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DEGRADATION OF FIELD TERRACES IN THE MALTESE ISLANDS - REASONS, PROCESSES AND EFFECTS

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There are several reasons for severe land and terrace degradation in the Maltese Islands. The main reason is the land abandonment which took place from the 1960s. Cultivated fields have constant protection against soil erosion by the crops and the farmer's care for both the field itself and the field terraces, as well as the rubble walls which are part of the cultural heritage in the Maltese Islands. Once a rubble wall is broken down, intensive soil erosion starts because then the tracks for the erosion processes are pre-determined. Usually the natural vegetation is able to reclaim abandoned land in a short period, but the dry, hot, and windy climate in the Maltese Islands creates unfavourable conditions. Starting in autumn every year rainstorms occur and cover the mainly unprotected land with flash floods. Meanwhile it is proven that global climate change is producing heavier rainfall than in previous decades.

With the help of old aerial photographs (1957) and high resolution satellite images (Ikonos, 2004) the percentage of abandoned land in the Gnejna Valley in Malta was determined. A Digital Elevation Model gave, via relief analysis, the possibility to assess the possible erosion tracks on an island which has no perennial streams. Field research gave major insight to the composition of the vegetation cover on the abandoned field terraces and other parts of the valley. The results are a forerunner to a solution to the problem in the entire Maltese Islands as well as, probably, other Mediterranean Islands with a dry climate.

KEY WORDS: Land-use change, Land degradation, Field terraces, Erosion, Tourism, Malta.

INTRODUCTION

A severe problem of many Mediterranean regions is a creeping land use transformation. Research on this phenomenon had already started in the 1980s. Arnold (1983) discovered a change in agricultural land-use. How closely this was connected to tourism was not clear during that

time. The last few decades have seen a surge in tourism, which has become a sector of high economic importance. There are other reasons for land use transformation, of course, for instance the population drain from rural areas into the industrial centres. A comprehensive description of this topic can be gathered from Friedrich & Cyffka (2000).

To observe land use transformation, it is important to have some background information about traditional land use. A good example of this was given by Hobbs & alii (1995). There was a diversified land use system that made use of the available natural resources, from fishing at the sea coast, to terraced farming on steep hillside slopes. Moreover, the main villages were often not built too close to the coast because of the danger of flooding or the mosquitoes from nearby swamps (e.g., the island of Elba/Italy up to the 1960s).

The «ideal» environment is highly diversified, especially in the case of forests. Wood has been used for construction purposes or as fuel since Roman times in the Mediterranean; therefore, vast areas of these regions have been deforested. In some areas there has been afforestation with pine or eucalyptus trees, and elsewhere the natural succession was able to reclaim areas in the form of maquis or garrigue. However, there is a significant amount of agricultural land in the valley floors or on the hillsides in the form of field terraces. The scenic views that these terraces provide, e.g., in Cinque Terre (Italy), forms part of the cultural heritage of many Mediterranean countries. Apart from the area covered by woodlands on both the islands and the mainland, the land use system shown is typical of most regions up to the middle of the last century. However, this system is rarely found in the today landscape.

In Malta there has been a retreat of the population from agriculture, specifically from agriculture as the main occupation. Because of economical changes and rising prices, many inhabitants of the Maltese Islands still have their small patch of land to grow vegetables after their full time job and on weekends. Large areas of the island are

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still used for agricultural purposes, but this does not compensate for the effects of a changing economy. In spite of a rising population, the percentage of employees in agriculture went down from nearly 10% in 1957 to less than 3% in 2002. During the same time, for example, in the service industries the number of employees went up from 12% to approximately 70% (cf. fig. 1)! All this took place while the population and the number of tourists were increasing.

The result of these changes is abandonment of agricultural areas. The majority of the rural population earns their subsistence at the coast by tourism or in the industrial centres. The remainder earn their living through more intensive agriculture in highly productive areas on the valley floors. This shows a diverse development with areas in intensive use and areas that are not being used. The effects were first investigated in the 1990s by Le Houerou (1990), Kulinat (1991), Brückner & Hoffmann (1992), Lehmann (1994), Deil (1995), Ries (1995), Mäckel & alii (1996), Molinillo & alii (1997) and Drescher & Ries (2002). Keywords of these articles are land degradation, soil erosion, land-use transformation, and biodiversity. Drescher & Ries (2002) very correctly described these phenomena in the title of their treatise: Land degradation as a consequence of land transformation - retreat from rural expanse, intensive production (translated from German).

This is valid for the entire Mediterranean area, for the islands and coasts, and also for the inland areas. But there is particular pressure on the islands especially on the smaller ones without an extensive hinterland. For example, studies on deforestation in the Mediterranean (Darby, 1956; Müller-Hohenstein, 1973) show clearly that continental forests are less reduced than the insular forests. The situation is even more precarious if the Island is a sovereign state where construction wood must be imported and cannot be bought from continental parts of the state. There are only two examples for this in the Mediterranean, namely Cyprus and Malta.

