs lies beyond the scope of this article as it depends on the specific actions required in each FCASV.

[43] There are numerous reasons why farmers would oppose such a change. Some of them are of a psychological nature, such as an aversion to losses, while others have sociocultural origins. The irrigated olive grove is considered an indefinite source of “income” for the future, while there is much more uncertainty about the future of rainfed land.

5.5.7. DISCUSSIONS AND CONCLUSIONS

The fragmentation of land ownership is an obstacle for the efficient management of farms. This is particularly true in the case of small farms in which the costs of fragmentation are very significant, sometimes to the extent of making them unprofitable, causing the owners to abandon the land, especially in crops with low margins such as the traditional olive grove.

One way for the public administration to reduce the fragmentation of land ownership is through land consolidation. This is based on the reorganization of ownership so as to ensure a more efficient production structure. Land consolidation is a complex, costly and sometimes controversial process, whose results must be carefully evaluated so as to avoid wasting public money. The ex-ante assessment of the land consolidation process enables those involved to identify the areas in which the probabilities of success of such initiatives are higher, in this way ensuring a more efficient management of the public funds used for this purpose.

In this paper we propose a methodology for identifying areas with a similar value which are perfectly connected. For this purpose, we studied the traditional olive grove in which the implementation of land consolidation projects would bring important benefits for those involved with only minimal costs for the administration. This factor is particularly important at a time of budgetary constraints and increasing restrictions on the subsidies and grants available via the Common Agricultural Policy in recent decades. It is also important to remember that land consolidation processes are temporary and are subject to a contrary process of re-fragmentation which puts the long-term viability of land consolidation in doubt. According to Lisec (2016), in Finland it has taken about a century for the property structure to become fragmented again after a consolidation process. Thus, costly consolidation initiatives should be carefully evaluated over a long timeframe. Given this situation, one possible way of extending the lifespan of the LC process would be by reforming the inheritance system in such a way as to reduce the number of heirs entitled to a share of the property on the death of the owner (FAO, 2003), or to limit the extent to which a property can be fragmented (minimum area) (Perujo-Villanueva and Colombo, 2018a).

In the case study analysed in this paper land consolidation would produce significant cost savings. If we take into account the effect of the changes in both the size and the shape of the plots (ex-antes and ex-post) and a reduction in the number of plots (less dispersion) with average cost savings of 119 €/ha. The resulting farms will be more profitable and efficient, increasing both their incomes and their real estate value[44] and in general bringing greater prosperity to rural areas.

The restrictions imposed by the methodology in terms of the criteria with which the areas must comply in order to be considered suitable (same value and full connection between the different plots) significantly reduce the potential area in which land consolidation projects can be applied. However, the relaxation of these restrictions would enable us to increase the area that could be covered by these processes. The relaxation of these restrictions would involve some post-consolidation expenditure, which would have to be evaluated taking into account the available budget in each specific situation and comparing it with the resulting benefits from the land consolidation process. The quantification of these costs in line with the relaxation of the different criteria is beyond the scope of this article and would be an interesting subject for future research.

The homogeneity of the areas identified also has the potential to increase the acceptability of land consolidation processes amongst those affected as there is a clear aversion amongst farmers to losses even if they are compensated (Kahneman, 2003). Reducing as far as possible the need for the different parties involved to compensate each other financially is therefore a fundamental requirement for increasing social acceptance of land consolidation processes. In the initial phase, the distribution of the consolidated land is one of the main concerns of the farmers (Lisec et al., 2014). Future studies must analyse the opinions of farmers and propose ways of increasing the comprehension and acceptance of farmers of schemes of this kind.

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[44] In Spain, the real estate value of land is calculated for official purposes using the income capitalization method, such that the more profitable the land, the higher its real estate value (Perujo-Villanueva and Colombo, 2018b)

Although this study is based on olive groves, the methodology can be applied in other crops and farming contexts. It is particularly applicable to other perennial crops, which tend to have a more rigid productive structure than annual crops. It would also be a good idea to carry out pilot projects in the areas identified as suitable for land consolidation. Assuming they were successful, these pilot projects would create a showcase for the benefits of land consolidation, so increasing its social acceptability. The authors believe that if these beneficial effects (removal of fences, hedges, walls etc between fields and of tortuous tracks, increase in the size of the fields) were made visible to farmers, together with the low costs involved (little or no monetary compensation payable between farmers) and a favourable legislative framework[45], pilot land consolidation projects in FCASV could encourage farmers themselves to present their own schemes. This means that farmers must be involved in the land consolidation process right from the beginning, so as to ensure the maximum possible consensus (LEADER approach). It is therefore necessary to implement a quicker, simpler administrative procedure to enable those involved to start working on their new properties as soon as possible. The European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI initiative) appears to be an excellent framework for the implementation of pilot projects using bottom-up approaches (EIP-AGRI, 2014). Future research must concentrate on the legal and institutional aspects of land consolidation processes which obviously vary from one country, and indeed from one region, to the next.

As well as making farms more efficient and productive, land consolidation can also bring social and environmental benefits. Burton (1988) observed several social and psychological changes triggered by land consolidation process in Cyprus, such as greater involvement of farmers in the agricultural sector, increase in the number of younger farmers in agriculture and improvement in farmers' social status. It would also be interesting in future research to try to quantify the positive impact in environmental terms of land consolidation processes, which although they are widely acknowledged are not normally properly evaluated (Hiironen and Reikkinen, 2016)

[45] The Andalusia Agriculture and Livestock Act (Regional Government of Andalusia, 2018) proposes the reorganization of agricultural holdings so as to create larger, better structured new farms.

Land consolidation does not solve the problem of small farm size but it does reorganize ownership in such a way as to make it easier for farmers to work together in the future, in that it reduces the number of neighbouring farmers with which it is possible and convenient to cooperate. In this sense, land consolidation can also be considered a complementary instrument to possible future measures aimed at encouraging cooperation between farmers. Future studies must analyse the possible beneficial links between land consolidation processes and cooperation, policies that would appear to be complementary rather than mutually exclusive, in that both seek to increase the competitiveness of smallholdings which still make up the vast majority of farms in Europe. At the same time within the framework of rural development plans it would also be a good idea to design measures to encourage both land consolidation and cooperation between farmers. Such measures would make the most of the social capital created during the land consolidation processes, so as to promote further horizontal and vertical processes of productive integration which would undoubtedly increase the profitability of the farms involved.

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5.6. ANALYSIS OF THE SPATIAL RELATIONSHIP BETWEEN SMALL OLIVE FARMS TO INCREASE THEIR COMPETITIVENESS THROUGH COOPERATION*

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5.6.1. ABSTRACT

Small olive farms typically find it hard to compete with their larger competitors due to unfavourable conditions in terms of labour costs, land fragmentation and structural capital. These conditions result in higher production costs that reduce their competitiveness, leading to progressive exclusion from domestic and international markets and the abandonment of farming. In this scenario, cooperation between farmers to increase farm size and reduce land fragmentation may be an innovative strategy to improve the competitiveness of small agricultural holdings and avoid farm abandonment. The aim of this paper is to characterize the spatial structure of the traditional olive grove in the province of Jaén (South of Spain), the world's leading olive oil producer, to identify the areas where farmer cooperation can be effectively implemented. The results of this study confirm that there are large numbers of small, barely viable olive groves and show different ways to promote cooperation between farmers according to the structural characteristics of their farms and their spatial relationships. In particular, when small olive farms have large neighbours, assisted cooperation systems should be implemented, while when small olive farms are concentrated in areas without larger farms, shared cultivation systems would be more efficient. This paper also provides information for the design of public policies aimed at enhancing the competitiveness of small agricultural holdings.

Keywords: Olive groves, Small agricultural holdings, Cooperation, Assisted cultivation, Share cultivation.

