Diversity of land use in sheep farming systems in semi-arid Mediterranean zones

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Introduction

In semi-arid zones of highly diverse geographical areas sheep farming is considered to be a valid choice of farming activity. Traditionally in the whole of the Mediterranean, sheep farming systems have operated following a widely used model that consisted of combining pasture systems with arable systems (Chassany & Flamant, 1995). In the semi-arid zone of the Middle Ebro Valley, there are large areas with considerable irrigated zones so that it could be defined as an agriculturally developed area. Moreover, it has been observed that it is precisely these irrigated zones that have a greater concentration of sheep (Olaizola *et al.*, 1995).

In large areas of the non-irrigated land of the Middle Ebro Valley the viability of cereal cultivation is being questioned and extensive zones, formerly given over to arable farming, have been abandoned. Sheep farming could be a valid alternative economic activity in these areas and recent measures established by agricultural policy have aimed at encouraging the extensification of systems. This process, however, involves technical, economic and financial difficulties (Tirel, 1992) and the possibilities of success depend, to a large degree, on the farming structures and areas available.

Like most small ruminant farming systems in Mediterranean Europe, the sheep farming systems of the Middle Ebro Valley are based on the use, by means of grazing, of spontaneous or cultivated pasture resources (Napoleone & Hubert, 1989). The great diversity that characterises sheep farming systems in these areas is due, to a large extent, on the variety of land that is used, to the varying availability of forage resources and to the different ways in which these are used. Consequently, it is considered that the sheep farming activity in these zones, apart from contributing to the economic viability of the farms and to maintaining the population fabric, plays a basic role in the managing of the rural space and in increasing the economic worth of the territory as a whole (Dedieu, 1987).

As a means of simplifying the great diversity of situations already alluded to, one of the tools most frequently used when studying farming systems is the creation of typologies (Gibon *et al.*, 1996), allowing us to identify groups or types of farms.

In this context, the aim of this research is to characterise the structural diversity of the forage system used by sheep farms in the Middle Ebro Valley and to study its relationships with other structural characteristics of the system as well as the use of other grazing resources outside the farm. This study is carried out within the framework of a more extensive piece of research into the possibilities and conditioning factors of sheep farming systems as an alternative to extensive farming in semi-arid non-irrigated areas.

Methodology

The information that has been used was obtained by means of a direct survey carried out on 99 sheep farms (1993-1994 season), located in the semi-arid zone of the Middle Ebro Valley. The zone was climatically delimited by calculating an aridity ratio for each municipality and subsequently a typology of municipalities was carried out in order to identify the diversity of agricultural resources available (Olaizola *et al.*, 1995) The sample of farms, in many cases with other than agricultural farming activities, was selected from the municipal typology. The information obtained from the survey was used to prepare variables referring to the structure of the farms' forage system, such as the size of the forage area, of the irrigated area and the non-irrigated arable land in relation to the Utilised Agricultural Area (UAA), the percentage of the forage area given over to certain crops specifically for sheep, both on non-irrigated and irrigated land and two variables referring to the stocking rate, one relating to forage crops for sheep production and another relating to stubble grazing from commercial crops (Table 1). Following the conversion of these variables into classes, a Multiple Correspondence Analysis (MCA) was carried out. Using the farm data of the first two factors obtained in the MCA, a Cluster Analysis was performed, resulting in six types of structures for the forage system. Subsequently, other variables of these types, referring to the farm structure, such as the physical size of the farm (UAA), the size of the forage area (FA), the flock size, the importance of certain crops and the use of other grazing areas outside the farm, such as common grazing land and rented grazing land, were also studied . Special attention was paid to the importance of irrigated land. All of these variables were divided into classes representing the distribution of the sample of farms.

Results and Discussion

Types of forage system structures

In the MCA carried out on eight variables that essentially refer to the structure of the forage system, the first three factors obtained explain 42 per cent of the total variation. Nineteen per cent is explained by the first factor which identifies farms without land. It establishes the relationship that exists between the absence of forage areas and hence the absence of a forage chain and zero values in stocking rates as these farms that do not have forage crops for sheep production nor remains of commercial crops (Figure 1). The second factor explained 15 per cent of

Table 1. Variables used in the Multiple Correspondence Analysis.