As far as land-use is concerned there were several research articles mainly in the 1990s. Some of them give a more general point of view (e.g., García-Ruiz & Lasanta, 1993; Deil, 1995; Drescher, 1995; García-Ruiz & alii, 1995; Ries, 1995; Tyranowski, 1995; Mäckel & Ries, 1996; Mäckel & alii, 1996; Stehle, 1998; Friedrich & Cyffka, 2000; Drescher & Ries, 2002). Others are more detailed and partly devoted to biodiversity as Berger & alii (1989), Richter (1989, 1993), Scherer & Deil (1997) and Schmitt (1998, 1999).

Richter (1993) comments on the situation with the provocative phrase «Mediterranean abandonment - Good prospects to regain nature-like areas?» But this sentence shows the contradiction between land degradation and land-use change. There is a more geomorphologic point of view where abandonment leads to soil erosion at least in the first years before the re-growth of the protective vegetation cover. The other point of view tends more towards conservation and biodiversity, and postulates a progressive succession in the form of maquis or garrigue. Time is required for degraded areas to progress to shrubs.

The truth possibly lies somewhere in between these two points of view. For instance on the island of Elba, where there is not much pressure on land-use by grazing and wood-cutting, there is a visible tendency to maquis, as long as wild fires do not occur. A high pressure on land-use (e.g., Malta) results in a tendency to soil erosion and land degradation with all accompanying phenomena. Transitions are possible in both directions (Brown, 1991).

If one focuses not on the farmed areas but on the abandoned ones it is obvious that both land degradation and progressive succession takes place on non attractive areas at the upper slopes. In former times these areas were terraced for agricultural use. It is common knowledge (Richter, 1989) that terraced slopes retard or even block soil erosion. A terraced slope is not as prone to erosion as normal ones. Normally the terraces are supported by rubble walls,

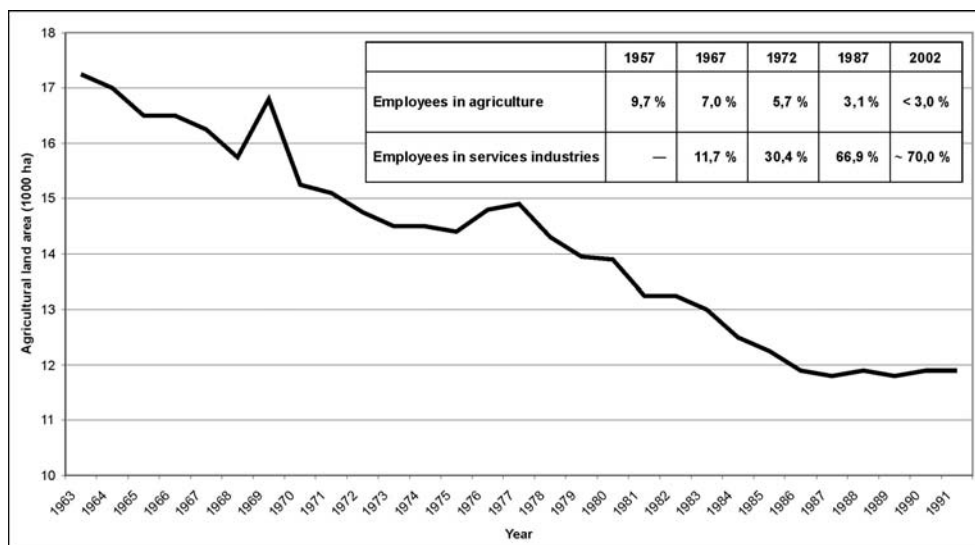


FIG. 1 - Employees in agriculture and registered agricultural land with time. Compiled from different sources: Axiak & alii (1999), NSO (2003), Aschemeier (2005).

and it is absolutely important that these rubble walls are maintained well. Otherwise they dilapidate and the break down aggregates new flow and erosion paths (fig. 2) which are not predictable - either in direction or in dimension (cf. Aschemeier & Cyffka, 2004a).

Even today land-use change is provoked by economy. The EU expansion includes Malta and Cyprus and possibly with the addition of Turkey in a couple of years, one of the largest coastlines in the Mediterranean will follow. How do EU economics influence agriculture and/or nature conservation? Even when one considers just these two examples of land-use, it appears that there is an area of conflict which has not really been investigated up to now. The first results were obtained by Aschemeier & Cyffka (2004a, 2004b) and Aschemeier (2005).