5.6.2. INTRODUCTION

SAHs (Small agricultural holdings)[46] play an important role in farming in the EU today. In 51% of EU member states, farms covering less than 2 ha occupy more than 25% of agricultural land. In the EU as a whole 69% of farms cover less than 5 ha and only 2.7%

[46] Due to the wide variation in farm structure across the EU member states and the lack of consistent data for all member states there is no commonly agreed definition of SAHs. Physical parameters such as farmed area or labour input, or economic criteria such as turnover are typically used (European Commission, 2011). The most common criterion is field size, with small farms often being defined as those with areas of less than 5 ha (European Commission, 2013).

are larger than 100 ha (European Commission, 2013). The structure of farms in Europe also differs depending on the type of crop. Olive growing, for instance, is a longstanding example of small farming and is concentrated in Mediterranean countries, where the production structure is highly fragmented (European Commission, 2011). In fact, in Europe's main olive producing countries, Spain, Italy and Greece, the average size of olive farms is only 5.8 ha, 1.8 ha and 1.5 ha respectively (Eurostat, 2015).

SAHs in olive groves are subject to sustained demographic, commercial, technological, institutional and economic pressures due to several interacting causes. Typically, they are located in rural areas that have been and often still are affected by rural exodus. This worsens the living conditions and quality of life in rural communities, and is a crucial factor in the decision to abandon farming. It also limits generational renewal in the management of farms. Currently, the most common age bracket for farm managers is 65 or over, and a majority (53.2 %) of farm managers in the EU-28 are aged 55 or above, in other words close to or beyond normal retirement age (Eurostat, 2010). Small olive farms are normally geographically dispersed and have low production, which from a commercial perspective means that they do not have the same power to negotiate in the market as larger agricultural holdings, and are forced to become "price-takers" (MARM, 2010; CEICE, 2011). In Spain, Italy and Greece, for instance, a few big groups control most of the olive oil market and set the price at which olives are bought and sold. Furthermore, the fact that the international olive oil market is now increasingly globalized means that European SAHs face direct competition from larger holdings in "new producing countries" (Argentina, Australia, Chile, China, Mexico, New Zealand, South Africa and United States of America) with better structural conditions and/or lower salaries, making exporting increasingly difficult.

In technological terms, SAHs tend to use older machinery because on the one hand it is difficult to repay the cost of acquisition of new machines within their normal lifetime and on the other it is harder for them to obtain credit to finance the purchase of new equipment. Due to their socio-demographic and financial limitations, small farmers often do not meet the criteria to access the credit they require (European Parliament, 2014). Institutionally, although the viability of SAHs depends heavily on institutional support, they have often been neglected by the CAP. This is because CAP support has historically been based on surface area and production levels, clearly favouring larger agricultural holdings. Even in the most recent policy reforms, where more emphasis was placed on the environmental and social benefits provided by farmers, smallholders did not receive enough administrative support to enable them to overcome the various administrative hurdles to access the available credit or funding. These limiting conditions reduce farm profitability, often rendering them unviable without the subsidy from the CAP (Colombo et al., 2015). Even with the existence of extensive subsidies, the continuity of these farms is often only possible due to unpaid family work. Many of them would be unprofitable if the labour provided by family members was valued at the same rate paid to external farm-workers (Mylonas, 2015).

Notwithstanding all these pressures and limitations, SAHs represent a model of social agriculture which is still predominant in EU and will continue to coexist with other, more large-scale, market-oriented models of agriculture (European Parliament, 2014). This is because in addition to purely economic considerations, the social, cultural and environmental aspects of production must also be considered to enable us to foster the sustainable development of rural areas. Here, SAHs play a role that goes far beyond agricultural production and includes the delivery of public goods such as environment and landscape conservation, the prevention of fire risk, the monitoring and care of rural areas, the maintenance of employment in remote areas and a whole set of cultural functions linked to the preservation of traditions, customs and other non-material heritage.

Olives are regarded as a “social crop” in that olive growing is amongst the agricultural activities that create most jobs per hectare. In Andalusia, the region with the highest production in the world of olive oil and table olives, olive farming provides more than 30% of agricultural employment and is the main economic activity in more than 300 of the region’s 771 municipalities (Rocamora et al., 2014). In these areas olive farming is one of the few, if not the only sustainable activity that holds back rural exodus and contributes to preserving the characteristic features of rural landscape. Environmentally, SAHs in the olive sector play a key role in the provision of landscape, biodiversity and soil conservation (Villanueva et al. 2014; Arriaza et al., 2008; Colombo et al., 2006), because they are typically farmed extensively with low inputs and semi-natural herbaceous vegetation. Finally, extensive olive groves are the basis for a whole series of cultural activities related to gastronomy, tourism and crafts (Instituto de Estudios Giennenses, 2008).

The multifaceted pressures described above directly or indirectly reduce the financial returns of SAHs in this sector, whilst the public goods they provide are not remunerated by the market[47]. As a result, their economic situation has worsened significantly over the last decade (Colombo and Camacho-Castillo, 2014), and there is currently a risk of farm abandonment, especially in marginal production areas (Duarte et al., 2008). The abandonment of olive-growing farms is already having significant effects on the land degradation process in traditional olive-growing areas, and these effects are expected to be exacerbated by the vulnerability of Mediterranean (semi-arid) regions to the impacts of climate change and extreme weather events (Palese et al., 2013). Such is their role in society that the abandonment of olive groves would lead to the loss of a wide set of social and cultural functions (Rocamora et al., 2014).

In this scenario new competitive strategies that allow SAHs to save on production costs, whilst maintaining a production model that allows the multi-functional development of rural areas, are urgently required. This is particularly true in areas where, due to topographical and climatic limitations, there are no other feasible alternatives for boosting profitability, such as for example the installation of irrigation or intensive cultivation (Sánchez Martínez and Gallego Simón, 2011).

Recent research has shown that cooperation between farmers can be an effective way to improve the economic, social and environmental performance of SAHs (Vitri et al., 2015; Rocamora et al., 2014). Fostering farmer cooperation in olive production, however, requires specific policies, aimed at horizontally and vertically integrating the SAHs production structure. This is because the olive oil production sector is generally very fragmented and poorly organized. Indeed, despite the fact that most farmers belong to

[47] Even in those places where AES are in operation, the payment mechanism is based on compensating farmers for the additional costs and the income foregone (including transaction costs) as a result of the commitments they assume and, while providing some additional income, does not significantly improve the profitability of their farms (Uthes and Matzdorf, 2013.).

cooperatives, these often do little more than distribute CAP subsidies and other administrative work, instead of acting as an organized business enterprise with a clear strategy (Mylonas, 2015).

In order to promote effective cooperation between producers that goes beyond the current level of cooperativism, we must find out more about the spatial relation between SAHs. Farmer cooperation relies on the relations between neighbouring farmers: in practise, the spatial relationship between SAHs is the main factor that acts as a catalyst or an impediment to cooperation, either encouraging or preventing the interactions that create economies of scale and reduce production costs. Of course this is not the only issue to be considered. As Rodriguez-Entrena and Arriaza (2013) point out, the promotion of social capital[48] is paramount in encouraging farmers to adopt innovative management schemes. Flexibility in the cooperation arrangements, transaction costs and the aid of experts who can advise cooperating farmers are also prerequisites for improving cooperation (Rocamora et al. 2014; Villanueva et al. 2015a). In this context, mixed evidence has appeared regarding the willingness of farmers to participate. Villanueva et al. (2015a) found that farmers' opinions about AES (Agri-environmental schemes) in olive groves vary a great deal, because of their differing perception of transaction costs and of the expected disutility related to losing part of their freedom to manage their farms. The same authors recognise that cooperation may be even more difficult in the case of irrigated olive groves, more oriented to the production of private goods (Villanueva et al., 2015b). In any case, all the published literature acknowledges that the expected benefits of cooperation far outweigh its expected costs.

