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PHYSICAL FACTORS, DISTRIBUTION AND PRESENT LAND-USE OF TERRACES IN THE TRAMUNTANA MOUNTAIN RANGE[1]

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ABSTRACT.- We have studied the present-day spatial distribution of terraced lands and their current uses in the main mountainous area of the Mallorca island. A pattern of physical factors affecting the terraces has been established; the greatest significance belongs to lithology, slope and altitude. The process of land degradation and the transitional process of conversion to vegetation-covered land has been quantified. This conversion has affected up to 25 % of the terraced lands during the last 25 years.

RESUMEN.- Se estudia la distribución actual de los terrenos abancalados en la principal comarca montañosa de la isla de Mallorca, y se analizan sus usos actuales. Se establecen los factores físicos a los que se ajusta la distribución de las terrazas, entre los cuales destaca la influencia de la litología, la pendiente y la altitud. Se cuantifica el proceso de desaparición de esta forma de acondicionamiento del terreno y su transición hacia su conversión en sectores ocupados por vegetación natural, de modo que a lo largo de los últimos 25 años en cerca de un 25% de los terrenos abancalados el aterrazamiento ha desaparecido.

RESUMÉ.- On a étudié la distribution actuelle des terrains aménagés en terrasses dans la principale contrée montagneuse de l' Ile de Majorque. On a analysé leurs usages actuels et on a établi les facteurs naturels qui ont déterminé la distribution en terrasses, facteurs parmi lesquels les plus importants sont la lithologie, la pente et l'altitude... On a quantifié le processus de disparition de cette forme d'aménagement du terrain et sa transition vers une transformation en secteurs occupés par la végétation naturelle. Ainsi au cours des 25 dernières années, cette disposition en terrasses a disparu dans presque 25% de ces terrains ainsi aménagés.

Key words: terraced lands, land use, mountain agriculture, Mallorca (Spain).

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The main mountain area on the island of Mallorca is the Tramuntana Mountain Range; it is 90 km long, 15 km wide and occupies a total area of approximately 1000 km^2. This chain is a prolongation of the Betic Mountain Range (Iberian Penninsula) called the Balear promontory, and is SW-NE orientated with average heights of over 800 m; the highest point is Puig Major de Son Torrella (1445 m). Slopes are normally steep with over a third of the area at over 20% gradient, which is the theoretical limit for agricultural exploitation (EQUIP TRAMUNTANA, 1988). The studied sectors (fig.1) occupy an area of 981.5 km^2.

Rainfall in the Tramuntana Range is relatively high, at over 1200 mm in the central area, and can be particularly intense with over 250 mm in 24 hours for as return period lower than 25 years. In some weather stations there are cases of rainfall of over 500 mm in less than 24 hours, although on two different days. (GRIMALT, 1989).

The combination of characteristics mentioned above produces a high potential for erosion, making agricultural labours on the slopes difficult if not impossible, especially if one takes into consideration the predominant lithologies (alternating marls and limestones), which in many areas consist of living rock without any edaphic cover with some sectors prone to landslides. Nevertheless a sizeable area (24.000 hectares, over 25% of the total area) has been cultivated and this is mainly due to terracing.

The terracing is carried out by lining each terrace with a wall of rocks without mortar (called «marjades» on the island). They are often provided with a drainage infrastructure and access to other plots. There is, however, a dissymetry in the size of the terraces which are larger and higher in irrigated lands (in order to obtain more cultivated land) and smaller on dry lands. Otherwise, we do not find the variety of terrace-types that there are in other mountain areas such as the Pyrenees (LASANTA, 1990) or Les Garrigues (MARTÍN, 1990).

In other mountain areas on the island -Serres de Levant and Masis de Randa- the cultivated areas have not been terraced. In these areas the building of stone walls perpendicularly to the axis of the stream beds is used systematically to reduce flooding and the slopes are cultivated without protection. The enclosure of land, also with stone walls, helps to prevent overland flow (ROSELLÓ, 1986) except during extremely heavy rainfall.