The objectives of the overall investigation are to seek areas and determine the ecological suitability of these areas for different types of land-use. Because the work shown here is preliminary (partly tentative) to the overall studies, the present initial research deals with finding the best methods and parameters.

METHODS AND PRELIMINARY RESULTS

Research was carried out on the northwestern part of the island of Malta. Due to the geological and climatic conditions (Schembri, 1997), and also because it is more than 20 km away from the industrial and tourist centres of the island, this area was one of the first to suffer from abandonment, and therefore was suitable for this kind of research (fig. 3).

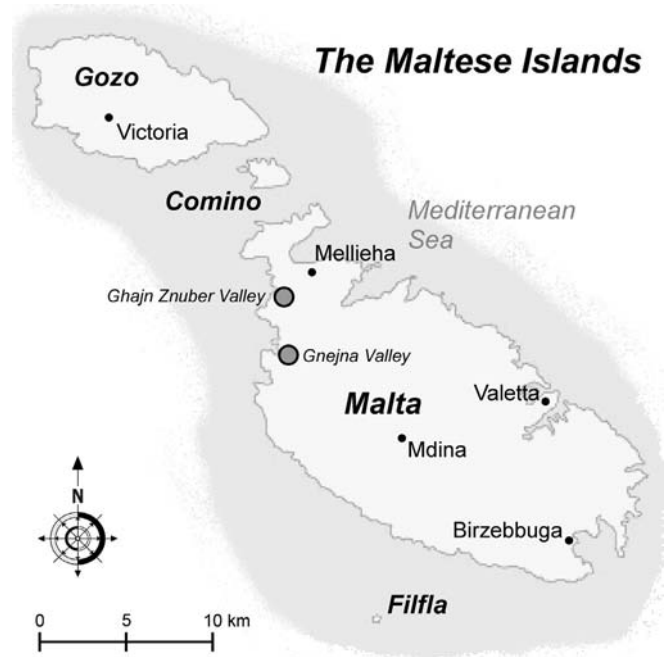


FIG. 3 - The Maltese Islands with both research areas (Gnejna Valley and Ghajn Znuber Valley).

To identify the land-use change it is necessary to have information spanning several years. For this purpose old and new aerial photographs as well as satellite imagery were compared. The aerial photographs available dated



FIG. 2 - Erosion on abandoned field terraces, Gnejna Valley, Malta. Bedrock is Middle Globigerina Limestone, slope angle ranges from 10 to 15 degrees. Photo B. Cyffka, September 2004.

from 1957 and 1998, and an Ikonos satellite image from 2004 were used (multispectral with a ground resolution of 4 m per pixel). From these sources (fig. 4) the change in land-use could be detected and mapped (fig. 5).

The aerial photo from August 1957 (fig. 4, right) shows vast areas of harvested cereal fields on the valley floors and moderate slopes. The terraced fields show trees, mainly olive trees with some fig and carob trees.

The aerial photo from 1998 was taken in November. Broad terraces are completely overgrown (see «2» in fig. 4). The dark grey patches are maquis and indicate the high degree of abandonment. However, these areas are not really prone to erosion. In contrast, the narrow areas at the steep slopes show light stripes (see «1» in fig. 4). These are dilapidated or broken rubble walls, and here, the entire slope is very prone to erosion (cf. fig. 2).



FIG. 4 - Change of land use in Gnejna Valley, Northwest Malta. Source. Aerial photographs from August 17, 1957 and November 11, 1998.