To the best knowledge of the authors no previous research has been done on the spatial relationship between SAHs. The aim of this study is to characterize olive farms according to their size and spatial fragmentation, so as to identify the areas where farmer cooperation could be successful and the most suitable policies for reducing SAH costs via more effective cooperation. In particular, we identify homogeneous areas where the profitability of small, fragmented farms could be improved by either shared or assisted

[48] Social capital comprises the networks, shared norms, values, and understandings that facilitate cooperation within or among groups (OECD 2001).

cultivation, two new management approaches within a framework of cooperation between neighbouring grove owners and an increase in the jointly cultivated surface area. Shared cultivation refers to a situation in which a group of farmers cooperate in the care of their olive groves using commonly owned resources. For its part, assisted cultivation is a system by which owners turn over the management of their olive groves, either completely or partially, to an entity with the sufficient human, technological and mechanical resources to farm them professionally, often a large neighbouring farm. Both systems make use of the economies of medium-scale production, which significantly reduce production costs. In the case of olive groves, Vilar et al. (2010) reported that a 21% reduction in costs could be achieved via shared cultivation and as much as 24% through assisted cultivation.

The paper is structured as follows. We begin by describing the general aspects of the study area focusing on the importance of olive growing and its current situation. In the next section we outline the cartographic sources and methodology used for data analysis. We then present the results and discuss the implications for decision-making, finishing the article with a set of conclusions.

5.6.3. CASE STUDY

In this paper we analyse the olive groves in the province of Jaén (Spain). This area was chosen because it has a characteristic monoculture of small-scale olive groves on fragmented plots. It is also one of the most productive olive-growing areas in Europe. The province of Jaén, located in southern Spain (Figure 24), has some 551,191 ha of olive groves, representing 83.3% of its agricultural surface area and approximately 26% of the total surface area of olive groves in Spain and 42% of the total for Andalusia (CES, 2011). It is also the leading olive-oil producer in the country, providing 80% of domestic production, and indeed in the world with 17% of global production (International Olive Council, 2015). Despite these figures, worrying symptoms regarding the profitability of the crop have appeared and deserve analysis. The CAP has also changed, reducing institutional support to the olive grove sector (Colombo et al., 2015). The sector is currently characterized by highly fragmented plots and insufficient cooperation, low professionalism, falling sales prices for the farmer, and high production costs (Cubero and Penco, 2012). In general terms, in Jaén province the agricultural structure, a concept that includes parameters such as ownership, farming methods and land tenancy, is characterized by heterogeneity and/or polarization, in the sense that there is a large number of small farms and very few large ones (Naranjo Ramírez, 2003). This structure is very difficult to alter over time due to the legal obstacles to property division, among other factors[49].

Source: Authors' elaboration.

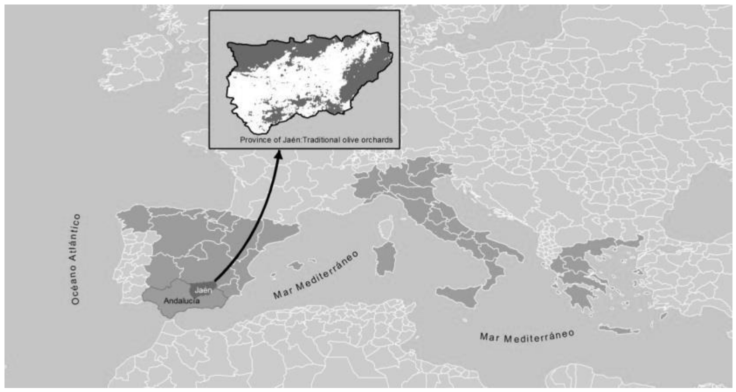

Figure 24: Map showing the location of the study area.

The analyses in this research were made in the traditional mechanized (i.e. accessible to tractors) olive groves in the province of Jaén. This type of grove was chosen because it is the most common type in the province (78.85% of the total) and has the most fragmented ownership structure where cooperation could bring major benefits for farmers.

5.6.4. MATERIALS AND METHODS

5.6.4.1. CHARACTERIZATION OF THE TRADITIONAL OLIVE GROVES

The methodology we followed, based on the use of a GIS, is schematized in Figure 25. The first job is to identify homogeneous production areas where farmers can cooperate by sharing production inputs and machinery. The information we used was from the shapefile of SIGPAC 2013 (MAPAMA, 2016). SIGPAC is the official government geographic information system that delineates the spatial configuration of agricultural plots in Spain. It provides the spatial details of all the "reference parcels", in which the

[49] Law 19/1995 on the modernization of farms.

minimum unit of cultivation is defined as a continuous land surface delimited geographically within a plot with a single use. This definition was enforced by Council Regulation (EC) No 1593/2000 for the identification of agricultural parcels when carrying out administrative checks on the areas declared by farmers.

Each olive grove plot was classified according to its structural and agricultural characteristics considering: 1) tree density (per ha), used to differentiate between traditional, intensive and super-intensive olive groves; 2) crop regime, whether rain-fed or irrigated; and 3) the average slope, used to differentiate between groves that can be mechanized and those that cannot. The tree density information was taken from the SIGPAC database (2009 edition, the last to record this parameter). The olive groves where this information was not available were attributed a tree-density value by nearest-neighbour interpolation. Rain-fed and irrigated groves were distinguished by compiling the layer created by the Confederación Hidrográfica del Guadalquivir (2008) and SIGPAC (2013). The average slope values were from SIGPAC (2013). We also conducted quality controls in the field to confirm the information in the databases. We used aerial photography interpretation to correct several attribute errors in which tracks were erroneously classified as olive groves. Finally, a topology check was performed to join slightly disconnected nodes and vertices.

After compiling all this information, we were able to reproduce the spatial structure of the traditional machine-workable olive grove for the parcels with a density of less than 200 olive trees/ha (criterion used to classify the olive grove as traditional) and an average slope of less than 25% (criterion used to classify the olive grove as machine-workable). These cut-off points were proposed in previous research on olive groves, in which extensive olive groves were considered to be traditional and machine-workable when formed by low densities of trees (less than 200 tree/ha), a wide planting framework and olives trees with 2 or 3 feet (CAPDR, 2015, Cubero and Penco 2012) on slopes of less than 20%[50]. We decided to focus on this type of olive grove because it is the most common type

[50] The recent Andalusian Government plan for olive groves considers densities of up to 180 trees per ha, whilst AEMO prefers 200 trees/ha. Both use 20% slope as the cut-off point for mechanization. We increased the cut-off for slope to 25% due to empirical findings, obtained in 200 surveys and field observations, that farmers typically use tractors "unrestrictedly" on slopes of up to this level.

in the study area, it has low profitability and is most likely to benefit from shared or assisted cultivation.

Source: Authors' elaboration.