	Classes			Classes	
Forage Area (FA) % Utilised Agricultural Area (UAA)	≤ 0	AA1	Forage crops for sheep production on irrigated land (% FA)	≤ 0	CC1
	> 0 ≤ 30	AA2		> 0 ≤ 27	CC2
	> 30 ≤ 70	AA3		> 27 ≤ 70	CC3
	>70	AA4		> 70	CC4
Irrigated Land (% UAA)	≤ 0	BB1	Forage crops for sheep production on non-irrigated land (% FA)	≤ 0 ≤ 6	DD1
	> 0 ≤ 27	BB2		> 6 ≤ 50	DD2
	> 27 ≤ 72	BB3		> 50	DD3
	> 72	BB4			
Non-irrigated cereals (% UAA)	≤ 0 ≤ 10	EE1	Sheep Livestock Unit (SLU) / (ha Forage crops * ha FA)	≤ 0	FF1
	> 10 ≤ 32	EE2		> 0 ≤ 0.54	FF2
	> 32	EE3		> 0.54 ≤ 1.73	FF3
SLU / ha of stubble grazing from commercial crops	≤ 0	GG1	Sequence of harvesting operations	1. Complete	HH1
	> 0 ≤ 1.2	GG2		2. Non-complete	HH2
	> 1.2 ≤ 11.85	GG3		3. No harvesting operations	HH3
	> 11.85	GG4		4. No area of forage	HH4

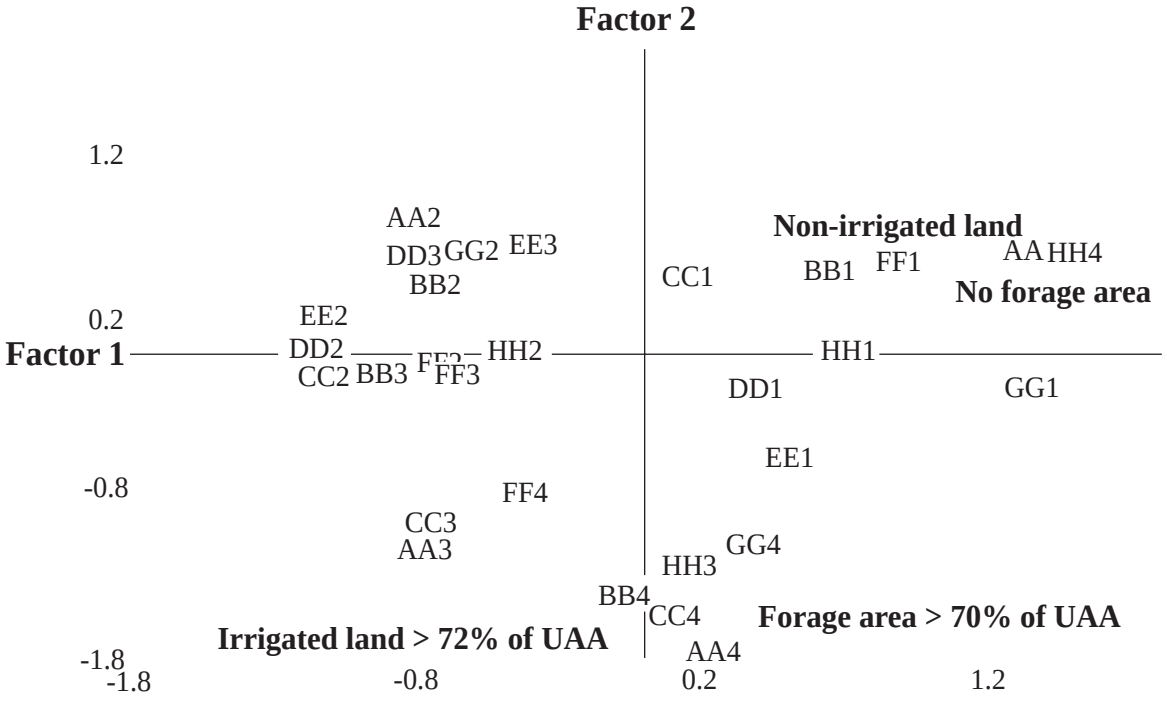

Figure 1. Location of variables on the two-dimensional space of the Multiple Correspondence Analysis.

variation and refers to farms with a small forage area and low percentage of irrigated land and irrigated forage crops for sheep production in relation to the forage area, whilst there is a considerable presence of cereal crops on non-irrigated land (more than 32 per cent of the UAA). The third factor (9 per cent of the total variation) identifies farms in which the forage area represents a considerable part of the UAA (between 30-70 per cent of the UAA) and which have a complete forage chain. In addition, irrigated land and forage crops are of great importance in these farms and the stocking rate on the the stubble grazing from commercial crops is also high.