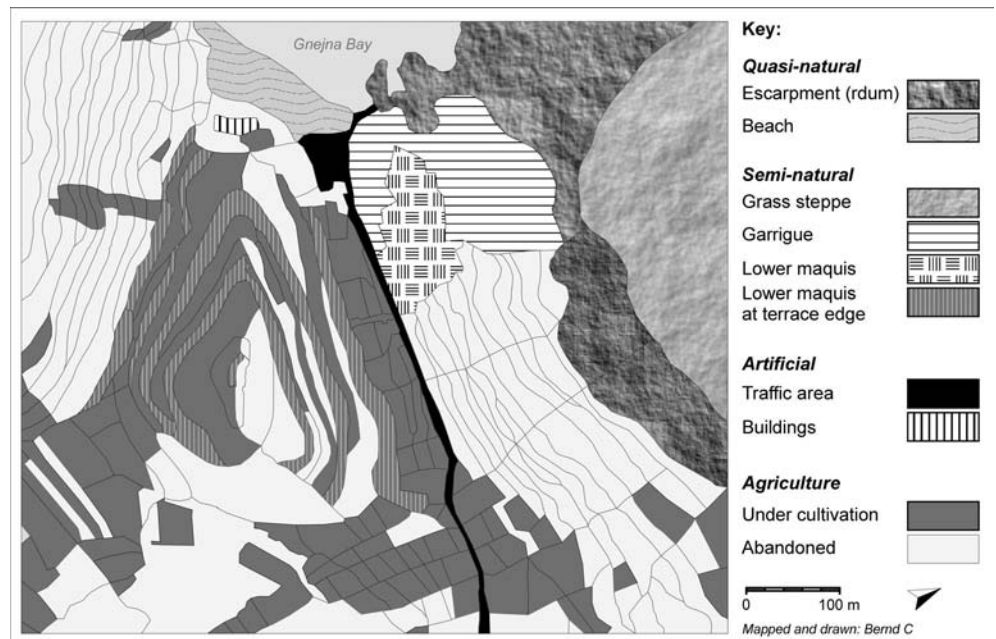


FIG. 5 - Recent land-use in Gnejna valley. Mapped in 2004, on the basis of the aerial photograph shown in fig. 6 («2»).

By using these photos, in combination with the satellite image, it was possible to draw a map of the recent land-use/-cover. Fig. 5 shows that there is a large proportion of abandoned land which is in fact degraded land, at least on the steep slopes. Comparing the area with similar ones in the northwest of Malta it is apparent that often the south-oriented, and therefore drier, slopes are those parts of a valley that are abandoned first.

The problem of erosion on terraced land is the unpredictability of the erosion path. Normally it is possible to set up a Digital Terrain Model and to calculate the slope angle and possible flow lines of the surface water in case of heavy rainfall. This was also the first approach here. Of course the DTM from a source in the scale of 1:25,000 (fig. 6) was too coarse to calculate slope angles valid for research at this scale. But even a DTM derived from maps in the scale of 1:2500 fails to give the desired result. It is not possible to model the field terraces from these sources. The only solutions could be a land survey, which is very expensive and time-consuming, or a DTM derived from an airborne laser scanning, which was not available at the time of research. In this area, the present work identifies the need for further research. At present there is ongoing work on the basis of fig. 6 to incorporate the geometry of rubble walls and collapses into the DTM.

Going into more detail, it is important to determine the vegetation currently present on the abandoned field terraces. This topic is demonstrated at the second research area in Malta, the valley of Ghajn Znuber. Vegetation mapping was carried out to get an estimate of the composition of the plant community on abandoned terraces. This was supported by cross sections of rubble walls to give an indication of their dimensions, and the relation between fields, terraces, and rubble walls. Finally an overall mapping of rubble walls and their collapses was done to show the possible paths of surface water flow and erosion. The results are shown in fig. 7. Several collapses of rubble walls below each other predetermine a flow path which will be used by heavy rain fall. This will lead to erosion events whose possible effects are shown in fig. 2.

Fig. 8 shows a cross section through a traditional field terrace. It can serve as an example of many terraces in the Maltese Islands. The figure does not show the collapses, but the state of the vegetation cover after more than 5 years of abandonment caused by rural emigration. Typical are the remnants of agricultural crops like grapevines (*Vitis vinifera*), fig trees (*Ficus carica*), and olive-trees (*Olea europaea*). Furthermore there are typical indicators of abandonment like fennel (*Ferula communis*), wild asparagus (*Asparagus acutifolius*), and summer asphodel (*Aspodelus aestivus*). Most important is that the rubble walls dam up the water from heavy rainfall and the plants bind the soil material and both protect the soil from erosion. But this only works with orderly maintained rubble walls.

To get an indication of the ecological potential of an abandoned field it is necessary to go into even more detail and to investigate the soil. Soil samples were taken at different terraces (under cultivation, recently abandoned, abandoned at an earlier time) and analysed in the laboratory. The main focus was on pH and calcium carbonate, on the carbon-nitrogen relation, on humus, and on the grain size distribution. The results are shown in tab. 1 and discussed in the subsequent paragraph.

TABLE 1 - Results of soil sampling analyses. Stones (> 2 mm): Percentage of total sample. Other parameters: Value of fine soil sample (> 2 mm). Date of sampling: September 2004. All values from topsoil, upper 10 cm

Sampling site	Type	pH [-]	CaCO ₃ [%]	C/N [-]	Humus [%]	Stones [%]	S [%]	U [%]	T [%]
2	abandoned	7.34	49.1	35	16.1	47.2	27.7	39.6	32.7
3	fallow, water melons till August	7.59	6.3	14	1.8	3.1	5.8	35.4	58.8
4	abandoned	7.14	41.3	36	13.5	50.7	23.6	42.2	34.2
6	freshly ploughed	7.34	2.3	13	5.1	2.7	4.2	55.8	40.0

Tab. 1 clearly shows that abandoned fields have the ecological potential to recover. Calcium carbonate and humus significantly have better values than on sites under