1. Outlining of terraced lands

We have outlined the sectors of terraced land by means of stereoscopic aerial photographs from 1979 to a scale of 1:18.000 (Fig. 2 is a reduction of the first scale of 1:50.000). Then the photo interpretation was checked and adjusted by field-work. Throughout the process of identification those areas where, as a result of human activity, the land has been stepped and lined with subblework and where the distance between the terrace-walls is no more than 100 m, have been considered as terraces.

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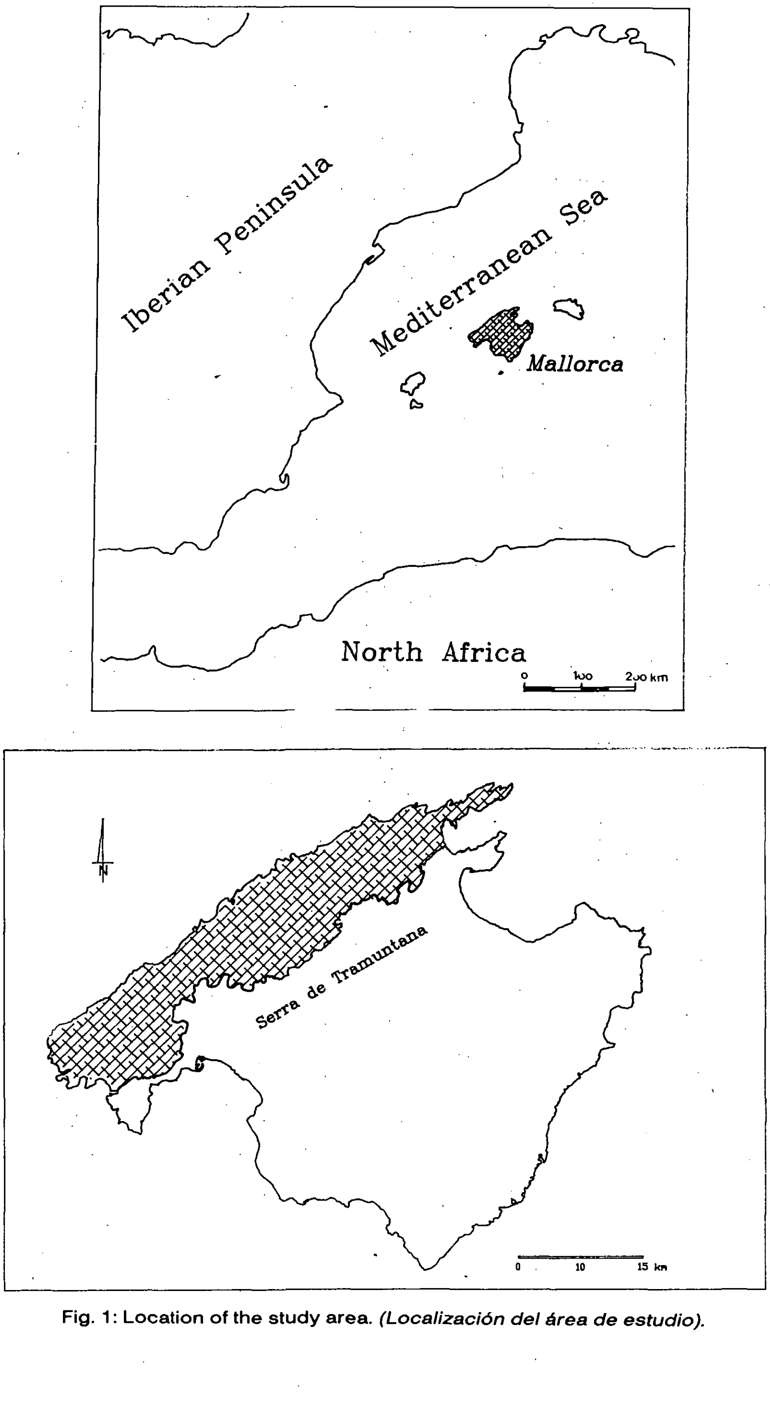

