

Socioeconomic Dimensions of Changes in the Agricultural Landscape of the Mediterranean Basin: A Case Study of the Abandonment of Cultivation Terraces on Nisyros Island, Greece

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Published online: 1 January 2008
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Abstract Agricultural landscapes illustrate the impact of human actions on physical settings, and differential human pressures cause these landscapes to change with time. Our study explored changes in the terraced landscapes of Nisyros Island, Greece, focusing on the socioeconomic aspects during two time periods using field data, cadastral research, local documents, and published literature, as well as surveys of the islanders. Population increases during the late 19th to early 20th centuries marked a significant escalation of terrace and dry stone wall construction, which facilitated cultivation on 58.4% of the island. By the mid-20th century, the economic collapse of agricultural activities and consequent emigration caused the abandonment of cultivated land and traditional management practices, dramatically reducing farm and field numbers. Terrace abandonment continued in recent decades, with increased livestock grazing becoming the main land management tool; as a result, both farm and pasture sizes increased. Neglect and changing land use has led to deterioration and destruction of many terraces on the island. We discuss the socioeconomic and political backgrounds responsible for the land-use change before World War II (annexation of Nisyros Island by the Ottoman Empire, Italy, and Greece; overseas migration opportunities; and world transportation changes) and after the war (social changes in peasant societies; worldwide changes in agricultural production practices). The adverse landscape changes documented for Nisyros Island appear to be inevitable for modern Mediterranean rural societies, including those on other islands in this region. The island's unique terraced landscapes may

qualify Nisyros to become an archive or repository of old agricultural management techniques to be used by future generations and a living resource for sustainable management.

Keywords Agricultural landscape · Landscape elements · Land-use change · Population migration · Animal husbandry · GIS mapping · Aegean islands

Introduction

Agricultural Landscape

Common definitions for agricultural landscapes focus on land use and production (Forman and Godron 1986; Wascher 2000a) as well as on micro- and macro-scale structures within the landscape (Wascher 1999, 2000a; CEC 2000). Such definitions are adequate for the analysis of agriculture and animal husbandry in an area, but they lack a broader perception at the landscape level because they consider the associated rural societies to be isolated or static entities. Landscapes, however, alter continuously in response to the changing characteristics of an area. Such characteristics can be environmental (isolation, natural boundaries, climate, resources, etc.) and societal (productive structures, power relations, etc.) (Muir 2003; Antrop 2005; Kayhko and Skanes 2006). The interaction of environment with society may bring about drastic modifications in the economic processes and systems of a society, and the effects of these modifications eventually become visible in the landscape. This is why the agricultural landscape is more than just a view (an “extensive area of sceneries viewed from a single place”; Haber 1990) or a morphological structure (“all the natural features... that

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distinguish one part of the surface of the earth from another part"; Steiner 1991; Wascher 1999). Instead, the agricultural landscape is defined by the numerous relationships between a society and the landscape it inhabits over a certain time period, and its form results from the interactions of natural and human factors over time (Wascher 2006). In this article, we have chosen to consider the agricultural landscape as the palimpsest of human actions over a landscape, reflecting natural and cultural goods or history in visible or invisible ways that are measurable to some extent.

This definition implies that an agricultural landscape is defined by economic, ecological, and cultural factors. Economic factors refer to the products of agricultural land uses in the landscape, including both commodities and services (e.g., tourism, recreation). The ecological dimensions of agricultural landscapes sustain a range of species and habitats, and every change in the landscape's agricultural systems and practices is reflected in corresponding changes in the diversity of species and natural resources (Forman and Godron 1986; Turner and others 2003; Jongman 1997; Wascher 2000b; Stobbelaar and van Mansvelt 2000; Mander and others 2005). The symbolic cultural dimension is also important, as it represents the wider meanings, values, and ideologies of rural societies, and is thus far richer in symbolic content than the agricultural land uses alone (Palang and others 2005).

Cultivation Terraces in the Mediterranean Basin

In the Mediterranean basin, traditional agricultural practices dating back hundreds or thousands of years have clearly shaped the landscape. Cultivation terraces are the most conspicuous landscape elements in the Mediterranean basin that have been created to manage agricultural land, second only to human settlements. Other important landscape elements in the Mediterranean basin include fences (hedgerows and dry stone walls), footpaths, structures built to support agriculture and animal husbandry (storehouses, animal yards, dwellings; structures that support watering of the animals or that support cultivation, harvesting, and processing of agricultural products, such as threshing floors, wine presses, wind and water mills, wells, tanks, etc.), and other rural structures such as temples and churches (Rackham and Moody 1996; Gasparis 1997; Petanidou and others 2001; Kizos and Spilanis 2004).

Terraces, which are referred to as *pezoules* throughout Greece and as *vastadia* on Nisyros Island, refer to horizontal man-made spaces created to permit or facilitate cultivation on sloping terrain (i.e., on hills and mountains), and in the Mediterranean region, terraces have almost always been supported by dry stone walls (Petanidou and others 2001).