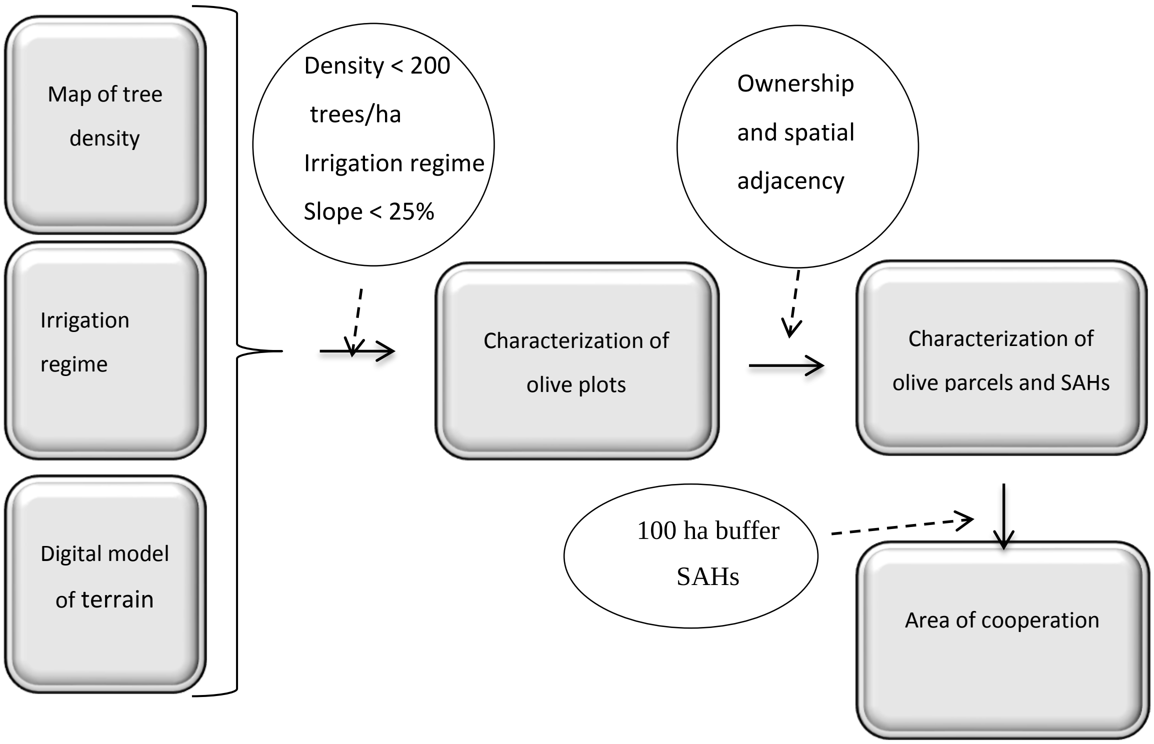

Figure 25: General methodology followed.

The geographic information used to delineate the spatial structure of traditional olive groves did not contain any information about land ownership, an important parameter to consider when analysing farmer cooperation. Information about land ownership was obtained from the single payment application for 2013 and was combined with the spatial information by associating each olive parcel to its owner. The resulting shapefile contained the location and ownership of the olive-groves in the province of Jaen. In this file, olive grove parcels were created by grouping together adjacent plots with the same production characteristics (i.e. all traditional olive groves) belonging to the same owner. The olive grove parcels defined in this way are the real units of work on each farm, and should therefore be used as the reference unit for analysing the spatial relationships arising from farmer cooperation. The set of agricultural parcels belonging to the same owner (which may or may not be spatially adjacent) constitute a farm.

5.6.4.2. PROPOSALS FOR NEIGHBOUR COOPERATION

Neighbour-cooperation analyses were conducted by defining the homogeneous areas of the olive groves on the basis of the hypothesis that where there is a high concentration of one type of olive grove, which therefore requires similar agricultural tasks and machinery, joint management approaches can be implemented more easily. Nonetheless, the most appropriate forms of cooperation will vary depending on the spatial structure of the neighbouring groves. In those cases in which SAHs border on large holdings, assisted cultivation systems are preferable. This is because large holdings already have the machinery and technology required to manage the plot efficiently and can take over the management of nearby SAHs[51]. Where SAHs are spatially distant from large holdings but close to each other, the shared cultivation system, in which small farms cooperate by sharing production inputs and machinery, is more suitable. The different situations are shown in Figure 26, which shows a real picture of part of the study area. In this figure, parcels marked with black stripes belong to large holdings, whilst those shaded in grey belong to SAHs. There are four parcels in black (Parcels A, B, C and D) around each of which there is a circular area in dark grey representing the assumed sphere of influence of each parcel where cooperation can take place. Each parcel has different spatial relationships relative to the neighbouring parcels. In Parcels A and B cooperation is not possible because there is a very low concentration of suitable parcels within their sphere of influence. In Parcel C assisted cultivation would be the most efficient system of cooperation, while in Parcel D the most feasible alternative would be shared cultivation.

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[51] Note that "take over" may refer to complete management of the farm or just to certain specific tasks that require machinery and technology that SAHs cannot afford.

Source: Authors' elaboration.

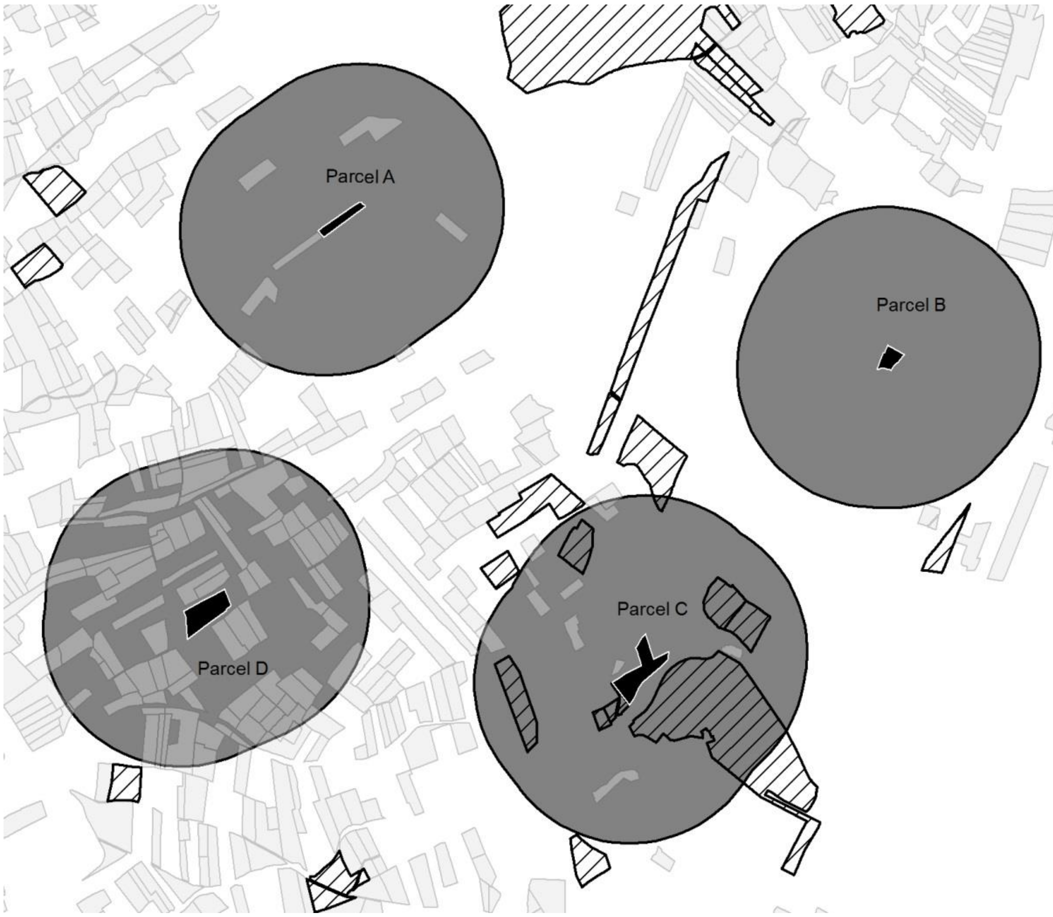

Figure 26: Examples of spatial relationships between parcels.