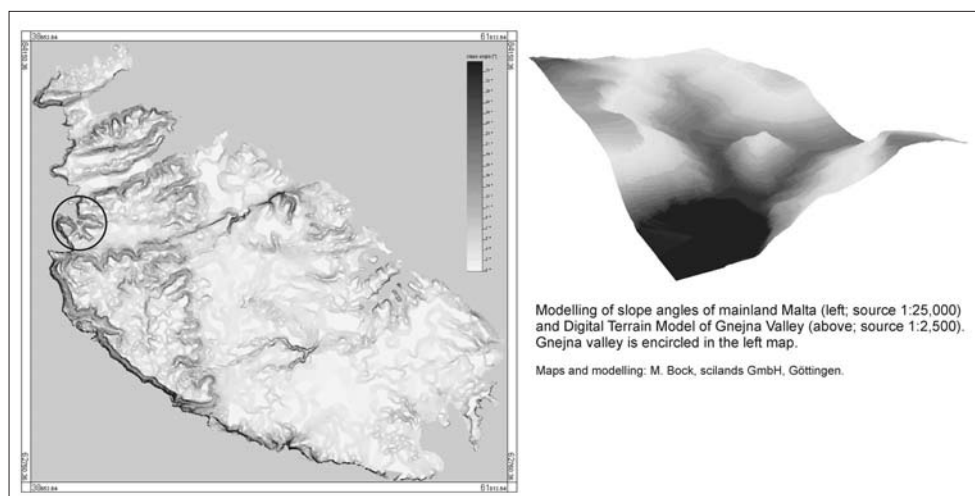


FIG. 6 - Digital modelling of Malta and Gnejna valley.

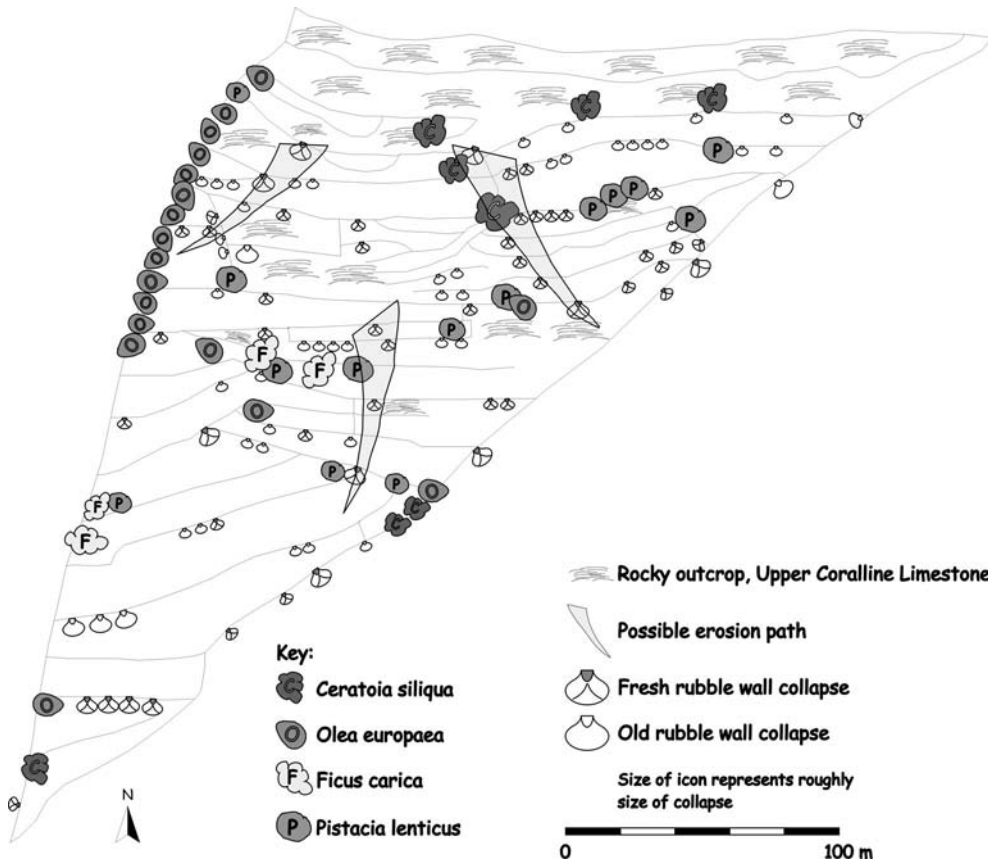


FIG. 7 - Sketch of abandoned area in Ghajn Znuber valley, Northwest Malta showing remnants of agricultural crops and rubble wall collapses. Mapping B. Cyffka, September 2004.