Although typical of the Mediterranean basin, these terraces are also found around the world (Netting 1993; Petanidou and others 2001). In cross-section, the terraces resemble wedges cut out of the slope by digging from above the eventual position of the terrace and then back-filling with the excavated material (or, in extreme cases, with soil brought from elsewhere) to create a level surface. Three major types of dry stone wall terrace are recognized in the Mediterranean basin: *step terraces*, which form relatively straight lines, often oriented along the slope's contour and perpendicular to the slope; *braided terraces*, which zigzag back and forth along a slope; and *pocket terraces*, which are isolated patches of soil that typically support individual trees (Rackham and Moody 1996; Fig. 1). The first two types of terraces have sustained a variety of different land uses in the past, such as cultivation of cereals, vegetables, and pulses; viticulture and tree farming (orchards, olives, chestnuts, and other dry nuts); and grazing (Grove and Rackham 2002; Kizos and Koulouri 2005). Pocket terraces are used to support individual trees, especially olives in the Aegean area (Petanidou and others 2001).

Land terracing has been one of the most important human interventions that has shaped the Mediterranean landscape (Petanidou and others 2001), and the presence of terraces throughout most of the Mediterranean basin suggests that this has been an effective land management tool (Veeck and others 1995; Hammad and Borresen 2006). Although the past distribution of terraces has been questioned, terraces were reported as far back as the 5th century BC (Brunet 1990; Rackham and Moody 1992, 1996; Lohmann 1992; Whitelaw 1994; Jameson and others 1994; Doukellis 1998; Fittschen 1998; French and Whitelaw 1999; Price and Nixon 2005) and there is evidence that they were present even during the Iron Age (Barker and others 1995; Grove and Rackham 2002; Petanidou and others 2001).

It is not clear when the currently evident massive landscape sculpturing with terraces took place in the Mediterranean basin. Construction probably followed the demographic demands of individual areas and undoubtedly did not happen all at once. Although direct evidence is lacking, historical data imply that large-scale terrace construction in the Mediterranean basin began after the end of the Middle Ages, around the time of the Renaissance: on the Dalmatian islands of Hrvar and Krk, this period begins around the 16th to 17th centuries (Nicod 1990), whereas on the island of Lesbos and throughout the Aegean, it began between the end of the 14th century and continued until roughly the 19th century (Argyris 2001). A historical review of the Aegean archipelago showed that all positive demographic events (e.g., inflow of immigrants) were followed by expansion of the area of arable land, most likely by establishing additional terraces in marginal lands (Argyris 2001).

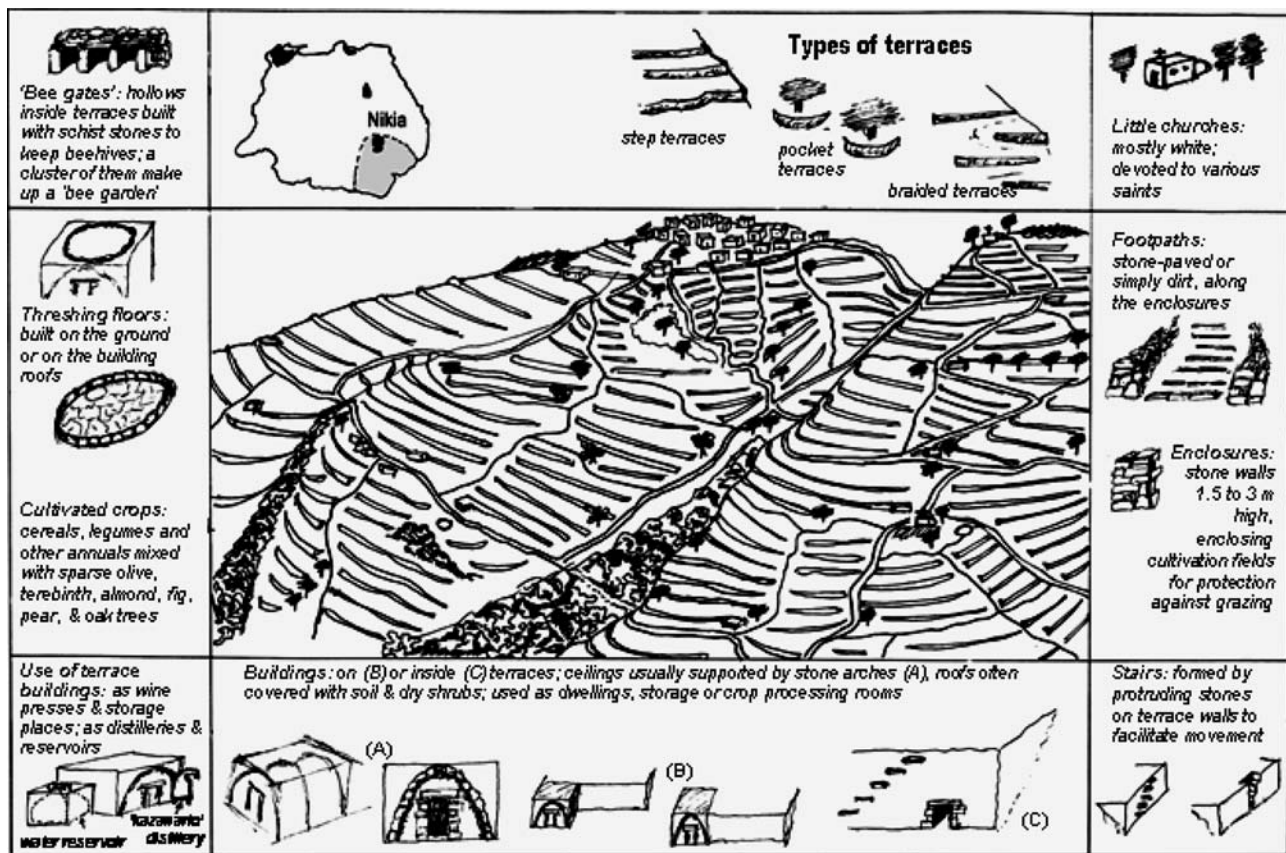


Fig. 1 Illustration of the Nikia settlement on Nisyros and the surrounding landscape, which faces south to the sea. Typical landscape elements, as they appear in reality, are depicted in the main picture, with detailed explanations given in the smaller surrounding pictures. Drawings by T. Kizos after a photo by C. de Vries (Economakis and de Vries 2001)