Given these criteria, when characterizing the olive farms we focused on the spatial structure of "SAHs" and large holdings, on the assumption that a holding is small when the total area of the farm is less than 5 ha and large when it is over 50 ha. These cut-off points were chosen after reviewing the existing literature and consulting experts. The under 5 ha limit is the most common threshold used to define SAHs (European Commission, 2013). Additionally, according to the experts we consulted, traditional olive farms of less than 5 ha are typically managed in a long-established conventional manner where low technology and machinery are used. Most of the agricultural tasks are performed manually, as is the harvest. This compares to the minimum area of 50 ha suggested by Hermoso et al. (2011) and Ruz (2012) in order to optimize production inputs (labour and machinery) in olive groves, so reducing costs. These large farms usually have all the technology required to mechanize work in the field. We recognise that this assumption does not include medium-sized holdings, which would either behave as small or large holdings depending on the specific machinery and technology they own. Anticipating which machinery and technology are owned by this kind of farms is a priori very uncertain, given that medium-sized holdings own a wide and heterogeneous set of machinery that varies according to a set of socio-demographic, economic and attitudinal variables and is not just linked to economic efficiency. Typically, they own less expensive machinery and outsource the work in those tasks that require expensive machinery and technology (e.g. rotary cutters and branch choppers). However, it is important to make clear that given the polarization of small and large holdings, even though we only analyse farms on either side of the 5 and 50 ha cut-off points we are still considering the vast majority (80%) of the farms in the study area. Even so, we decided to find out to what extent including medium-sized farms would affect the results. To this end we conducted a sensitivity analysis, in which the cut-off point below which a farm would be considered small was 20 ha. This cut-off point, albeit arbitrary and based on the assumption that a farm of less of 20 ha behaves like a SAH, allows us to include practically all existing farms[52]. The results of this analysis are set out in the results section.

We identified the homogeneous areas for cooperation by calculating the "neighbour relationships" of all the agricultural parcels belonging to a SAH. For each SAH olive parcel we established an area of influence within which we assume cooperation can take place. The area of influence measured 100 ha around the centroid of each parcel (the grey area around each parcel in Figure 26). This means that all the agricultural parcels within the area of influence are within 564 metres (the radius of 100 hectare circle) of the centre, a distance considered close enough for cooperation between the parcels. In each sphere of influence we calculate the number of SAHs, the number of large holdings and the areas covered by each one. Depending on the "density" of the small and large agricultural holdings within each sphere of influence, we can determine whether assisted and/or shared cultivation should be implemented, which policies should be adopted to promote farmer cooperation and where they should be applied.

[52] Just 3.4% of farms are in the 20 to 50 ha range.

In the final stage of the characterization, for each SAH we obtain detailed information that enabled us to identify: firstly, at farm level, the production factors that directly affect management costs, i.e. the dimension and fragmentation of their agricultural plots; also, the likelihood of cooperation of nearby olive growers to achieve an increase in the surface area of the grove to benefit from economies of scale that reduce production costs, and secondly, at provincial level, a description of the real situation of SAHs to enable us to identify the most suitable areas for the application of policy instruments aimed at encouraging cooperation between olive growers.

5.6.5. RESULTS

5.6.5.1. CHARACTERIZATION OF THE OLIVE GROVES

Table 17 summarizes the data characterizing the structure of the traditional mechanized olive-grove parcels and farms in the province. Overall, there are 261,450 olive grove parcels that together make up 84,878 farms. Columns 2 to 5 show the number and accumulated area of the olive grove parcels whilst Columns 6 to 9 illustrate the same variables for farms.

Starting with the olive grove parcels, the data indicate the high degree of fragmentation of this crop in the province of Jaen, with an average plot size of 1.7 ha, and a high proportion of small plots: 62.9% of the parcels have a surface area of less than 1 ha (17.8% of total olive-growing land), and 94.1% less than 5 ha (54.6% of total olive-growing land). Most of these small parcels belong to SAHs. Specifically, of the 246,102 parcels that have less than 5 ha, 143,962 (59%) belong to SAHs, 94,084 to medium-sized farms and 8,056 to large farms. SAH parcels are extremely small. 77% have less than 1 ha with an average size of only 0.76 ha, revealing a very high degree of fragmentation in the structure of SAHs.

If we analyse farms, the data confirm that the study area is dominated by small-scale farming. 78.5% of the farms have a total area of less than 5 ha (i.e. are SAHs), whilst only 1.4 % are larger than 50 ha, which is considered the minimum size for an optimum use of inputs and machinery. Most of the holdings in between are also quite small, measuring between 5 and 10 ha. Most of the holdings are composed of a small number of parcels; 36% have only one parcel, 45% have between 2 and 4 parcels and 12% have between 5 and 7 parcels. If we refer solely to SAHs the average number of parcels is 2.2.

Source: Authors' elaboration.

Size (ha)	Plots		Accumulated surface area		Holdings		Accumulated surface area	
	Nº	%	Ha	%	Nº	%	Ha	%
0 – 1	164526	62.9	79896	17.8	25484	30.0	14113	3.1
1.01 – 5	81576	31.2	164975	36.7	40336	47.5	96103	21.4
5.01 – 10	9103	3.5	62564	13.9	9727	11.4	67556	15.0
10.01 – 15	2764	1.0	33515	7.4	3486	4.1	42455	9.4
15.01 – 20	1253	0.4	21506	4.7	1693	1.9	29209	6.5
20.01 – 50	1832	0.7	54081	12.0	2895	3.4	87908	19.6
50.01 – 100	314	0.1	20772	4.6	837	0.9	57129	12.7
>100	82	0.03	11519	2.5	330	0.3	54357	12.1
Total	261450	100	448831	100	84788	100	448831	100

Table 17: Olive-grove plot structure in Jaén province.

5.6.5.2. ANALYSIS OF NEIGHBOUR COOPERATION: ASSISTED CULTIVATION

Table 18 describes the number of large holdings that lie within the sphere of influence of a SAH parcel. The analysis of the spatial relationship between SAHs and large holdings reveals that 42% of the SAH parcels in the study area have no large holding within their sphere of influence, whilst the remaining 58% have at least one. As can be seen in the second column in Table 18, a significant number of SAH parcels have more than one large farm in their sphere of influence, although very few have more than four (only 3.1%). The fact that most SAHs have more than one large farm in their sphere of influence is good news for cooperation, because when several large farms are nearby we can assume on the one hand that cooperation is more likely, given the possibility that some large farmers may not be willing to assist their smaller neighbours, and on the other that there is greater competition between the large farms when it comes to offering the services required by their smaller counterparts, so improving conditions for the SAHs. At a provincial level, 63,775 ha (58%) of the traditional olive groves that belong to SAHs could potentially take part in an assisted cultivation system. This high percentage indicates how important assisted cooperation could be in increasing the economic return from small farms and highlights the need for specific policies that foster assisted cultivation systems.

In assisted cooperation, both small and large holdings are expected to benefit from cooperation. Small holdings can benefit from more "efficient management" of their groves without having to buy the machinery required for the different agricultural tasks or to acquire the training needed to use them; large holdings obtain an alternative source of income and, by reducing their fragmentation, also reduce their production costs. This is because, large holdings are often very fragmented too[53] and by taking over the management of the SAH parcels that lie between their (fragmented) parcels, they can reduce this fragmentation and as a consequence production costs (Colombo and Perujo-Villanueva, 2016).

In the last two columns of Table 18 we show the number of large holdings within the sphere of influence of a SAH parcel, assuming a cut-off point of 20 ha for defining SAHs instead of 5 ha. As expected, the number of SAHs that have one or more large holdings within their sphere of influence rises (from 58% to 62.2%), so increasing the likelihood of cooperation between farms. However, in this case it is worth making clear that a farm with 15-20 ha typically owns some of the machinery and technology necessary for carrying out the main agricultural tasks. Thus, cooperation with a smaller farm with less than 5 ha, is likely to be restricted to a more limited subset of tasks that require the most expensive equipment not owned by the "small" farms.

[53] Our database shows that on average large holdings are composed of 11 parcels.

Source: Authors' elaboration.