Using the co-ordinates of the farms to the first two factors, which are those that explain the greatest percentage of variance, we carried out an Ascending Hierarchical Classification and obtained six groups of farms which correspond to six types of forage system structures (Table 2).

Type 1. Sheep farms on non-irrigated and irrigated land with high stocking rates. This type comprises 25 farms which have the highest mean values of corrected stocking rates on forage crops for sheep production and on stubble grazing from commercial crops (4.1 SLU and 16.5 SLU, respectively). The average percentage of forage area in relation to the UAA is 36 per cent and, in the case of irrigated land, 51 per cent, which indicates the considerable importance of both of these types of areas. In addition, there is also a high percentage of forage crops for sheep production on irrigated land, representing, on average, 29 per cent of the forage area. Most of the farms in this group have a complete or almost complete forage chain which means that 44 per cent of this type fall into one of these categories.

Type 2. Sheep farms with cereal crops and forage crops for sheep production on non-irrigated land. This type is formed by 18 farms which, on average, have 45 per cent of their UAA given over to cereal growing and 55 per cent of the forage area to forage crops for sheep production, both of these on non-irrigated land. This type of farm does not have specific forage crops on irrigated land and there is only a small percentage of the UAA given over to forage areas and irrigated land. Sixty-seven per cent of the farms in this group do not have a complete forage chain. They are also characterised by the fact that the average stocking rates both on forage crops for sheep production and on stubble grazing from commercial crops are low (0.5 SLU and 1.3 SLU respectively).

Type 3. Farms without land. This group comprises 16 farms which do not have a utilised agricultural area and thus do not have a forage chain.

Type 4. Intensive, specialised sheep farms on irrigated land. This group consists of thirteen farms in which 90 per cent of the UAA is given over to forage area and 96 per cent of the utilised agricultural area is irrigated land. In addition, 81 per cent of the forage area is used for the cultivation of forage crops for sheep production, on irrigated land. These farms do not therefore have forage crops for sheep production on non-irrigated land, nor do they grow cereal crops on non-irrigated land. The average stocking rates can be considered to be high and 46 per cent of the farms (six farms) do not have machinery to harvest forage. This only occurs in 10 per cent of the total number of the farms studied.

Type 5. Sheep and cereal farms on non-irrigated land. This group comprises nine farms characterised by the considerable importance of cereal crops on non-irrigated land in the UAA, with an average value of 51 per cent. On the other hand, this type of farm does not have forage areas nor forage crops for sheep production and they have very few irrigated areas (only 3 per cent of the UAA). Logically these are farms which have no forage chain and which have an intermediate stocking rate on stubble grazing from

Table 2. Characteristics of types of forage system structure (averages for each variable).

	Type 1	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**
Number of farms	25	18	16	13	9	18
Forage Area (% UAA)	36	11	0	90	0	14
Irrigated land (% UAA)	51	7	0.4	96	3	18
Forage crops for sheep production on irrigated land (% FA)	29	0	0	81	0	7
Forage crops for sheep production on non-irrigated land (% FA)	20	55	0	0	0	62
Non-irrigated cereals (% UAA)	17	45	0	0	51	35
SLU / (ha Forage crops (ha FA)	4.1	0.5	0.0	2.4	0.0	3.0
SLU / ha of stubble grazing from commercial crops	16.5	1.3	0.0	12.3	7.9	0.8
Sequence of Harvesting Operations	Complete and non-complete	Non-complete	No area of forage	No harvesting operations	No area of forage	Complete

commercial crops in relation to the rest of the groups.

Type 6. Sheep farms with a predominance of forage crops on non-irrigated land. This group comprises eighteen farms in which an average of 62 per cent of the forage area is given over to non-irrigated forage crops for sheep production although the forage area only represents an average of 14 per cent of the UAA and the percentage of UAA on irrigated land is only 18 per cent. However, on these farms non-irrigated cereal crops take up 35 per cent of the UAA and 55 per cent of the farms have a complete forage chain. This represents just 21 per cent of the total farms studied.