Fig. 1: Location of the study area. *(Localización del área de estudio).*

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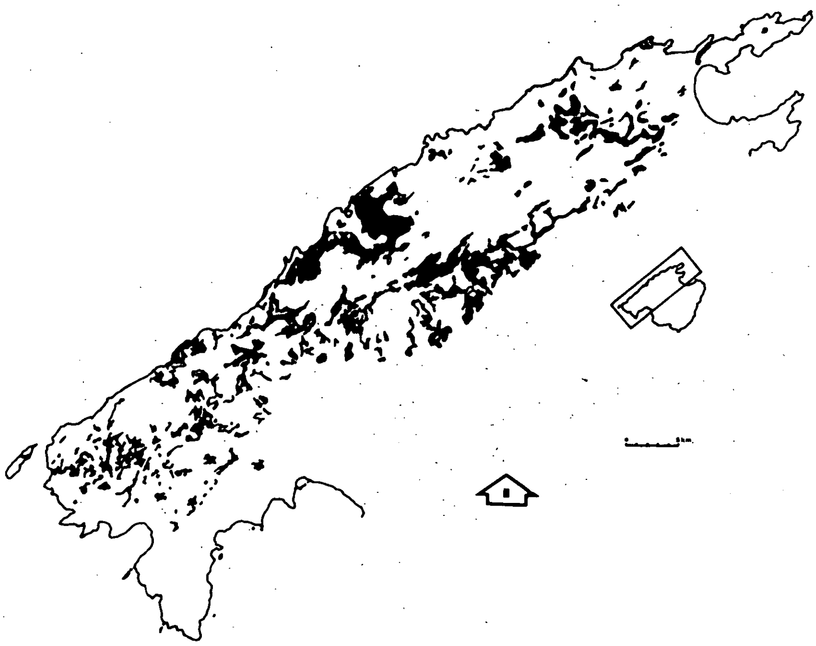

Fig. 2: Location of terraced lands, by means of aerial photographs, 1979. *(Localización de los campos aterrazados, a partir de la fotografía aérea de 1979).*

Those areas where only some signs of terracing can be seen, where walls have fallen down and do not fulfil their retentive function, were not considered. Terrace systems require periodic maintenance work to offset their fragility in very long or very strong rainfall periods. The collapse of the terraces after such rainfall is caused by either soil expansion or the direct action of overflowing drainage ditches. General collapse has taken place in the heaviest rainfall years (1973/74, 1978/79, 1986/87, and 1990/91).

In the same way slope movements and scree advances have progressively brought about the disappearance of terracing, especially where there has been no reconstruction.

The total terraced land area identified is 16.765 Ha, which is over 50% of the cultivated land and over 10% of the total Tramuntana Range area.

Distribution of the terraced lands is clearly territorially dissymetrical. On the south-western side of the area there are only a few small unconnected terraced sectors on the slopes of the basin and valley. In the central area there are continuous, relatively large, areas of terracing, as there are on the sea-facing slopes (especially the Sollèr basin slopes with a total of 2.162,5 Ha), on the southern foothills and the hillsides and basin in the interior. The identified areas in the north-eastern sector are somewhat less important.

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2. Terracing and physical features of the environment

Distribution of terraced land is mainly determined by its environmental attributes. The presence of physical impediments to crop-growing on terraced lands at over 800-1 000 m altitude, and on large areas of intense karstification or of bare soil-less karst, has been proven.

A very clear relationship between the predominant lithology and the presence of terraces can therefore be deduced from the analysis in Table I

TABLE 1.
Terracing and predominant lithologies *(Aterrazamiento según litologías dominantes)*

Lithology	He lithology	He terraced	% terraced/ lithology
0	6300	2609.6	32.54
1	8750	2068.1	18.57
2	4400	1146.0	20.45
3	625	159.3	20.00
4	729	287.8	33.00
5	1825	668.2	28.77
6	5775	1050.5	14.28
7	62025	6904.8	8.70
8	5775	606.2	8.20
9	2000	1273.5	62.63
	98150	16765	100

0 .- Marls with gypsum intercalations and volcanic rocks (Upper Triassic)
1.- Marls and marly limestones (Jurassic)
2.- Marls, calcarenites, conglomerates and breccias (Miocene)
3.- Red sandstones and lutites (Lower Triassic)
4.- Marly limestones and conglomerates (Eocene/Oligocene)
5.- Calcarenites and conglomerates (Lower Miocene)
6.- Conglomerates, calcarenites, marls and lignites (Mesozoic)
7.- Limestones, dolostones and carbonatic breccias (Mesozoic)
8 .- Alluvial deposits (Quaternary)
9.- Colluvial deposits (Quaternary).