Throughout the Aegean archipelago, terraces have been cultivated for centuries, and cultivation continued until the beginning of the 20th century. Since then, terrace cultivation was progressively abandoned in favor of farming in easy-to-cultivate lowlands (Margaris 1992). A visible consequence of terrace abandonment has been the collapse of the network of dry stone walls due to a lack of economic interest and a loss of the necessary knowledge and skills, as well as other reasons of secondary or local importance. As a result, soil erosion (Inbar and Llerena 2000; Duiker and others 2001; Cammeraat and others 2005; Koulouri and Giourga 2007), a decrease in soil fertility and crop yield (Vagen and others 1999; Gebremedhin and others 1999), and possibly biodiversity loss (Petanidou and others 2001; A. Dalaka and T. Petanidou, unpublished data, University of the Aegean) are more likely to take place where the terraces have been abandoned, thus increasing the risk of desertification in these regions, at least in the short term (Petanidou and others 2001). In the latter study, it is stated that the research respondents in many islands of the south-eastern Aegean agreed that frequent landslides and gully erosion on the islands in recent years were potentially

related to terrace degradation and destruction. Because terraced environments have largely been abandoned, and the terraces and their support structures are no longer maintained, the terrace landscape element is endangered and the terrace ecosystems that have evolved over centuries or millennia may be lost if they are not actively preserved.

Inbar and Llerena (2000) proposed that terrace degradation results from a combination of physical and socioeconomic factors. We believe that terrace degradation is the physical symptom of these factors, and results from land abandonment caused by socioeconomic processes. We hypothesize that terrace abandonment goes hand-in-hand with changes in population structures and economic development, and that these changes have dramatic, or even irreversible repercussions for the type and extent of land use in an area. One possible cause of this abandonment could be the reduction in profitability of agriculture, resulting in emigration of farmers to other areas or changes in their profession. We tested these hypotheses by means of a case study of the island of Nisyros, in the Dodecanese region of the Aegean archipelago. Our research objectives focused on defining landscape change in the context of two

working hypotheses: (i) intensive terrace use for agriculture was related to high population densities on the island, and (ii) the progressive abandonment of cultivation on terraces resulted in different types of land use that reflected changes in the socioeconomic structure of local society as a result of external influences (e.g., political, economic). We also explore potential management objectives for the terraced landscape, and particularly the preservation and future management of such landscapes despite the low population inhabiting these islands: Does it make sense to preserve such landscapes by continuously managing them by following traditional methods, given that they are no longer essential to sustain human survival, and is it feasible to do so?

Sources and Methods

Study Area: The Island of Nisyros

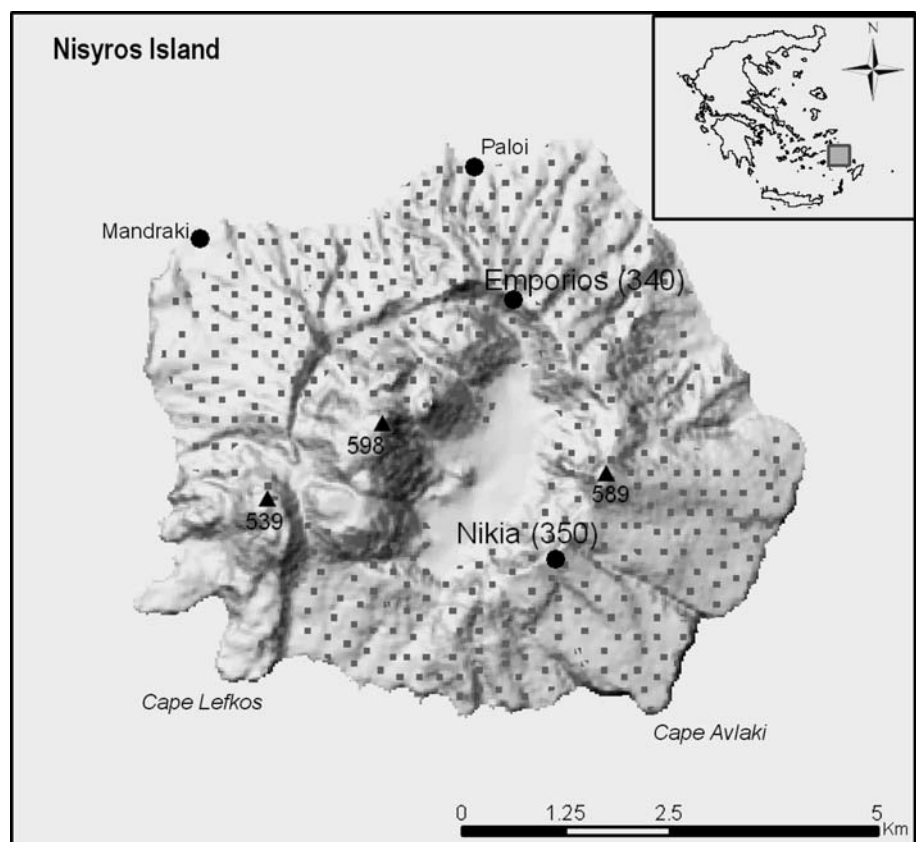
Nisyros, 40.92 km² in size, is a volcanic island and is the only cone-shaped island in the south-eastern Aegean (Fig. 2). It is mostly hilly to mountainous, with elevations of up to 598 m asl and slopes of up to 53%, with only one plain (located inside the caldera). This plain is the only nonterraced area on the island that is used for cultivation. Based on data from a