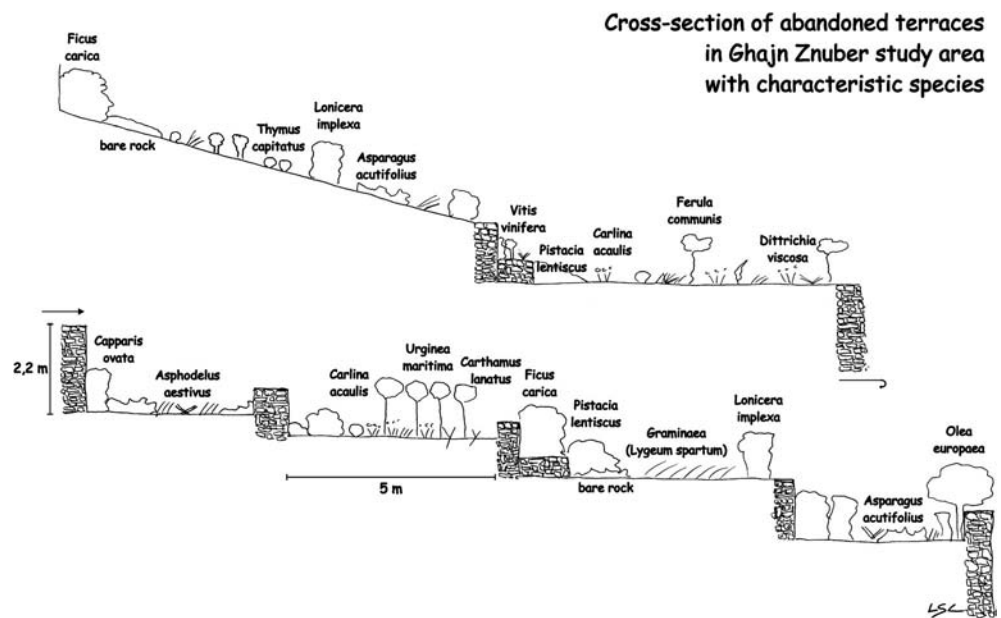


FIG. 8 - Cross section through a typical field terrace. Mapping B. Cyffka, September 2004, drawn by L. Cyffka.

cultivation. The amount of stones is also higher there due to the wash out effect of fine soil particles by soil erosion. The result is a relatively higher percentage of the grain size silt (U) and clay (T) in cultivated soils and shows the effects of heavy rainfall on abandoned fields.

To observe the effects and the extent of erosion of heavy rainfall on different soil surfaces (i.e. different types of cultivation and/or abandonment) a rain gauging station was installed during the field campaign in September 2004. But unfortunately there was no significant rainfall to

be measured in a period of nearly three weeks. Therefore there has not been any possibility yet to set up a correlation of heavy rainfall and the results of soil sampling.

DISCUSSION

The 1960s produced a complete change in the Maltese economy and agriculture. Industry and the services sector increased in importance, especially tourism. As on Elba, it became more and more attractive to work in the cities, factories, shipyards, and hotels. Again land abandonment accompanied these phenomena and triggered a complete change in the Maltese agriculture. Aside from the part-time farmers, there was, and still is, a process of intensification in growing vegetables as well as vines. The difficult-to-cultivate field terraces were abandoned and major farms emerged on the valley floors (see fig. 9, left background). In more recent times, additional new techniques, such as green houses and plastic films are being used to grow new products for the near European market that Malta joined in May 2004.

Fig. 9 illustrates the situation described above. Modern Maltese farmers grow lettuce for the European market in plastic gutters with fluid culture medium in greenhouses. Strawberries grow under the plastic films during the winter months. There is no frost on Maltese Islands, but greenhouses and plastic films protect the fruits and vegetables against the wind and the salty sea spray.

The field terraces right in the middle of the photo (fig. 9) are mainly abandoned. Only a few patches of land are

cultivated, though the slope gives a stable and intact impression because of the gentle terrace edges. They are naturally stabilised by vegetation and without rubble walls. A terraced slope of this type will overgrow within a short period of time, and in this case, abandonment might be a chance for nature to reclaim certain patches. In former times nearly every single piece of land in this area was used for agriculture. Obviously a major change has happened. These changes can be quantitatively proven by aerial photographs. It is possible to determine major changes by analysis of aerial photos from 1957 to 1998. The result of this analysis has been shown above (fig. 4).

The large number of abandoned fields is very obvious. Nearly every field shown in fig. 5 as «abandoned» was under cultivation in 1957. The land cover of the abandoned fields is variable and depends on the natural conditions. The geology is the same, Blue Clay and Globigerina Limestone, with the aspect and inclination of the slopes being the determining factors. Southern aspects lead to more evaporation and water stress for the vegetation. These slopes are much drier and generally covered by garrigue or grass steppe (fig. 10). Inclination less than 5° is still cultivated while steeper slopes are abandoned.