Colluvial deposits are thus the most terraced lithology due to their preference for lower slopes. The table also shows a second group of lithologies which are also occupied by terracing: lithologies 1 to 6 where marls are present amongst calcareous rocks. On the other hand there is a smaller presence of terraced land on alluvial deposits, which could be explained by the connection between alluvial deposit locations and scarce flat lands. The limestone lithology (7) is also poorly represented with regards to the percentage of terraced land vs. total lithology area; the higher parts and bare karst areas of the range are comprised of limestones, dolostones and carbonatic breccias.

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TABLE 2.
Mean slope of the terraced land areas. *(Pendientes medias en las áreas de terrazas)*

Mean slope %	He	% total terraced
0-9	2248,1	13,41
10-19	2060,5	12,29
20-29	6307,1	37,62
30-39	2622,1	15,64
40-49	2186,2	13,04
50-59	561,6	3,35
60-69	405,6	2,42
70 and more	373,8	2.23
Total	16765	100,0

Terracing is present in areas of slopes between 20% and 30%, occupying 37.62% of the terraced land. There is a substantial group of lands with slopes of below 20% (25.7%) while 28.68% of the terraced areas have slopes of 30 to 50%. There are also extreme examples of terraced and cultivated land on slopes of 70%, exploiting favourable conditions (such as springs) that allow the development of agriculture.

Height above sea-level is also a factor and for this reason we find a maximum concentration at between 100 and 400 m a.s.l.(where there are 69.1% of the terraced areas). Only 8.35% in situated at lower altitudes and 9.68% at higher altitudes. 600 m is supposed to be the altitudinal limit for terracing and this coincides with the limit for olive tree cultivation, taking into account some dissymetry with regard to slope orientation.

Traditionally, at over 600 m, crops and agricultural exploitation took place even though they were basically cereals grown at valley bottoms without systematic terracing.

Over 700 m there are some terraced lands but only small areas with wide terraces used not for cultivation but for gathering and storing snow in deep pools (called «pous de neu»)

TABLE 3.
Distribution of the terraced lands according to its heigh above sea level. *(Distribución de terrenos abancalados en función de su altura sobre el nivel del mar)*

Interval	He	%
0-99	1399,9	8,35
100-199	3054,6	18,22
200-299	4581,9	27,33
300-399	3944,8	23,53
400-499	2130,8	12,71
500-599	1495,4	8,92
600 and more	157,6	0,94
total	16765	100

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3. Terracing and human activity.

Land-uses throughout the study area have been identified and the data has been compared with the presence of terracing (Table 4). The normal use of terraced land is the cultivation of dry-fruit trees (olive, casob and almond trees in order of quantity) at 67.76%. In the study area 58.70% of these crops are on terraced lands. Irrigated land occupies very little area in our study: 4.39% of the terraces are irrigated.

Wild or spontaneous vegetation occupies 19% of the recognized terraces. Most is covered by wood-land (holm-oak, or holm-oak with pine trees) and 4.83% is covered by brush-wood (with wild olive trees and other shrubs in Oleo-ceratonion community). We have, incidentally, identified seed-beds *(Ampelodesmos mauntanica)* which are associated with the practice of setting fire to vegetation in order to obtain green pastureland. The recuperation of natural or subspontaneous vegetation clearly shows the retrogressive direction in agricultural uses.

Urban uses, however, are becoming more important not only among the traditional villages already integrated into the terraced landscape but also from the creation and growth of large new secondary-residence ubanizations.

TABLE 4.