digital elevation model (DEM, discussed in the next section), the average slope for the island as a whole is $18.0 \pm 0.9\%$. Climate is Mediterranean with mild winters and hot and dry summers (in the nearby island of Rhodes, mean monthly temperature is 19.2° C and mean annual precipitation 687 mm; <http://www.uk.weather.com/weather/climatology/GRXX0017?from=smartlinks>).

The natural vegetation of the island consists mainly of Mediterranean evergreen sclerophyllous shrubs (the dominant species are *Pistacia lentiscus* L., *Ceratonia siliqua* L., and *Olea europaea* L. var. *sylvestris* Brot.) and phrygana communities (dominated by *Cistus incanus* L. subsp. *creticus* (L.) Heywood, *C. salvifolius* L., *Thymus capitatus* (L.) Hoffmans. & Link, *Phlomis fruticosa* L., *Anthyllis hermanniae* L., *Lavandula stoechas* L., *Origanum onites* L., and *Sarcopoterium spinosum* (L.) Spach), with scattered trees of terebinth (*Pistacia terebinthus* L.), olive (*O. europaea* L. var. *europaea*), and oak (*Quercus coccifera* L. and *Quercus macrolepis* Kotschy) (Petanidou and others 2001).

Nisyros is an interesting example of an Aegean island because it has several features that make it unique: First, the terraces were carved on the slopes of a volcano's cone, across a wide range of slope gradients and with exposure to the sea at many positions (i.e., on the outer slopes of the cone) and shelter from the sea (i.e., inside the caldera) at other positions (Fig. 2). Second, Nisyros has a higher

Fig. 2 The cone-shaped island of Nisyros, with its main settlements and major areas covered with terraces (dotted areas). The density of terracing is not illustrated. Mapping was performed using a GIS system combined with a digital elevation model (DEM), as described in the text. Numbers represent elevations (m) above sea level



degree of terracing than is observed on most of the Dodecanese islands (Petanidou and others 2004). Because it is a small- to medium-size island, with limited port facilities, Nisyros has always been somewhat isolated and loosely connected to nearby major islands (such as Kos and Rhodes) and to the mainland (Greece and Asia Minor); as a result, its inhabitants have been forced to adopt subsistence farming, and the economy has developed accordingly. As a consequence, the island has been intensively cultivated in the past, and is known for a variety of local products, both comestible and durable (Petanidou and others 2001).

There are three major settlements on the island (Fig. 2): Mandraki, the modern port where most of the island's current population resides, and Nikia and Emporios, typical settlements that were protected from pirates during historical times, both of which are located at two of the highest points on the caldera, in naturally well-defended spots. "Emporios" is a common place name within the Aegean islands because it means "a place of merchants," which provides clues to the village's significant role in commerce within the island (Papahristodoulou 1969; Ekonomakis and de Vries 2001). The decline of Emporios during the first half of the 20th century in favor of the coastal villages of Mandraki and Paloi (the latter was created entirely from people displaced from Emporios in the 1930s) illustrates the typical coastalization development process that has occurred in the Mediterranean basin (Papahristodoulou 1969; Grenon and Batisse 1989).

Estimation of the Terraced Area and Evaluation of the Dry Stone Walls

Based on our experience in the region and through questions posed to the local population, we determined that the major terrace complex of Nisyros was built before World War I and was in full use by the beginning of the 20th century.

We mapped the island's terrace complex regardless of the condition or age of the supporting dry stone walls. First we attempted to map the terraces based on photointerpretation using three series of aerial photographs purchased from the Geographical Agency of the Greek Army (GYS), with each series covering the entire surface of the island, for the years 1960 (scale 1:40 000), 1981 (1:15 000), and 1990 (1:30 000). However, mapping terraces from these aerial photos proved to be complicated and unreliable, mainly due to the low quality of the available photos (Petanidou and others 2001). Topographic maps (scale 1:5000) also proved to be useless because terraces were seldom recorded. In the end, terrace mapping was carried out in situ by means of visual observation of the terraced areas. Areas having a uniform density of terraced fields were considered as a "map unit" and were

mapped, at a scale of 1:25 000, by using the GPS device to geo-reference the positions of their corners. While performing the GPS survey, the percent coverage by terraces was estimated within each map unit, considering any un-terraced land sections in the unit. Terrace density and mapped area per unit were used to calculate the total area occupied by terraces at the unit level, and then summed up to the island level. The condition of the dry stone walls was also recorded and the walls were assigned to one of the following groups: relatively well preserved, with destruction of <25% of the wall; 25 to 50% destroyed; >50% destroyed; and various combinations of different levels of destruction.