Number of Large Holdings within the sphere of influence of SAHs	Number of SAH parcels that have large holdings in their sphere of influence[a]	% of SAH parcels that have large holdings in their sphere of influence[a]	Number of SAH parcels that have large holdings in their sphere of influence[b]	% of SAHs parcels that have large holdings in their sphere of influence[b]
0	60,535	42.0%	86,801	37.8%
1	37,363	26.0%	60,634	26.4%
2	23,490	16.3%	40,132	17.5%
3	12,180	8.5%	22,134	9.6%
4	5,913	4.1%	11,063	4.8%
5	2,465	1.7%	4,803	2.1%
6	1,087	0.8%	2,197	1.0%
7	474	0.3%	1,012	0.4%
8	270	0.2%	566	0.2%
9	103	0.1%	240	0.1%
10	53	0.0%	118	0.1%
11	13	0.0%	32	0.0%
12	15	0.0%	26	0.0%
13	1	0.0%	2	0.0%
14	0	0.0%	1	0.0%
Total	143,962	100	229,761	100

a. SAH farms are those whose total area is smaller than 5 ha, while large holdings are those with over 50 ha.
b. In this case SAH farms are defined as those with a total area of less than 20 ha while large holdings are those with more than 50 ha.

Table 18: Number of large holdings in the area of influence of SAHs.

5.6.5.3. ANALYSIS OF NEIGHBOUR COOPERATION: SHARED CULTIVATION

Those SAHs that have no large holdings within their sphere of influence and are not isolated (Figure 26 parcels A and D) can potentially cooperate with other SAHs, using the shared cultivation system.

Table 19 summarises the characteristics of the shared cultivation system that might be implemented in the study area assuming that cooperation can take place in an area of 100 ha around the centroid of each SAH parcel. In Column 1 we report the total area resulting from joining together all the SAH parcels that lie within the sphere of influence of a SAH parcel. Column 2 and 3 report respectively the average number of SAH parcels and farmers that would be needed to form a group of parcels of the size described in Column 1.

As can be seen, the typically small size of the olive parcels belonging to SAHs means that a large number of farmers have to cooperate to reach the minimum area required for optimizing labour and machinery use. In order to form a joint estate of between 20 and 30 ha, 36 parcels would have to be joined together requiring the cooperation of 30 farmers. To achieve the optimum area of 50 ha the number of parcels and farmers rises to 93 and 78 respectively.

Source: Authors' elaboration.

Area of SAHs resulting from aggregating the SAH parcels in the sphere of influence (Ha)	**Average number of parcels (N)[a]**	**Average number of farmers (SAHs owners)[a]**	**Average number of parcels (N)[b]**	**Average number of farmers (SAHs owners)[b]**	**Ha of SAHs[b]**
20-30	36	30	30	28	6425
31-40	51	43	45	36	8048
41-50	67	56	55	43	9075
>50	93	78	90	73	60304

a. SAHs are those farms with a total area of less than 5 ha
b. SAHs are those farms with a total area of less than 20 ha

Table 19: Number and average area covered by small holdings within the sphere of influence of SAHs.

These results highlight the extreme land fragmentation in the traditional olive groves and suggest that farmer cooperation through the shared cultivation system is unlikely to be an efficient alternative to increase the competitiveness of SAHs. In the current rural development program in the Andalusia Region (CAPDR, 2014) there are specific grants for the acquisition of machinery by groups of farmers, which will encourage shared cultivation. However, results indicate that the large number of farmers involved hinders the practical implementation of cooperation measures. High transaction costs are also expected in this situation. In several cases, not only have transaction costs been found to be significant for the government body managing rural development programs (Weber, 2014; Mettepenningen, 2011), but also to be an important factor discouraging farmers from participating in agri-environmental schemes (Mettepenningen, 2009) or from belonging to a cooperative (Hernández-Espallardo, 2013).

If we assume that shared cooperation can take place amongst farms of up to 20 ha (Columns 5 to 8), fewer parcels and farmers would be required for cooperation. Having said that, the numbers are still very high and no changes are expected relative to the situation in which we used a 5 ha threshold to define SAHs. Thus, the inclusion of "medium-sized" farms in the shared cooperation system did not improve on the results obtained for just SAHs.

5.6.6. DISCUSSION

The production structure of olive farms in Mediterranean countries is characterised by SAHs. The small size and fragmented structure of these holdings increase productions costs because of economic, institutional and social factors, leading to the progressive exclusion of these farms from international markets and to farm abandonment. Results confirm the massive presence of SAHs in the study area and the extraordinary degree of fragmentation within them. The average parcel size is just 0.76 ha in these holdings.

Assuming that this kind of agriculture is socially desirable (European Parliament, 2014), it is important to find ways of making it profitable in order to ensure its survival. Farmer cooperation represents an interesting option to increase the competitiveness of SAHs. The shared management of olive groves by increasing farm size promotes economies of scale that reduce production costs. To make cooperation possible and economically viable, it is essential to analyse the spatial configuration of farms, their size and type. When farms are spatially close and have the same production system, cooperation is, at least theoretically, much easier to implement. When large holdings lie within the sphere of influence of SAHs they could assist them in the management of their groves. This support could range from just a few agricultural tasks that require specific technology not owned by the small farms, or extend to a complete take-over of the grove, depending on the specific requirements of each SAH owner. When SAHs have not larger holding in their neighbourhoods and at the same time there is an agglomeration of small farms they can share the production inputs in order to achieve economies of scale and reduce production costs. According to an EU report on olive oil farms based on FADN data[54], the largest groves are the most profitable. This is particularly true in Spain where the olive farms with the highest income are on average three times bigger than the national average (European Commission, 2012). Ruz (2012) and Hermoso et al. (2011) suggest an area of at least 50 ha as the best size for optimum use of the production inputs in traditional olive groves. In this case optimum use refers to the possibility of acquiring and fully depreciating the machinery and technology necessary for olive management during their life span. However, when this threshold cannot be reached, for instance because there is a low concentration of SAH parcels, smaller areas can also be considered. In these cases joint management will not achieve the optimum results achievable where larger areas are shared, but results will still be much better than those obtained by managing a single small parcel. In the shared cultivation system, cooperation involves a group of farmers acquiring and sharing the production inputs and machinery needed to manage their farms more efficiently[55].

In addition to the spatial distance between farms, there are other factors affecting the feasibility of cooperation that must be considered. Rodriguez Entrena and Arriaza (2013) for example concluded that by using the social capital networks to which they belong,

[54] FADN is a European system of sample surveys that take place each year to collect structural and accountancy data relating to farms. The aim is to monitor the income and business activities of agricultural holdings and to provide representative data in three dimensions: by region, economic size and type of farming.

[55] Obviously, the exact set of machinery they decide to buy will vary depending on each specific case. Our experience suggests that the most expensive machines, such as branch choppers, trunk vibrators or buggies, sprayers and rotary cutters, will need to be purchased.

farmers can reduce the transaction costs of cooperation and so contribute to the success of innovative management systems. Rodriguez-Entrena et al. (2014) also found that not only does social capital have a significant impact on the adoption of innovative management schemes, but also that this impact is significantly greater in the case of small-scale olive orchards than on their larger counterparts. In the same line, social capital, collective learning and transactions costs have been found to be important factors for cooperation in other studies about olive farming (Rocamora et al. 2014; Villanueva et al. 2015a). Thus, to increase cooperation between farmers, the relevant authorities should promote schemes that help develop social capital. In this context prioritizing collective agri-environmental schemes may be an alternative way of fostering cooperation, as these schemes help form the networks of farms necessary for shared or assisted cooperation.

In this paper we estimate the potential level of cooperation that can be achieved in the traditional olive groves of the province of Jaén. Theoretically, almost all SAHs could cooperate with other holdings either via assisted or shared cooperation. However, assisted cooperation is the form that is most likely to be implemented successfully. Large farms can assist SAHs over an area of 67,775 ha, 58% of total SAH area. The remaining 42% of the SAHs do not have any large farms nearby that could assist them to produce more efficiently. At the same time, extreme land fragmentation hinders the creation of groups of SAH parcels where farmers can share production inputs and machinery, because a large number of farmers are required.