Land uses on the terraced land of the Tramuntana Mountain Range. *(Ocupación del suelo en los terrenos abancalados de la montaña de Tramuntana)*

Land uses	He terraceds	%/total terraced
Holm-oak wood	440,8	2,63
Holm-oak and pine tree woods	995,5	5,70
Pine tree woods	881,8	5,26
Brushwoods	809,7	4,85
Dry herbaceous crop	110,7	0,66
Dry tree crop	11360,2	67,76
Irrigated lands	736,0	4,39
Urbanization	1470,3	8,77
Total	16765	100,0

In the absence of other specific studies into this subject, we have noted the maximum expansion of the terraced system throughout the nineteenth century. The study of the decrease in farmed areas between 1860 and 1960 (SALVA, 1975) in all the municipalities within the study area shows this up well. Soller is an exception to this evolution as the village experienced great economic development at the end of the nineteenth century and beginning of the twentieth.

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Unlike the French Midi where farmed terraces are arranged into small properties (REPARAZ, 1990), in the Tramuntana Range they are often associated with the medium to large properties common to this island (SALVA, 1978).

There is a clear decrease in terraced land throughout the second half of this century, in this particular area. Our methodology has consisted of sampling the real terraced land area and its land-uses in two municipalities in the central sector of the mountain Range, Deià and Fornalux. We have also compared terraced areas calculated from aerial photographs taken in 1956 and 1979.

These two municipalities are the richest in terraced land area. As is shown in Table 5 the decrease in terraced areas is obviously in conjunction with the abandonment of agricultural labour. This can be seen in the study of percentage variation in farmed areas (data taken from annual ground rent censuses, which do not coincide with the areas in the aerial photographs).

TABLE 5.

Evolution of the terraced land area. Municipalities of Deià and Fornalutx (1955-1979).
(Evolución de la superficie abancalada. Municipios de Deià y Fornalutx, 1955-1979)

Municip.	1955		1979		
	He.	%/area	He	%/area	Difference
Deiá	750.8	49.93	544.7	36.22	-27.45
Fornalutx	924.7	47.03	714.4	36.34	-22.74

Evolution of the cropped land (He.) Deià and Fornalutx *(Evolución de la tierra cultivada en Ha en Deià y Fornalutx)*

Municip.	1860	1960	1860/1960	1989	1960/1989
Deià	745,3	626,3	-15,97	523,0	-16,49
Fornalutx	770,2	647,7	-15,91	473,0	-26,97

Environmental trends and the various human interferences have brought about a varied land evolution.

Reforestation of the abandoned terraced areas has been helped by the presence of holm-oak woods in areas just above the old farmed lands. While farming has been abandoned, therefore, there has been an advance in forest areas. Table 6 and 7 show the evolutional pattern of the terraces once abandoned.

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TABLE 6.
Evolutional pattern of the terraced land. Non cropped terraces evolve to wood lands. *(Modelo evolutivo en tierras abancaladas. Las terrazas no cultivadas evolucionan hacia bosque).*

HUMAN ACTION	TERRACING	VEGETATION
Crop	Operative	Dry trees, especially olive trees
Abandoning of the crops Occassional hunting and gathering	Operative Abandoning of the periodic works of upkeeping.	Olive trees. Formation of Mediterranean brush-woods
Posible forest exploitation. Hunting and gathering.	Maintenance of the terraces, with landslides for the action of the roots. The dry trees avoid the formation of drainage.	Mediterranean brush-woods (*Hypericion balearici, Oleo-Ceratonion, Rosmarino-Ericion..*), occasionally with presence of pine trees (*Pinus halepensis*)
Hunting and gathering. Leisure space, occasionally conservation.	Continuation of the terraces, although a slow process of disappearance. Low erosion.	Mediterranean brush-woods (*Hypericion balearici, Oleo-Ceratonion, Rosmarino-Ericion..*), occasionally with presence of pine trees (*Pinus halepensis*). In the cases where there are holm-oak woods near there are slow colonization in transition to *Quercetum illicis*.

Some specific environmental conditions at low altitudes or in the absence of nearby woods, produce negative evolution processes. When farming has been abandoned, erosion forces overpower the regeneration process and overland flow carries away the soils. This process increases on landslide slopes and favourable lithologies.