Field measurements were digitally processed using a Geographical Information System (GIS) (ArcView 3.2, ArcMap 8.1) to: (i) create a digital map of the terrace complex; (ii) develop a database containing the % coverage of sites by terraces and the quality of the dry stone walls; (iii) link the digital map with the coverage and wall databases; and (iv) visualize the information in a cartographic form. The total area of the island covered by terraces was estimated using the GIS software (the Spatial Analyst extension of ArcView 3.2).

The topographic maps used to position the terraces (scale 1:50 000) and the DEM used in the mapping exercise were purchased from GYS.

Socioeconomic Data

Population, land use, animal husbandry, and other data used in the study were retrieved from a variety of sources. These included: (i) official statistics from ESYE (the Greek National Statistical Agency) and the Regional Municipality of Nisyros; (ii) the local cadastral records; (iii) the inhabitants themselves (through questionnaires); and (iv) other available documents and literature.

Although they originated from official statistics, the statistical data that we collected were not always comparable and trustworthy, thus we paid particular attention when interpreting these statistics. When necessary, significant inconsistencies are noted in the present paper.

Livestock populations were obtained from ESYE (1976, 1998, 2003), and were converted into animal units (AU) following the KYA 568 (2004) guidelines. According to this approach, a cow or bull equals 1 AU, a calf equals 0.6 AU, and a sheep or a goat equals 0.15 AU.

Important data were drawn from the official cadastral records for the island. These cadastres, one for each of the three villages (Paloi is included in the Emporios records), covered the period from 1884 to 1947, the year when Nisyros became part of Greece. All the registers covered personal and family possessions (i.e., fields and houses), and provided information on the size and location of the

fields, as well as the dates and motives for transfers of ownership. The Nikia cadastre only provided the sizes and locations of fields. We independently analyzed each of the three cadastres that were available for the island. In each cadastre, we examined all records in the cadastre, in the order in which they were listed. To facilitate our analysis, we grouped these records into triplets (e.g., records 1 to 3, 4 to 6, 7 to 9, and so on), then analyzed only the first record in each triplet (e.g., 1, 4, and 7). Where the first record in a triplet was illegible, we instead analyzed the second record (e.g., 2, 5, or 8), and where that record was also illegible, we analyzed the third record. As a result of this approach, we were able to analyze a sample amounting to one-third of the available data. In total, we recorded 5562 cultivated fields, which suggests a total of $3 \times 5562 = 16,686$ fields for the entire island during this period.

Data concerning the period after annexation by the Greek State (i.e., after 1947), which roughly coincided with the major period of terrace abandonment, were almost totally lacking. As a result, we obtained these data directly from the island's inhabitants through two questionnaires. The first survey collected qualitative information on management practices, especially those related to terrace maintenance. It was carried out from April to August 2000 and consisted of nine open interviews of 1 to 2 hours each with local farmers and other knowledgeable people. The number of interviews was determined by the quantity of information added by each new interview. The survey was concluded when little or no new information was gained. The second survey (based on a structured questionnaire) collected quantitative and qualitative data on the process involved in the abandonment of terrace cultivation on Nisyros in terms of time and extent, and the associated motives. This survey was carried out in May 2003 using a total sample of 30 farmers, including some of the nine farmers from the first survey. The interviewees were selected from among farmers who were still actively cultivating land on the island (the 2001 agriculture census listed 42 farmers, not all of whom were still active) using the snowball sampling method (Robson 2002). The sample was distributed among three settlements proportionally to their population size (24 in Mandraki, and 3 each in Nikia and Emporios–Paloi). Both surveys focused on gaining information on the period before the 1990s, a decade when the most dramatic farming changes had already occurred on the island. For this reason, we believe that the 3-year interval between the two surveys had no measurable effect on the quality of our data.

Results and Discussion

The results presented in this article mainly concern two broad periods: from the 19th century through to the 1940s,

and the modern period after World War II. These periods correspond roughly to different groups of social and economic factors that were important in shaping the agricultural landscape of Nisyros; in the earlier period, the basic landscape elements were established, whereas in the later period, these elements began to deteriorate seriously.

The Agricultural Landscape of Nisyros Before the 1940s

Agricultural Production and Practices

Agriculture on Nisyros appears to have been typical of that practiced in many small or remote locations in the Mediterranean basin, with production oriented towards consumption by the farmer and their family, but always with a view to local or nearby markets. As Horden and Purcell (2000) point out, under Mediterranean conditions, *autarky* (the Greek term for self-sufficiency) was a desired goal, even though the goal has rarely been feasible. Diversification of production and land uses, storage of raw or processed products, and redistribution to markets lowered the economic risks and insured a strong connection with markets within the dense communication networks that developed in this region (Asdrahas and others 2003).