Other structural characteristics of the types of sheep farms established

With regard to the physical size of farms, in spite of the high degree of variability within the sample of farms studied, it is noteworthy that the farms with a predominance of non-irrigated forage crops (Type 6) are the largest in size as 61 per cent of them have more than 100 ha of UAA (Table 3). At the other extreme are Type 4 farms which are intensive, specialised farms on irrigated land, most of which are smaller in size (77 per cent of the farms have < 30 ha of UAA), taking into account those which actually have a UAA. It is observed that there is a greater predominance of farms with an intermediate UAA in the types of farms on irrigated and non-irrigated land with high stocking rates (Type 1) and in types 2 and 5, as 56 per cent, 55 per cent and 50 per cent of these farms, respectively, fall into the category of > 30 to ≤ 100 ha of UAA.

Nevertheless, in the type of sheep farms in which cereal crops and forage crops for sheep production on non-irrigated land are of considerable importance, 39 per cent of the farms have more than 100 ha of UAA whilst this only represents 24 per cent of the total of the farms studied.

Type 4 which presents a greater predominance of farms with less UAA, is the group in which most of the UAA is given over to forage areas. The types with large areas of non-irrigated forage crops (Type 6) and high stocking rates (Type 1) are those in which there is a greater predominance of farms with a large forage area (> 22 ha FA). In Type 2, 88 per cent of the farms have forage areas of between 0 and 22 ha.

Flock size is very variable in the different groups obtained, especially in cereal farms with no forage areas (Type 5), in the sheep farms in which there are large areas of forage crops for sheep production on non-irrigated land (Type 6) and in intensive specialised farms on irrigated land (Type 4). There is a greater predominance of small flocks on non-irrigated farms (Type 2) and on sheep farms without land (Type 3); as 38 per cent and 37 per cent of these farms, respectively, have less than 51 SLU. However, in this latter type 50 per cent of the farms have an intermediate flock size (> 51 ≤ 104 SLU). The Type 1 farms with high stocking rates are those with a greater presence of large flocks, as in 52 per cent of these farms there are more than 104 SLU. These represent only 31 per cent, approximately, of the farms included in the study.

If we analyse the relative importance of lucerne with regards to the areas given over to forage cultivation, a greater predominance of this crop can be seen in the farms with high stocking

Table 3. Structural characteristics of the types of sheep farms (% of farms).

Variables	Classes	Total farms	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Utilised Agricultural	0 ≤ 30	38	24	17		77	33	0
Area (UAA) (ha)	> 30 ≤ 100	37	56	44	-	23	55	38
	> 100	24	20	39		0	11	61
Forage Area (FA) (ha)	≤ 0	25	0	0		0		0
	> 0 ≤ 22	50	60	88	-	69	-	56
	> 22	24	40	11		31	22	44
Sheep Livestock Unit	0 ≤ 51	28	28	38	37	15	44	22
(SLU)	> 51 ≤ 104	40	20	50	50	46	33	44
	> 104	31	52	11	12	38		33
Lucerne (% FA)	≤ 0	52	16	50		61	-	33
	> 0 ≤ 57	24	40	5	-	30	77	50
	> 57	23	44	44		8	22	17
Irrigated cereals (% UAA)	≤ 0	55	20	61		77	0	33
	> 0 ≤ 18	31	52	39	-	15	66	38
	> 18	13	28	0		8	11	28
Other non-irrigated	≤ 0	76	72	83		92	22	50
crops (% UAA)	> 0 ≤ 20	17	20	11	-	0		44
	> 20	6	8	5		8		5

rates (Type 1) and those with cereal and forage crops for sheep production on non-irrigated land (Type 2) The specialised farms on irrigated land (Type 4) are those in which a smaller proportion of forage area is given over to this crop as 61 per cent of the farms do not grow it. The exception to this is, logically, Type 3 (farms without land) and Type 5 (farms without forage areas).

With regard to the importance of other crops in the UAA, it can be stated that cereal crop growing on irrigated land is more predominant in the UAA (> 18 per cent) in Type 6 sheep farms and in the sheep farms with high stocking rates (Type 1). There is a predominance of farms that do not cultivate irrigated cereal crops in Types 2,4 and 5. There is little presence of other types of non-irrigated cultivation, such as vines, almond trees, olive trees and fruit trees, in the sample of farms studied. However, in 44 per cent of Type 6 farms, there is a certain presence of this type of cultivation (> 0 ≤ 20% UAA).