4. Conclusions

The farmed terraced lands in the Tramuntana mountain Range occupy an area of 16.765 Ha. which is over half the total cultivated land area. Their distribution is related to physical patterns, preferential lithologies of marls and colluvial deposits, average slopes of between 20 and 30% and an altitude between 100 to 500 metres above sea level. Dry-crops is the most common use of the land (67.76%).

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Terraced lands have been submitted to degradation processes in which farmed terraces have decreased by up to 25% between 1956 and 1979.

In spite of showing vestiges of marginal farming, until now terraced cultivation has been typical of this range, not allowing the mechanization of farm labours and therefore making the farming of crops unprofitable.

Nevertheless the protective effect of terraces is extremely important. Plant succession allows a quick covering of the soil surface because of the soil depth and of the hydrological behaviour of the terraces. Their importance will increase in the next future, when a preservation law of the area is developed.

TABLE 7.

Evolutional pattern of the terraced land. Non cropped terraces evolve to a unforested slopes. *(Modelo evolutivo en tierras aterrazadas. Las terrazas no cultivadas evolucionan hacia la deforestación)*

HUMAN ACTION	TERRACING	VEGETATION
Crop	Operative. Periodic works of upkeeping	Dry trees, especially olive trees
Abandoning of the crops. Cattle raising, sheep and bovine	Operative. Abandoning of the periodic works of upkeeping	Olive trees. Ruderales, gramíneas, asphodels
Cattle raising. Growing of thorny brushes, and problems to the pass of the livestock	Operative. First landslides for drainage or livestock pass.	Olive trees, first colonization of *Oleo-Ceratonion shrubs* At the central sector of the mountain range, proliferation of *Calicotome spinosa*
Fire-raising to favour the growing of green grass and passage of the livestock. Cattle raising, sheep and bovine	Acceleration of the destruction process Massive landslides.	Missing of the trees. Terofits grass, dominion of *Ampelodesmos mauritanica* and *Cistus ssp.*
Periodic fire-raising. Normally, every two or three years. Cattle raising, sheep and bovine	Non operative. Disappearance of the terracing. Quick erosion,	Grasses of *Ampelodesmos mauritanica*, low diversity
Continuing the periodic fire-raising	Slope without protection, without vegetal covering, erosion of the soils	Progressive impoverishment of the diversity. Reedbed (*Ampelodesmos mauritanica*)

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References

AMBROISE, R. , FRAPPA, P. et GIORGIS, S. (1989): *Paysages de terrasses.*- Edisud, 189 pp., Aix en Provence

EQUIP TRAMUNTANA (1988): *Pla territorial parcial de la serra de Tramuntana.* Universitat de les Illes Balears- Conselleria d'Obres Públiques y O.T. del Govern Balear, 5 vols. Palma.

GRIMALT, M. y BLÁZQUEZ, M. (1989): Cultivos abancalados en la serra de Tramuntana (Mallorca).- *Actas del XII Coloquio de Geografía.*- AGE.- vol II:100-109, Madrid.

LASANTA MARTÍNEZ, T. (1990): L'agriculture en terrasses dans les Pyrénées centrales espanoles.- *Méditerranée* , 71 (3-4): 37-42.

MARTÍN, F. (1990): La construcció en pedra seca a la comarca de les Garrigues. Comunicación presentada al *I colloqui Internacional de construcció de pedra en sec.* Universitat Politècnica de Barcelona.- julio 1990. En prensa.

REPARAZ, A. (1990) La culture en terrasses, expression de la petite paysannerie méditerranéenne traditionnelle.- *Méditerranée* , 71 (3-4): 23-29.

ROSELLÓ VERGER, V. M. (1986): Ramblas y barrancos, un modelo de erosión mediterránea. *IX Coloquio de Geografía.- AGE* : 177-184, Murcia.

SALVÁ TOMAS, P. (1975): La utilización agraria del suelo en la isla de Mallorca.- *Mayurqa:* 13: 69-100.

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