As shown by our fieldwork and subsequent GIS analysis, 58.4% of the island's surface is still terraced (all categories of wall quality combined). This means that if none of the terraced fields have disappeared as a result of erosion or conversion to other land uses, most of the island's surface was terraced and cultivated during the first decades of the 20th century: terraces covered a total of 2390 ha, with nonterraced areas excluded from this total (e.g., the plain inside the volcano's caldera). If the latter are considered, then the island's cultivated land covered a much broader area (Fig. 2). This high percentage differs noticeably from the value estimated based on the cadastral data, in which cultivated lands were limited to only 35.3% of the total area. This low percentage may have resulted from deliberately falsified field size records in the cadastres (i.e., to reduce taxes, which were calculated based on the area of the land), from unique characteristics of the social behavior of the villagers, or from the fact that these fields constitute grey records (fields that were recently terraced but not declared, that were left behind or unclaimed, that belonged to the church, or that were not recorded at all for various other reasons).

The main agricultural land uses on Nisyros were cereal cultivation (primarily barley, with a lesser amount of wheat) and viticulture, followed by trees (figs, almonds, olives, and terebinths), all in mixed cultivation of the terraced land. Trees were generally planted (or grafted) in

a sparse *dehesa* style (a mixed-cultivation system encountered mainly in Spain, consisting of scattered trees grown for various products and fuel, with the soil beneath the trees grazed or cultivated for field crops, typically cereals, or for other herbaceous species; Plieninger 2006). The arable lands were managed collectively at each location using a crop rotation system: a large part of the total area was sown with winter cereals and the rest was cultivated to produce legumes, summer cereals, and sometimes seasonal vegetables. The local name for the area sown with winter cereals is *kritharia*, which means “the barley place;” this suggests the dominance of barley, which generally grows better than wheat in relatively barren soils such as those of the Aegean islands. See Logothetis (1963) and Petanidou and others (2001) for more details. Due to its exceptional fertility, the plain’s area inside the volcano’s caldera was sown almost entirely with cereals every year. In all cases, manure was used as a fertilizer, and was provided by grazing animals (mainly sheep and goats, as well as working or pack animals). All grazing animals were under the vigilance of specially appointed guards to avoid any possible damage to the land sown with cereals throughout the island. This traditional practice contributed greatly to keep terraces in place over time. Due to a shortage of cultivated land, Nisyrians very rarely left fertile land fallow. Other activities of local importance to Nisyros were the collection of terebinth nuts and olives, both used on the island to make oil. The part of the island that was not cultivated constituted grazing land managed to support oaks, from which acorns were gathered and exported for use in tanning. Such pluri-activity and land uses were common practices in the Mediterranean basin, especially the eastern end, until the end of the 19th century (Kostis 1987; Pratt and Funell 1997; Gasparis 1997; Horden and Purcell 2000; Asdrahas and others 2003).

The general picture at the end of the 19th century and beginning of the 20th century was that of a place with limited resources (water, soils, and plains) that was managed extensively and effectively, as suggested by the relatively large area of cultivated land compared with later periods. This large area of agricultural land coincided with peaks in the island’s population (see the section “Demographic issues and the local economy”).

Landscape Elements

Characteristic landscape elements related to the traditional agricultural practices on Nisyros include terraces, enclosures with stone walls, paved paths, and different types of living and storage buildings (Economakis and de Vries 2001; Petanidou and others 2001; Petanidou 2005).

Terraced fields currently cover a total of 58.4% of the island’s area. The dominant type is step terraces, whereas pocket terraces are totally absent. The supporting walls range up to 3 m in height, and are made of nondressed stone, which is usually excavated locally or which is occasionally obtained from nearby quarries. Many of the walls bear cavities at their base that are used for storage or for production, such as the *melissothyries* (“bee gates”; Fig. 1) that are used for bee-keeping (Petanidou and others 2001; Petanidou 2005).

Stone wall enclosures of medium height (between ca. 1.5 and 2.0 m), also constructed from nondressed stone (mainly volcanic material), are very common. Many of them bear spaces meant for wooden doors, which indicate that animals were kept within the enclosures during certain times for grazing and to provide manure for fertilizer. Paved paths were also very common on the island, forming a dense network that connected settlements and cultivated sites. Remnants of this network can still be seen today.

Buildings constructed on the terraces were always small and simple. Either alone or in small groups, they provided temporary accommodation for the farmer’s family during extended periods of fieldwork. Such buildings, locally called *spiladi*, consisted typically of a single room frequently built with thick stone walls, usually with a two- to three-arched stone ceiling, or simply excavated underground at the height of a terrace or carved into solid rock. Other similar constructions served as animal shelters or storage places and, if supplied with the necessary equipment, as foot-presses for winemaking and the famous distilleries (*kazanario*) used to produce a local alcoholic drink made of grapes (Tarsouli 1950; Petanidou 2005). Threshing floors constructed either on the ground or on the roof of a building were common throughout the island.

An important characteristic of the landscape of Nisyros is that all the abovementioned functional elements are combined with small fields of irregular size in a way that is unique to the island and the Mediterranean basin. Figure 1 shows the different elements of this complex landscape under the Nikia settlement.

