

IMPACTS OF AGRICULTURAL INNOVATION AND TRANSFORMATION OF THE MOUNTAINOUS HINTERLAND IN THE MEDITERRANEAN - AN EXAMPLE FROM SOUTHERN SPAIN (COSTA GRANADINA)

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RESUMEN.- Una investigación agroecológica se llevó a cabo entre 1985 y 1989, y en 1994, en la costa mediterránea de Andalucía (Sur de España). La comparación de fotografías aéreas de 1950 y 1978, las entrevistas a agricultores y el trabajo de campo revelan que el paisaje ha sufrido grandes cambios. Las innovaciones en las prácticas agrícolas han tenido múltiples consecuencias ecológicas. Los principales resultados son: El uso tradicional de la tierra ha sido sustituido por prácticas agrícolas orientadas al mercado. Los cambios en las pautas de uso del suelo han sido muy rápidos, iniciándose a comienzos de la década de los ochenta y no alcanzando el máximo hasta hoy. El rasgo principal del desarrollo ha sido la destrucción del paisaje mediante métodos ecológicamente inapropiados de construcción de terrazas en fuertes pendientes, que antes quedaban protegidas por el aterrazamiento tradicional. El desarrollo diferente de la Alta Alpujarra y de las llanuras costeras en relación con las pautas de inmigración y emigración está amenazando la interacción entre ambas áreas, especialmente en lo que respecta a la gestión del agua. Las llanuras costeras dependen por completo de los recursos hídricos de la Sierra Nevada y de la Alta Alpujarra. El cultivo de secano ha sido abandonado casi por completo.

ABSTRACT.- Between 1985 and 1989 and in 1994 an agroecological research was carried out at the Mediterranean coast of Andalucía (Southern Spain). Comparison of aerial photos of 1950 and 1978, interviews with farmers and field work made clear that the landscape is subject to enormous changes. The innovation of agricultural practices cause manifold ecological consequences. Main results are: The traditional land use pattern was replaced by market oriented agricultural practices. The changes of the land use pattern occurred very quickly starting in the early eighty's, not reaching their peak up to now. Main feature of the development is the destruction of the landscape by ecologically non - adapted methods of terracing steep slopes, which were formerly protected by traditional terraces. Heterogeneous development of the higher Alpujarra and the coastal plains with respect to the emigration and immigration pattern is threatening the interaction between both areas, especially the water management. The coastal plains are entirely dependent on the water resources of the Sierra Nevada and upper Alpujarra. Dryland farming has been abandoned nearly completely.

Key-words: *Mountain agriculture, Mediterranean, Southern Spain, landscape changes, tropical crops terracing.*

Key-words:**1. General considerations on land use changes in the Mediterranean**

The Mediterranean coastal areas and mountainous hinterlands are highly sensitive ecological systems (Brueckner & Hoffmann, 1992), which are increasingly threatened by different types of overexploitation. Extreme examples can be found in most of the Mediterranean countries: Italy, Spain and France in the western part and, more and more, Greece and Turkey in the eastern Mediterranean are the most affected states.

By joining the European Communities (EC), agricultural structures change unavoidably in many countries. Great risks can be assessed in the unification of the productive surface for crops exclusively produced for export, the creation of monocultures on huge surfaces, intensification of agricultural production and, in relation with these, the destruction of the traditional landscape formed by man's hand (Geiger, 1970; Drescher, 1993).

Through the application of modern agricultural techniques, it has been possible to use areas which until now were left to natural vegetation.

After a long period of hard work on the land, farmers today have recognised and adopted the advantages offered by a highly technified and simplified plant production. This evolution leads to a merciless exploitation of the resources, with all the disastrous consequences which this implies for the economy and the ecology.

Immigration towards the coast disrupts the capacity of the available resources and causes ecological problems on the coast as well as in the mountainous hinterland.

Conflicts exist in many coastal areas between the agricultural, industrial and tourist uses of the land and water resources. Experience has proven that the double or triple use is not possible, since the resources are extremely limited and land use conflicts are pronounced. Often, the coastal plains are very narrow due to the proximity of the surrounding mountain ranges, so that the usable surface is very limited. This fact eventually leads to soil speculation, especially in cases of foreign capital participations.