More humid conditions lead to thick green fuzz, the Maltese type of maquis. This large shrub layer often consists principally of Carob (*Ceratonia siliqua*), which was formerly planted by man (Schembri, 1997). From the view of nature this might be a progress in an often karstic landscape, but as far biodiversity is concerned, it is a retrograde step. Development of this type of maquis often occurs out of fewer than only (!) eight species (own investi-



FIG. 9 - Modern agriculture vs. abandoned field terraces, Gnejna Valley, Northwest Malta. Economically agriculture in plastic green houses is more productive than farming on terraces. Photo B. Cyffka, April 2003.



FIG. 10 - Slope with abandoned field terraces in southern aspect under very dry conditions (in the foreground). Vegetation was grass steppe that had burnt down at time of taking the photo. In the middle of the photo, in the valley floor and on shallow slopes there are field terraces and greenhouses in cultivation. Photo B. Cyffka, September 2004.

gations in 2001) because the dense Carob shrub brings a lot of shadow to other plants. Recent investigations not far from this area in a semi-natural maquis at a relatively inaccessible site at the foot of an inland cliff (the Maltese word for such areas is *rdum*) gave results of 15-20 species. Interestingly enough, Carob was missing in the shrub layer of this area completely and obviously «replaced» by Lentisk (*Pistacia lentiscus*) and a Spurge (*Euphorbia dendroides*), which are more natural in the Maltese Islands than Carob.

The most impressive change has happened on the lower parts of the sunny southern slopes, mentioned above. In 1957, this slope was built up by field terraces supported by rubble walls. In 1998 this slope was completely devastated. The rubble walls were broken down, and large patches of land were heavily eroded because of lack of maintenance. Without regular care, the stones break out of the walls and fall down. Over time, a gap forms in the wall, and this becomes the first path for water erosion. And so, in the Maltese case, there is no invasion of alien plants as on Elba, but the hot and dry Maltese climate - especially on southern and steep slopes - prevents quick and dense vegetation covering of the soil. According to Aschemeier & Cyffka (2004a), there is a chronological sequence of the collapse of terraces and rubble walls:

1. abandonment of the field terrace;
2. continued abandonment leads to damage and gaps in the rubble walls (e.g., fig. 6);
3. eventually some parts of the rubble walls completely collapse;
4. during winter conditions (cloudbursts, flash floods), erosion of parts of the soil slides down onto the next terrace (depending on the size of the gap);
5. the gaps begin to form large gullies;
6. when the gullies form a «pass» or «gate», additional soil material behind the rubble wall is eroded;

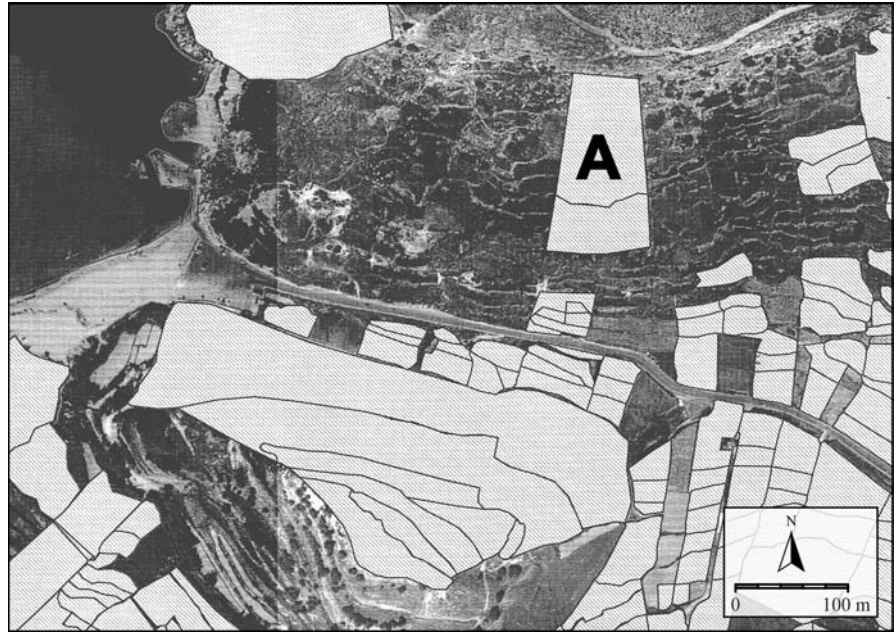
7. erosion spreads to the next lower terrace;
8. the entire slope is endangered (fig. 2).

A huge amount of soil loss results from the above-mentioned processes. For this reason, soil erosion is one of the biggest problems in the Maltese Islands. It must be stopped, not only to preserve the field terraces and rubble walls as a culture heritage, but also to prevent the soil from being washed down to the sea. The significance of this problem indicates that there is an urgent need for more research on this subject (Brown, 1991).