These figures have to be taken with caution given that it is likely that some form of cooperation already exists, without being officially registered. Many small farmers no longer live in their “native” villages and their fields are managed by neighbouring farmers or by relatives. With the available (official) data is it impossible to estimate the extent of this form of cooperation. At the same time, there may be areas where machines cannot be used due to soil and slope constraints. This is particularly true in the case of soil developed over marls on slopes of more than 12-15%, in which it is very difficult for tractors to carry out many of their normal tasks. In these areas the supposed increase in mechanization is therefore unlikely to happen. Once again, it is difficult to quantify exactly how much land is affected by these constraints, given that the problem also depends on the weather, and is much worse in wet conditions.

Different policies are required to promote either assisted or shared cooperation. In the assisted cultivation situation, policy measures should focus on financial support programmes to encourage private arrangements between the large and the small holdings, such as for instance tax reductions for those farms that offer these services to SAHs and financial incentives to SAHs that require the aid of large farms. The services of intermediaries who could facilitate information exchange and reduce the transaction costs between farmers should also be promoted.

When shared cultivation is required, measures could be taken to incentivize the common management of SAHs and as such should focus on the reduction of the transaction costs arising from cooperation, by subsidizing the shared acquisition of machinery, and providing the necessary training for its use. Another possible alternative could be the creation of local rental services[56] for specific machinery and services that would increase the productivity of SAHs in this situation. However, given the large fragmentation of olive groves, policy measures should also focus on reducing land fragmentation before incentivizing the common acquisition of machinery and technology by groups of farmers. This is a long-standing, well-researched issue. As long ago as 1953, Garcia de Oteyza (1953) stated that land fragmentation was a basic problem of Spanish agriculture which limited any improvement and innovation. Since then, the Spanish Government has made several attempts to reduce land fragmentation culminating in the publication of Law 19/1995[57]. This law established thresholds in agricultural land transactions to prevent further fragmentation. According to this legislation, in purchases of agricultural land in the province of Jaen, the land being sold cannot be divided into plots of less than 2.5-3 ha for rain-fed groves and 0.25 ha for irrigated ones[58]. Considering that the average SAH plot sizes are 1.47 ha and 1.72 ha for rain-fed and irrigated groves respectively, the legislation halted the land fragmentation process in the former but had little effect on the latter. Thus,

[56] These services should be located in areas where no large holdings are present and, at the same time, a large concentration of SAHs exists.
[57] Ley 19/1995, de 4 de julio, de modernización de las explotaciones agrarias (Modernization of Farms Act).
[58] The thresholds are defined at municipal level for rain-fed and irrigated crops.

before cooperation policies can be implemented, changes in current legislation are needed on the one hand to prevent further land fragmentation and on the other to promote land consolidation programs. Only after these changes have been introduced, can farmers be incentivised to cooperate so that they can take advantage of economies of scale in production.

5.6.7. CONCLUSIONS

In this paper we characterised the traditional olive groves of the province of Jaen, putting special emphasis on the spatial configuration of the SAHs and on their relation with either small or large holdings. This analysis allowed us to create an accurate picture of the olive grove sector in the world's highest-producing olive oil province. It also enabled us to identify the areas where cooperation is most feasible, which kind of cooperation should be implemented and finally suggest a set of policy measures to encourage cooperation.

Although the study focuses on the province of Jaén, the proposed methodology could be applied to other sites and crop systems. In the case of olive groves, we expect that in the other main producer countries, Italy and Greece, the effect of cooperation may be even larger, because farms there are on average even smaller and more fragmented than in Spain (European Commission, 2012).

The results of this study rely on several assumptions and limitations that must be considered with care. Firstly, our sample only considers traditional mechanized olive groves. We chose this type of olive farming because it is the most widespread system in the study area and because this is where the benefits offered by the economies of scales achieved through cooperation can be maximized. It is also a system at risk of abandonment. Nonetheless, in the study area there are also SAHs in mountainous areas that were not included in our research and to which our results are not applicable. Secondly, we assume a sphere of influence of 100 ha in which cooperation can take place. This area was chosen after consulting experts and for practical purposes. However, different spheres of influences would produce different results, and it is important to stress that the methodology used here can be easily adapted to any sphere of influence. Thirdly, we have no information about farmers' willingness to cooperate. According to Rocamora et al. (2014), olive groves farmers are usually prepared to cooperate. Nonetheless, Villanueva et al. (2015b) found that farmers are unlikely to participate collectively in agri-environmental schemes unless a high incentive is offered. In any case, future research must assess farmers' opinions regarding either shared or assisted cultivation. The information generated in this study could help identify the areas where it would be more efficient to investigate their preferences on this question. Finally, we did not investigate the effect that concentrating parcels could have on employment. Olives are the crop that generates most employment in Andalusia, even more than dynamic sectors such as horticulture and fruit, including citrus fruits. The search for economies of scale that reduce production costs by increasing production efficiency and mechanization inevitably implies a reduction in the number of working days needed for management and maintenance of the fields. This should also be investigated in future research.

In conclusion, the characterization of the spatial structure of the farms provides a more accurate picture of the real structure of the olive-growing sector in Jaén province and offers useful information for designing policies to improve competitiveness. In the case of Jaén province, the information generated can be used to fine-tune the incentives of the rural development program for Andalusia either through subsidies to promote cooperation (art. 35) or through the Leader programme or the Operational Groups of the European Innovation Partnerships.

5.6.8. ACKNOWLEDGMENTS

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BLOQUE V:

ANÁLISIS DE DATOS Y DISCUSIÓN DE RESULTADOS

Capítulo 6. Resumen global de los resultados

Los resultados principales de la tesis son los siguientes:

El sistema de propiedad sobre el que se asienta el OTM de Jaén se encuentra fuertemente fragmentado. Más del 94% de las parcelas tienen una superficie inferior a 5 ha. Este hecho disminuye significativamente la eficiencia en el manejo agrario.

El 14,4% de la superficie agraria se maneja de manera ineficiente por el escaso tamaño y la forma irregular de las parcelas, hecho que origina significativos sobrecostes de producción.

Junto a los efectos de la fragmentación, también son notables los costes extras derivados de la dispersión geográfica de las parcelas de una misma explotación. El gasto debido a los desplazamientos (medido en coste de gasoil y gasto de personal laboral) representa más de un 25% del coste total en determinadas explotaciones.

La UMC establecida actualmente en la legislación autonómica no cumple con su cometido de preservar las propiedades con una dimensión suficiente para garantizar su viabilidad. La actual UMC se debería redefinir, atendiendo a cada tipo de cultivo, y en el caso concreto del olivar, se debe aumentar considerablemente.

Los efectos de la fragmentación también se visibilizan en el valor patrimonial de la explotación agraria. La fragmentación de la tierra reduce su valor entre un 56,4% para una explotación de 10 hectáreas y 12,3% para una granja de 30 hectáreas, en la provincia de Jaén.

Para paliar los efectos perniciosos de la estructura minifundista en la que se asienta el OTM se proponen dos soluciones diferentes, teniendo en cuenta las características geográficas y estructurales del entorno más cercano de cada una de las explotaciones. En unos casos se aconseja un procedimiento de concentración de tierras que, en las áreas identificadas, generaría una mejora notable en la estructura de la propiedad y un ahorro en los costes de producción de entre 5,8% y 15,3%, dependiendo de si la finca es trabajada por la familia o por empleados contratados. En otros espacios se proponen acciones de cooperación entre los propios agricultores, atendiendo a la cercanía de propietarios de grandes dimensiones (cultivos asistidos) o no (cultivos compartidos). El 58% de las parcelas son potencialmente aptas para la ejecución de los cultivos asistidos, mientras que la mayor parte de los olivares de pequeñas dimensiones tienen posibilidad de asociarse mediante los cultivos compartidos.