The advantageous climate allows the practice of an intensive agricultural use of coast sites, especially for the production of early vegetables, citrus and subtropical and tropical fruit trees. Thus, a major part of the early vegetables sold on the Central-European markets are grown on the production sites of the Mediterranean coast, such as the south of Italy (Sicily), Southern Spain, Greece (Crete) and in the south of Turkey, where greenhouse-landscapes have emerged on huge surfaces. These represent an important ecological burden for the agricultural ecosystems (Drescher, 1993).

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In comparison to the Belgian, Dutch and German glasshouses, the advantageous situation of the Mediterranean greenhouses implies nearly unexistent heating costs and lower salaries. However, the limited soil resources are quite obvious as in the case of Southern Spain. There, the narrowness of the coastal plains leads to an expansion of the production surface into the foothills; either for greenhouses, and also to produce exotic fruits great surfaces are terraced and planted with chirimoya (custard apple), medlars (*Eriobotrya japonica*) and avocado (Drescher & May, 1989).

Industry is also interested in coastal areas for its production location and supply functions. Good reasons for this are the substructural advantages for a coastal location, the better communications to the consumer markets and to the suppliers of raw materials, as well as the uncomplicated "treatment" of industrial sewage.

It can be shown that the kind of utilisation have varied greatly over the last years. From traditional, extensive agricultural landuse, change had led to a modern, extractive agriculture or to a touristical or industrial landuse. New dependencies have been created which never before existed on such scale. The export-oriented agricultural production and the manufacturing industry are equally dependent upon the economic situation of the importing countries which is also true for the tourist industry. Economical crises, dollar fluctuation and political factors can have a pronounced influence upon the Mediterranean region.

For many of these relatively poor states, the European Community appears like a sun ray of hope. To become a member of the EC means, at least, to better the poor economic situation through access to consumer markets and subsidies. It is, however, undeniable that the membership also has its' consequences upon the agricultural landscape. This is particularly obvious with the example of Spain and Portugal, where a real "production exuberance" has broken out among the farmers.

The introduction of modern agricultural techniques, unknown until then, confronts the farmers with a totally new situation which often exceeds their aptitudes. The modern application of agrochemical products, the cultivation of highly sensitive plants and the use of modern farming machines are only a few examples of the introduced changes.

Thus, the capacity to function of the regions of the Mediterranean coast is jeopardised, not only keeping in mind the natural sensitivity of the coastal ecosystems: they are also submitted to additional burdens, caused by different anthropogeneous factors. These burdens are induced by the ample range of uses of these regions. An erroneous use, or one not adapted to the environment, damages these systems often in an irreversible way. Especially highland - lowland interactions get more and more focused on with respect to the management of mediterranean ecosystems, like e.g. in the case of the Sierra Nevada in Southern Spain. Water management and soil conservation are highly dependent on a sound functioning of these interrelationships.

For all the above reasons, it seems necessary and of interest to the European Community, to take part in these processes, either through research and practical help, preventively or also in reparation of damages already caused. This lies mainly in health considerations for European producers and consumers of agricultural output, as well as in the maintenance of diversity in Europe's landscapes.

The delineating of practical proposals for the use of small and fairly limited coastal territories requires intensive research and advice, which should at first be concentrated on the population and should also take into account the planning offices at political level. The lack of a sound regional planning is one of the great shortcomings of the implicated areas.

2. Example from Southern Spain: The Development of Landuse Pattern in the Vega of Motril and the Adjacent Hinterland

The research area, situated in the mediterranean winter-rain subtropics, is called Costa Granadina because it forms the mediterranean shoreline of the Spanish province of Granada. It is bordered by the provinces of Almería in the north-east and Málaga in the south-west.

Landuse changes were recorded by interpretation of aerial photos. Recent landuse pattern was observed by using cross profiles from the coastal plains to the hinterland (approx. 490m above sea level).

The Vega of Motril and the foothills are subject to changes in different ways. In both areas tropical and subtropical fruit trees like avocado (*Persea americana*) and chirimoya (*Annona cherimolia*) are established. In the plain sugar cane (*Saccharum officinarum*) and potato (*Solanum tuberosum*) are replaced by these new cash crops, while in the hinterland mainly traditional groves of almonds (*Prunus dulcis*) are replaced. Additionally the foothills are subject to transformation for the establishment of plastic greenhouses (invernaderos) for early vegetable production (cultivos extratempranos) resulting in an almost completely terraced landscape. These measures caused heavy erosion and destruction of large parts of the natural vegetation (monte bajo) leading to the "sterilisation" of the landscape and the overexploitation of the natural water resources. The landuse options of the future will be restricted significantly.