Use of grazing areas outside the farm

In relation to the use of common grazing land, bearing in mind the high variability that has been observed in the sample of farms studied, it can be concluded that there is a greater proportion of farms that do not use common grazing land in the groups of sheep farms with cereals and forage crops for sheep production on non-irrigated land, in cereal-growing sheep farms and in those with a predominance of non-irrigated forage crops for sheep production (Types 2, 5 and 6 respectively) (Table 4). In the first of these types 77 per cent do not use common grazing land, and in the other two groups 55 per cent, whilst the overall percentage is 40 per cent in the farms studied. The specialised intensive sheep farms on irrigated land (Type 4) and with high stocking rates (Type 1) are those with the largest proportion of farms (46 per cent and 28 per cent respectively) which use common grazing land in municipalities in which over 30 per cent of the arable land is irrigated, although this only represents 18 per cent of the total of farms studied. With regards to sheep farms without land (Type 3), practically 100 per cent of these use common irrigated grazing land. 85 per cent of the farms in this group graze in municipalities with an intermediate irrigated area (> 0 ≤ 30 per cent of arable land).

In relation to the renting of other areas for grazing, there is great diversity amongst the farms studied. However, it has been observed that 67 per cent of sheep farms with cereals and forage crops for sheep production on non-irrigated land (Type 2) do not rent areas outside the farm (this represents just 40 per cent of the farms studied).

In the group of sheep farms with a predominance of non-irrigated forage crops (Type 6) 50 per cent of the farms do not rent grazing land and in the cereal-growing farms without any forage area (Type 5), 44 per cent. Out of all of the farms studied only nine rent stubbles (basically winter cereals, corn and lucerne). On irrigated land only five of these belong to the type of sheep farms with high stocking rates (Type 1) which represents 20 per cent of the farms in this group. A greater predominance of renting of stubbles on non-irrigated land was found in farms without land (Type 3) and in farms with large areas of irrigated land (Type 4) and they represent 31 per cent of the farms in both groups but only 21 per cent within the whole of the sample of farms. In addition, 37 per cent of Type 3 farms rent non-irrigated and irrigated stubble land, which represents just 28 per cent within the context of the whole of the sample of farms studied.

Conclusions

The variables that most differentiate the structure of the forage system in sheep farms of the Ebro Valley are the area of irrigated land and the area of irrigated forage crops for sheep production.

Despite the diversity of systems, it can be concluded that the biggest farms are the ones that have high availability of non-irrigated land, mainly cereals and forage crops for sheep production (Types 2, 5 and 6). There is also high variability in terms of herd size, nevertheless, a small number of animals seem to be related to farms with no owned land (Type 3). The farms with bigger herds mainly belong to the group of sheep

Table 4. Use of grazing areas outside the farm (% of farms).

Variables	Total farms	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Use of common grazing land							
1. No use	40	24	77	6	31	55	55
2. Use in municipalities with ≤ 30 per cent irrigated area	41	40	22	69	38	22	39
3. Use in municipalities with > 30 per cent irrigated area	18	28	0	25	31	22	6
Areas for temporary rented land for grazing							
1. No rented land	41	3	67	31	23	44	50
2. Stubble grazing from irrigated crops	9	2	6	0	15	0	6
3. Stubble grazing from both irrigated and non-irrigated crops	28	20	11	37	31	22	27
4. Stubble grazing from non-irrigated crops	21	16	16	31	31	33	17

farms on non-irrigated and irrigated-land with high stocking rates (Type 1). In this group lucerne is a very important forage crop. Lucerne is less important in farms with high proportion of irrigated land (Type 4). Mediterranean non-irrigated crops , such as vines, almond trees, olive trees and fruit trees, are not important in sheep farms. These crops are more important in sheep farms on non-irrigated land with high proportion of forage crops on non-irrigated land (Type 6).

The use of common grazing areas characterises farms with no owned land (Type 3). Those common grazing areas usually have high proportion of irrigated land. On the contrary, in farms with high proportion of forage crops for sheep production or with high proportion of cereals, the use of common grazing resources is less important (Types 2, 5 and 6). These systems usually do not rent out farm land for grazing.

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