The results from figs. 7 and 8, and tab. 1 show the ecological potential of the areas. It is very interesting to see the change in grain size between abandoned and cultivated fields. On the abandoned ones there is a kind of stone plaster on top of the soil which is the result of the continuous outwash of fine soil material. The C/N ratio is much lower and therefore better on cultivated fields, of course because of the use of fertilizers. But at about 35, the C/N ratio in abandoned fields is not much worse, and so there is still the potential for the re-introduction of agriculture in future. But before this can start it is absolutely necessary to maintain the rubble walls.

On the other hand, not everything is on the decline in the Maltese Islands. Malta joined the EU in May 2004, and with this accession came new problems as well as new possibilities. The Maltese pre-accession negotiations went very well for the country, and therefore, many special or transitional rulings were established (cf. Aschemeier & Cyffka, 2004b). Some regulations in this process of integration included the recommendation to grow more vines, and over the past several years there has been a major increase in wine-growers buying abandoned vineyards. Therefore, many of the previously abandoned fields, often used for wheat growing in the past, are now becoming wine-growing areas (fig. 11). Several farmers are waiting for a break-

FIG. 11 - Recommissioning of abandoned fields. Areas where land owners have indicated the intention to farm at present or in the near future. Map redrawn from friendly communication with Maltese Environmental and Planning Authority, 2004.



through in economy, but wine-growing is not without problems. It is obvious and quite normal for grapevines to grow on a field without any other vegetation covering the soil. Weeds are unwanted, so grapevines are an open cultivation. Therefore, these fields are prone to soil erosion as well. Under these terms, the Maltese agriculture continues to have a major erosion problem, regardless of whether one considers the abandoned fields or the newly formed ones.

Agriculture on the valley floors is slightly better protected because of the accumulation of eroded sediments from the slopes. In some places it is questionable whether reclaiming of cultivated land for wine-growing or other purposes will be successful. The area marked with an «A» in fig. 11 is exactly the same area shown in the foreground in fig. 10. It is obvious when comparing these two illustrations that there are many problems to overcome before vine growing can be totally successful.

This explains the dilemma of agriculture in Malta. Abandonment, on the one hand, does not necessarily mean the regaining of natural or at least nature-like areas. But, it is necessary, from both an environmental and a political perspective. After the integration in the European Union, not only are there possibilities for wine-growing, but European law also demands more nature reserves in the Maltese Islands.

Preliminary investigations by the authors show that abandonment may also mean soil erosion and degradation – a very undesirable aspect of land transformation. On the contrary, if efforts are being made to bring as many abandoned areas as possible into agriculture, there is again the risk of soil erosion and additional economical risks and damages. No matter what is decided, land use change will provoke land cover transformations, and thus establishes the need to form an intelligent master plan for

sustainable land use development. In any case, the process of land abandonment must be stopped. There are many land use conflicts in other countries of the Mediterranean region (García-Ruiz & Lasanta, 1993), and land cover transformation seems to be one of the most urgent problems.

How can tourism help to solve these conflicts? Tourism is one of the most driving economical forces in many Mediterranean countries, especially on the islands. It is a fact that unattractive and unsightly scenes deter tourists. If the percentage of built-up areas is too high – as in many parts of the Maltese coast – it is necessary to compensate by having some kind of more or less pristine natural environment. Modern investigations (Aschemeier, 2005) even show that it is not only nature, but also the traditional regional products which attract tourists. And here things come together. It is necessary to transform the partly spoilt and degraded Maltese countryside into a nature-like environment, and to create favourable conditions to grow traditional products as well as vine and vegetables.

Scenic views which are nearly everywhere at the Maltese coastline can be replenished by terraced fields, and by ‘terraced nature’ in case of the abandoned fields, if maquis regains the former field terraces. All this, complemented by an intelligent tourist infrastructure – which is partly also missing, e.g., marked footpaths, catering stops, toilets at reasonable distances – can make the Maltese countryside very attractive. Thus, geomorphic and landscape features can help boost Maltese tourism!

The main problem is that there is a struggle between the different types of land-use.

The future task of research and planning in the Mediterranean will be to overcome this struggle and to balance the different demands.

OUTLOOK

One of the main results of this research is that land use changes influence land cover transformations in different and often uncontrollable ways. For this reason, there is an urgent demand for more field research to find out what can be done to change it. It is necessary to set up large maps for landscape planning that show the state of the present land use and land cover, and it is also important have the historical state of the landscape to identify the changes that have occurred over time. With this knowledge, one can start a process of planning to determine the concepts that are needed (e.g., for landscape development or landscape management). It is necessary to include as many aspects as possible into these concepts, such as vegetation, soil, agriculture, tourism, urban sprawl etc.

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