Figure 1 shows the rapid changes of the landuse in the area between 1986 and 1994. A south-westerly exposed cross section was recorded twice. The section is stretched from the Mediterranean Sea through the lower and upper Vega up to about 490 m above mean sea level in the foothill area. The distance covers about 8 km.

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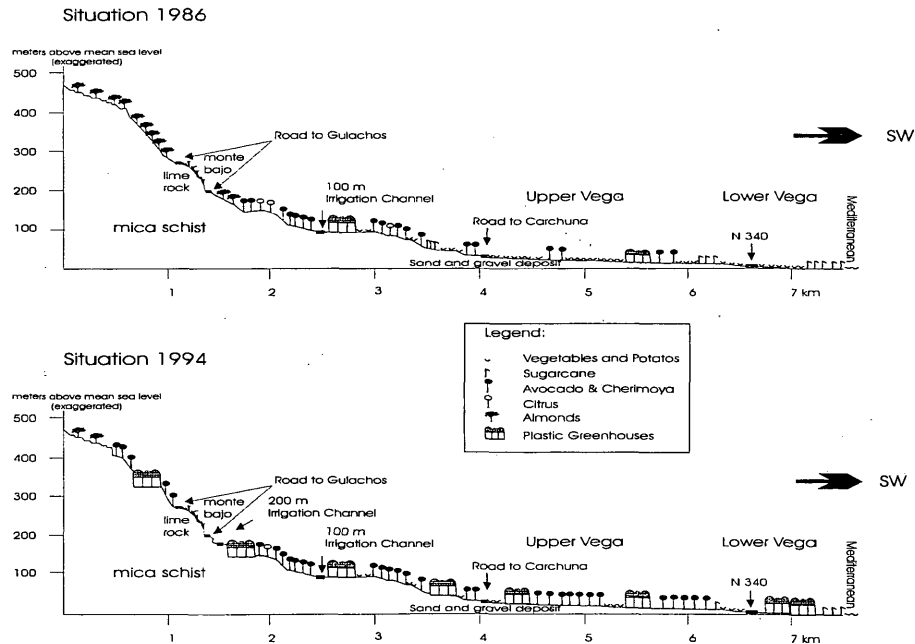


Fig. 1. Landuse Changes at the Mediterranean Coast of Andalucía (1986-1994).

2.1. Situation 1986

500 m - approx. 180 m: Traditional almond groves (dryland farming span. cultivo en secano), in the upper parts (300-500 m) terraced on slopes $> 10^\circ$. Age of terraces approx. 14 years, vegetation on the slopes deficient, evidence of erosion, lower parts not terraced.

In between (300 m - 230 m): monte bajo - vegetation on lime rock outcrop, where the hard stone has hindered agricultural use.

180 m - 100 m: Main area of (sub-) tropical fruit trees (chirimoya, avocado, medlars) and partly oranges and mandarins as relicts of former use as private homegardens. Few greenhouses are already established. In between areas of non-protected vegetable production are recorded. Avocado is the main cash crop for commercial production, while in private gardens mixed cropping of avocado, chirimoya, medlars, bananas and oranges is predominant. Irrigation is realised by tubes or irrigation ditches (partly drips irrigation). The irrigation water is delivered by the irrigation channel on the 100 m - isohypses.

100 m - 0 m: Below this channel, first time sugar cane occurs. This is caused by the irrigation technique, realised by flood irrigation. Production

of vegetables is predominant, few plots are protected by plastic. In the upper Vega, chirimoya has been established recently. Due to the high input of salt, the sea shore is occupied by sugar cane only.

2.2. *Situation 1994*

500 m - 450 m: Few traditional almond groves are left on original terraces .

450 m - 300 m: Landscape transformation for the cultivation of subtropical fruit trees and the establishment of greenhouses on large terraces mostly without any protection of the slopes. High evidence of erosion.

In between (300 m - 230 m): relict of monte bajo - vegetation on lime rock outcrop, where the hard stone still hinders agricultural use.

200 m: A new irrigation channel has been established. From this channel all area up to 450 m is irrigated by using pumps.