Terrace Abandonment and Land-Use Change on Nisyros

Demographic Issues and the Local Economy

Population estimates for Nisyros before the 18th century are uncertain, as this humble island has not received the same attention bestowed on larger Dodecanese islands, such as Rhodes or Kos (Saviorianakis 2000). Assuming that it

Table 1 Population changes on the island of Nisyros from 1821 to 2001

Settlement	1821	1850	1900	1910–12	1917	1922	1931	1936	1941	1947	1951	1961	1971	1981	1991	2001
Mandraki										1362	1240	1114	853	718	677	708
Emporios										676	643	364	244	182	41	192
Nikia										461	444	322	192	84	61	48
Total	3300	3500	4700	5000	4300	3160	3430	3404	2592	2499	2327	1800	1289	984	779	948

Sources: Anonymous (1956), Logothetis (1963), Agapitidis (1969), Gerozisis (1998), ESYE (1991, 2001)

followed the same general pattern as other small islands in the area, Nisyros in the 18th century was probably self-governed under the Ottoman Empire and later under the Frankish regime (Liata 1987; Lock 1995; Savorianakis 2000; Lowry 2002), and was only taxed by the Ottoman province of Rhodes (Savorianakis 2000). In the late Empire, most of the region's Muslims resided on the islands of Kos and Rhodes, and the population of Nisyros was Christian. The population also included local officials representing the empire, a common Ottoman practice in remote or Christian-populated areas (Savorianakis 2000; Lowry 2002).

Population estimates are available for the 19th century, and show a maximum population of 5000 by the beginning of the 20th century (Table 1). These data parallel the developments on similar nearby islands. The population of Rhodes did not exceed 35,000 from the 16th century until the last quarter of the 19th century (totalling 30,606 in 1886; Savorianakis 2000), but reached 55,000 by the beginning of the 20th century (an increase of ca. 80%). For Kos, the increase from 1886 to 1928 was ca. 63% (from 12,965 to 21,170 inhabitants). Similarly, the population of Nisyros increased by ca. 52% from 1821 to ca. 1910 (Table 1). Such an increase in population size is interesting given the limited primary production potential of the island: this amounts to a maximum cultivated area of 0.30 ha per capita according to the cadastral and population data available (Tables 1 and 2). Assuming that the results from the cadastres are reliable, such a small area could not cover the dietary needs of all inhabitants at that time based on the estimated basic metabolic rate per capita (Psihogios 1995); intensification of agricultural production was limited under the conditions at that time, since only labor could be intensified (i.e., technological change was not a factor). This may explain the poly-culture and extensive terracing revealed by our data. This conclusion is also corroborated by our fieldwork, even though our GIS measurements reveal a much higher coverage of the island by terraces (58.4% of the area, for a total of 0.46 ha of cultivated land per capita).

Sources of data on economic activity on Nisyros are scarce, but the island's strong agricultural base is certain. According to 19th century sources, the most important

agricultural islands in the area were Rhodes, Kos, and Karpathos, followed by Leros and Nisyros, whereas the remaining islands supported mostly seafaring cultures that engaged in sponge fishing (Savorianakis 2000). No significant port operated on Nisyros, but small-scale trade between islands by merchant ships from nearby areas (Kos, Rhodes, and Bodrum) and part-time work in fields on the continent (olives, cereals, silk, and cotton) is known to have occurred (Logothetis 1963; Ekonomakis and de Vries 2001). The main exports of Nisyros were almonds and acorns (Savorianakis 2000). However, nonagricultural activities were generally underestimated by local sources (Logothetis 1963), who depicted a romantic peasant society for Nisyros. This concept of a "society of abundance" is contradicted by data for areas more suitable for agriculture with similar technology and productivity in continental Greece, where the threshold of arable land needed to feed a person ranged from 0.7 to 1.1 ha, depending on precipitation and soil fertility (Psihogios 1995). This threshold is much higher than the per capita amount of land that was available on Nisyros. This discrepancy suggests that around 66 to 75% of the nutritional requirements of the Nisyrians were obtained by means of activities other than agriculture (e.g., fishing or trade) or were obtained from other islands or the mainland. Households with smaller cultivated areas in continental Greece had several options to provide the required amount of nutrition: (i) use their land for the production of commercial crops (especially raisins, then olive oil); (ii) emigrate to perform seasonal work, with one or more family members leaving for this purpose; (iii) emigrate for permanent employment so that money could be sent home; and (iv) employ pluri-activity and the production of "cash crops" (Psihogios 1995; Bournova and Progoulakis 1999; Asdrahas and others 2003). The traditional society of Nisyros undertook mainly the last two options during various periods. It seems therefore that the island's reduced resources and the reduced possibility to support a population as large as that in 1910 forced Nisyrians to emigrate, often over long distances. In this respect, the 0.46 ha of cultivated land per capita can perhaps be considered to serve as an estimate of the instability in Nisyrian society just after the turn of the 20th century.

Table 2 Cultivated and utilized agricultural land^a on Nisyros Island in 1947, 1956, 1961, 1971, 1991, and 2001

Settlements	Cultivated land (ha)				Utilised ^a Agricultural Land (ha)	
	1884–1947 ^b	1956	1961	1971	1991	2001
Mandraki	918.0	300.0	220.0	206.1	820.6	346.0
Emporios	255.3	200.0	110.0	88.3	34.1	77.5
Nikia	311.1	150.0	110.0	56.5	59.1	41.8
Total	1484.4	650.0	440.0	350.9	913.8	465.3

All areas in hectares were converted from the original data, which were recorded in *stremmas*, using the conversion factor of 1 *stremma* = 0.1 ha (Sources: 1884–1947, cadastral data; 1956, Anonymous (1956); 1961, Logothetis (1963); 1971, ESYE (1976); 1991, ESYE (1998); 2001, ESYE (2003))