Capítulo 7. Discusión de resultados y líneas futuras de investigación

La caracterización del OTM pone de manifiesto que las explotaciones de la provincia de Jaén se definen por ser minifundistas y atomizadas. Este hecho aumenta considerablemente los costes de producción por la ineficiencia generada en las labores, lo que puede llevar a la exclusión progresiva de estas explotaciones de los mercados internacionales y al acaparamiento de la propiedad en manos de los propietarios de las medianas-grandes propiedades, con la consiguiente pérdida patrimonial y la despoblación del medio rural.

El mantenimiento de las explotaciones de pequeñas dimensiones es de vital importancia para la supervivencia del medio rural. Considerando los precios de venta medio de los últimos diez años, la viabilidad de las explotaciones minifundistas sólo serían rentables bajo la gestión familiar y un mantenimiento o incluso aumento del soporte de la PAC. La realidad es muy distinta a este presupuesto, debido a que la partida presupuestaria de la PAC se reduce de forma más acusada en las últimas reformas, además del insuficiente relevo generacional. Por tanto, las políticas agrícolas, aparte de garantizar un soporte de renta, deben también proyectar otros escenarios centrados en la disminución de los costes de producción y en la creación de redes de cooperación, entre los propios agricultores en función de sus preferencias y condicionantes sociales.

Asegurar una UMC suficiente para este tipo de cultivo, que frene la paulatina fragmentación y a la vez asegure un rendimiento satisfactorio, es una posible opción a seguir. La actual UMC no cumple con su cometido para el cultivo del olivar al establecer unos umbrales significativamente inferiores a la rentabilidad del cultivo. Por ello, se considera oportuno redefinir una UMC específica por cultivos o al menos por grupos de cultivos con rentabilidades similares. Incluso, una UMC que tenga en cuenta las diferentes rentabilidades que se establecen para un mismo cultivo. Además, se considera oportuno establecer una UMC para la explotación agraria y no así para la parcela.

La concentración parcelaria es otra alternativa viable en determinados espacios olivareros. A pesar de que sea un proceso complejo, costoso y a veces polémico, un análisis territorial ex-ante de la división de la tierra y de las potencialidades de la herramienta permite simplificar el proceso, abaratarlo e incluso generar el convencimiento necesario para que sean los propios olivareros lo que soliciten dicha estrategia.

La cooperación de los agricultores es otra alternativa evaluada en esta tesis. La determinación de qué tipo de cooperación es la potencialmente idónea (cultivo compartido o asistido) y dónde se puede llevar a cabo (análisis ex-ante de los espacios olivareros idóneos) facilita el proceso de implementación y garantiza un ahorro de costes de producción a los participantes.

Junto a las transformaciones propuestas, de forma complementaria, es necesario el diseño de líneas de trabajo que permitan la integración vertical del sector (agricultores-cooperativas-mercado) con el objeto de hacer copartícipes a los agricultores en la cadena de valor del aceite de oliva y estar presente en la toma de decisiones sobre el futuro del olivar. Estos aspecto, no considerados en esta tesis son merecedores de ser investigado en futuras investigaciones.

Las futuras investigaciones tienen también que centrarse en aspectos relevantes como el impacto que puede originarse en el trabajo por la ejecución de las diferentes estrategias propuestas, considerando la idiosincrasia del sector, la edad media del agricultor y el papel que juega el olivar, entre otras, como renta complementaria en numerosas familias propietarias de pequeñas explotaciones.

De forma paralela, se deben analizar y proponer nuevos horizontes centrados en la creación de capital social que facilite la culminación de dichas estrategias e implique a los diferentes sectores del olivar, involucrando desde el inicio a los agricultores, cooperativas, grupos de investigación, etc. Los olivareros deben implicarse desde el inicio en el desarrollo de los modelos de contratos de cesión de tierras, en la clarificación de los calendarios agrícolas de trabajo, etc. La creación de redes y la transferencia de la información deben formar parte de las estrategias de transformación del sector olivarero y han de ser insertadas de manera transversal en programas, planes y acciones por sus efectos en la configuración y viabilidad del sector en el medio y largo plazo. Por ello, ulteriores estudios deben centrarse en conocer la opinión de los olivareros frente a estas estrategias territoriales. La opinión de los mismos en cuanto a su disposición para participar, condicionantes u obstáculos que sopesan o las garantías que requieren, pueden perfilar la metodología propuesta.

El desarrollo de iniciativas pilotos de carácter experimental representa un escaparate para la transferencia de los resultados de esta tesis al sector, que puede provocar que los agricultores emprendan acciones de cooperación y concentración parcelaria de forma voluntaria. En este sentido, investigaciones futuras de carácter aplicado pueden analizar las mejores fórmulas para los Grupos operativos de la Asociación Europea de Innovación (AEI), enmarcados dentro del Plan de Desarrollo Rural 2014-2020, que pueden generar las sinergias suficientes para la transformación de un sector eminentemente tradicional y poco proclive a las transformaciones socio-económicas.

El marco actual de la política de desarrollo rural favorece explícitamente las acciones colectivas de gestión agraria a través de distintos modelos de cooperación. Incluso el PDO o la futura Ley de Agricultura y Ganadería de Andalucía, proponen un enfoque jurídico que se preocupa por la excesiva fragmentación de la tierra y auguran una agricultora sostenible gestionada de forma eficiente a través de redes de cooperación y la reestructuración de la propiedad agraria en determinados espacios. Esta tesis, propone una metodología general que facilitará la puesta en marcha de estas iniciativas, considerando tanto los aspectos agronómicos como territoriales de los cultivos (enfoque integral), especialmente diseñadas para el mantenimiento de las pequeñas explotaciones de baja rentabilidad agraria.

CONCLUSIONES

En esta tesis se pone de manifiesto que la viabilidad futura del OTM de la provincia de Jaén es incierta, y que en campañas de precios medios-bajos, sólo es rentable por el soporte que supone la mano de obra familiar y la PAC. No obstante, se atisba la reducción de este modo de gestión del olivar debido al paulatino envejecimiento de la población rural, además de cambios en las políticas presupuestarias de la Unión Europea, donde se establecen nuevos objetivos prioritarios (política antiterrorista y gestión de la inmigración-refugiados) que se prevé disminuyan el soporte a la agricultura. En este contexto, se debe incentivar al sector para acometer medidas de reforma estructural que le permita aumentar sus márgenes de beneficio y por tanto, su rentabilidad.

Esta situación, que se agrava para las pequeñas explotaciones agrarias, puede revertirse si, entre otras medidas, se buscan nuevas formas de gestión que permitan abaratar los costes de producción e incentiven una gestión profesionalizada del olivar. Los cultivos compartidos y asistidos, incrementando el tamaño de la explotación y reduciendo al mismo tiempo la ineficiencia que establece el sistema de propiedad representan una alternativa de futuro. En este sentido, políticas públicas que incentiven la gestión en común de la tierra se estiman necesarias y urgentes, especialmente en cultivos de baja rentabilidad y de futuro incierto como el olivar tradicional. Es también una herramienta territorial de interés la concentración parcelaria, siempre que se realice evaluando previamente los beneficios económicos en la zona y se cuente con la participación de los propietarios afectados del inicio de procedimiento. Estas acciones, junto con otras como el fomento de la movilidad de la tierra agraria, la exenciones fiscales en la compra-venta de fundos colindantes, la sensibilización de la población para la participación en los tipos de gestión de la tierra cooperativos (por ejemplo, a través de estrategias pilotos) y la integración vertical del sector en su sentido más amplio, mejorarán la calidad de vida de los agricultores, ayudando a fijar la población en el medio rural.

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