180 m - 100 m: Main area of (sub-) tropical fruit trees (chirimoya, avocado) and more and more greenhouses partly on terraces. The medlars, oranges and mandarins become less important and have partly disappeared because the terrain has been transformed for commercial use. Non protected vegetable production is reduced to a minimum due to declining profitableness. Drip irrigation becomes more important. The irrigation water is partly delivered by the irrigation channel on the 200 m - isohypse, which enabled the change of landuse pattern in this area.

100 m - 0 m: Below the 100 m - channel, sugar cane disappears more and more. The upper parts of the Vega are now occupied by greenhouses and avocado, while in the lower Vega more chirimoya is to be found and vegetable production areas are mostly protected by plastic greenhouses. The direct shore line of the Mediterranean is still occupied by sugar cane only.

Figure 2 and 3 demonstrate the dynamic of the development. The intensification of the landuse has proved to be doubtful for the water resources as well as for the natural vegetation and soil conservation in this area. High emigration rates in the upper Alpujarra started already in the sixties and have not stopped until now (Spahni, 1983). Population decline threatens sound highland - lowland interactions, which especially affect the functioning of the irrigation system of the coastal area, highly dependent on the proper management of the upper parts.

High evidence of erosion, frequently occurring water shortages and additional heavy pollution of the environment by plastic residues and pesticides put the long-term profitableness of the new production systems into question.

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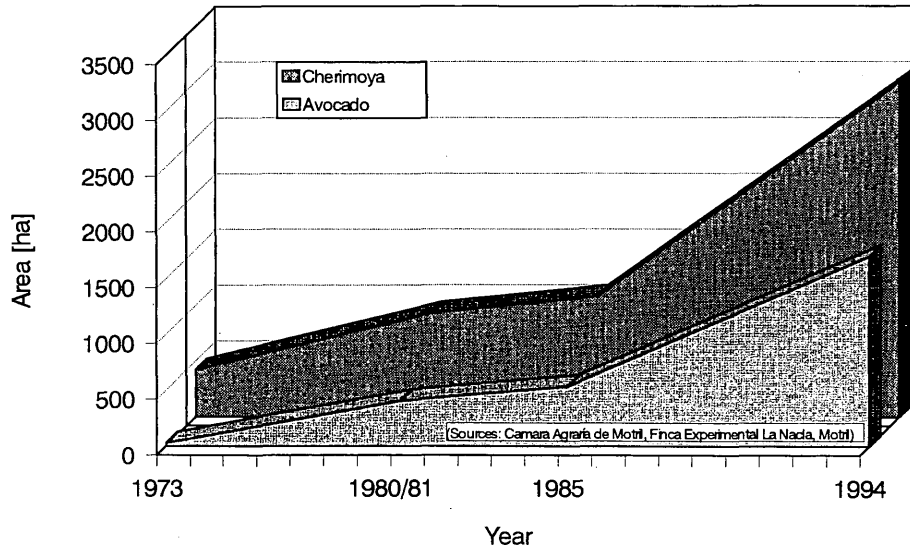


Fig. 2. Cultivated area of Avocado and Chirimoya at the Costa Granadina (Motril and Almuñécar).

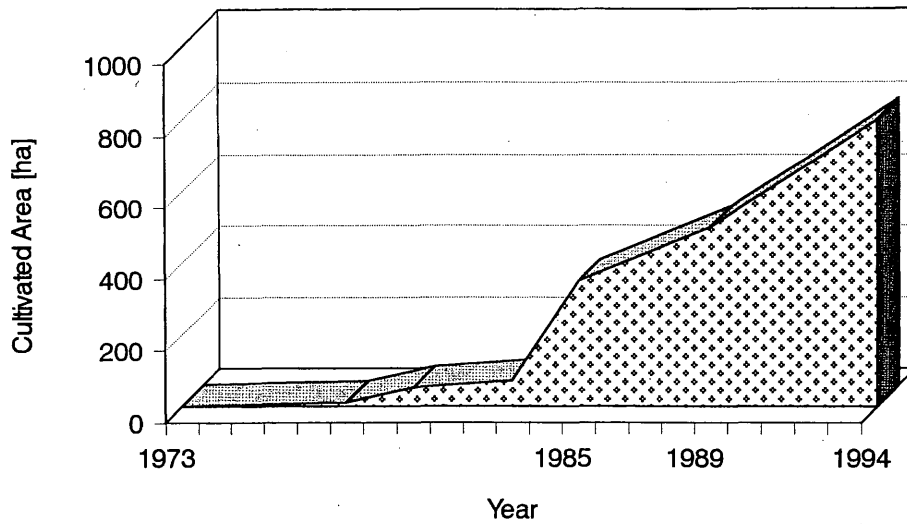


Fig. 3. Cultivated Area by Early Vegetable Gardening in Greenhouses ("invernaderos") at the Costa Granadina.

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Photo 1. Landuse in the Lower Vega of Motril in 1985 (Starting transformation: new Chirimoya Plantation).

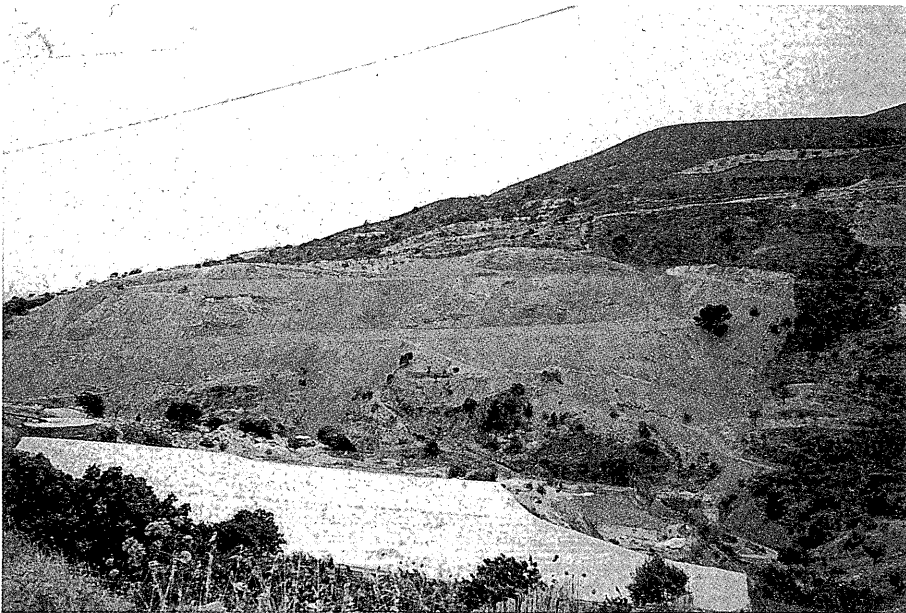


Photo 2. Landuse in the Vega of Motril and the Foothills in 1994 (New Plantation of Tropical Fruittrees).

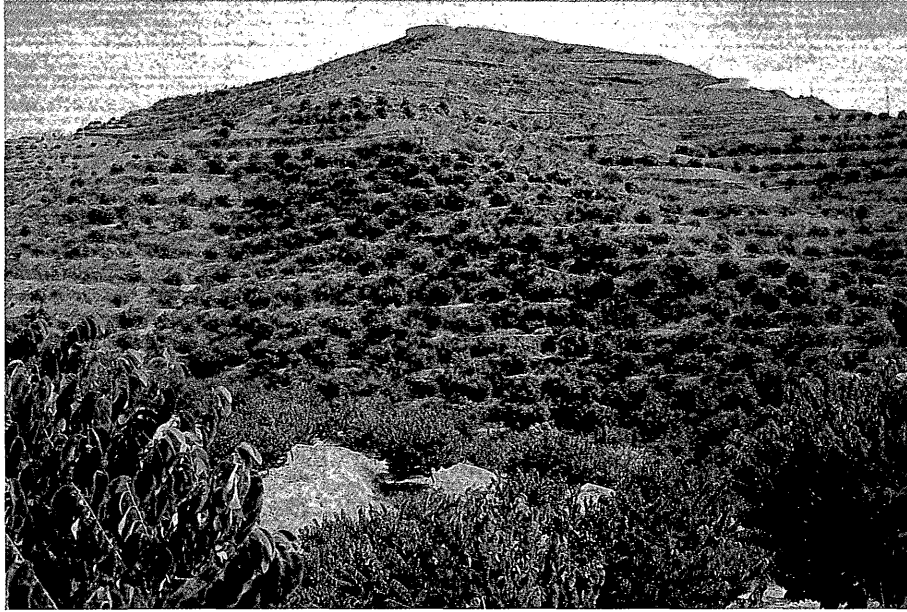


Photo 3. Transformation of the Foothill Area in 1994.



Photo 4. Transformation of the Natural Landscape by Terracing for Greenhouses (Motril/Carchuna).