^a Utilized Agricultural Land represents cultivated land (i.e., arable land, vineyards, groves, and fallowed land) plus private grazing lands, farm buildings, and other structures used to support agricultural activities

^b The total cultivated area for the villages on the island was calculated based on 1/3 of the cadastral data, as described in the text; the numbers in the table thus represent the cadastral data multiplied by 3 to produce a total. Original records on land area were given in *kafizia* units in the cadastres, and have been recalculated here as hectares: 1 *kafizi* = 1/6 *stremma* = 1/60 ha (Logothetis 1987)

The Agricultural Landscape of Nisyros in Modern Times: From Agriculture to Animal Husbandry

A continuous population decrease began around 1910 (Table 1), and agriculture on Nisyros responded with a serious decline in the cultivation of terraced land (Tables 2 and 3). Abandonment of fields and the resulting neglect of the terraces became most serious in the middle of the 20th century according to the responses of inhabitants to our questionnaire, and was largely completed from the 1970s through the 1990s. This decline had the following consequences:

- Decline in the area of cultivated land and in the associated traditional agricultural practices. This decline (76.4% by 1971; Table 2) is probably smaller than the actual value because the cadastral data for the 1884–1947 period (Table 2) underestimate the actual land use. Applying the results of our GIS calculations for the period before 1947 (i.e., a total of 2390 ha) produces an even greater estimated decline (85.3% by

1971). The decline was even more severe in recent years (1991 and 2001) because the more recent data include areas of private pasture in the total, which account for 90.8% of the utilized agricultural land shown in Table 2, followed by 7.8% for cultivated land and 1.4% for groves.

- Dramatic reduction of the number of active farms coupled with a similar reduction in the number of fields (97.7 and 96.7%, respectively, from 1884–1947 through to 2001; Table 3) as a result of the decrease in cultivated land (Table 2). Note that due to the limited area available for cultivation on the island, each family farm consisted of several fields scattered throughout the island. These reductions clearly demonstrate that farming has become an increasingly unattractive activity, possibly because of the difficulty in earning a profit. This reduction does not discriminate between local farmers and distant owners, who usually possess small and easily accessible farms that they rented to or had managed by local farmers, as is the case in other islands of the Aegean (Kizos and Spilanis 2004).

Table 3 Changes in the numbers and sizes of farms and fields on Nisyros from the 1884–1947 period through to 2001

Settlements	Number of farms (and number of fields)			Average farm size (and field size) (ha)		
	1884–1947 ^a	1971	2001	1884–1947 ^b	1971	2001
Mandraki	915 (8826)	145 (1310)	26 (281)	1.00 (0.103)	1.42 (0.16)	13.31 (1.23)
Emporios	438 (2943)	64 (628)	11 (151)	0.58 (0.087)	1.38 (0.14)	7.05 (0.51)
Nikia	438 (4917)	53 (822)	5 (114)	0.71 (0.063)	1.07 (0.07)	8.36 (0.37)
Total	1791 (16 686)	262 (2760)	42 (546)	0.83 (0.088)	1.34 (0.13)	11.08 (0.85)

All sizes are in hectares converted from original data in *stremmas* using the conversion factor of 1 *stremma* = 0.1 ha

Sources: 1884–1947 cadastral data, 1971, ESYE (1976); 1991, ESYE (1998); 2001, ESYE (2003)

^a The data show the number of owners indicated in the cadastral data (deduced based on the samples that we used). Original size records were given in *kafizia*, which we recalculated as hectares (1 *kafizi* = 1/6 *stremma* = 1/60 ha; Logothetis 1987)

^b Data were calculated based on the areas in Table 2 and the numbers of farms and fields in this Table

Table 4 Change in the amount of land used for pasture on Nisyros

Settlement	Pasture area (ha)		
	1956	1961	1991
Mandraki	1350	1580	2040
Emporios	900	1000	960
Nikia	700	900	890
Total	2950	3480	3890

Sources: 1956, Anonymous (1956); 1961, ESYE (1965); 1991, ESYE (1995)

- An increase in the average farm size (ca. 1235%) and field size (ca. 866%) from 1884–1947 through to 2001 (Table 3). In the earlier years of the agricultural decline, this increase was probably due to the selection of larger fields from among those available on the island that were left behind by emigrants. After the 1980s, the increased farm size arose from the conversion of abandoned arable land into grazing land. Farms remain highly fragmented, however, with an average of 13.0 fields per farm in 2001 versus 10.5 and 9.3 in previous periods (in 1971 and 1884–1947, respectively; Table 3).
- An increase in the area of pasture (Table 4). The observed increase (31.9%) between 1956 and 1991 is certainly lower than the actual increase because the official statistics used in Table 4 were derived from rough estimates by the local administration. Interestingly, there has been an increase in the number of animals since 1991 (Table 5), but a decrease compared to 1971 levels, when abandonment of the land was not yet complete. This overall increase probably resulted from EU subsidies and the lower amount of labor required by the free-range animal husbandry system employed by the islanders. This system is structured around abandoned arable land, which herders use freely, regardless of ownership. Thus, animals are almost completely free to roam even in the few remaining cultivated fields, as all wooden gates and

many of the enclosing stone walls used to keep out animals have been destroyed. This practice has caused serious conflicts between herders and field owners because of the damage caused to properties and crops (destruction of crops, terraces, walls, etc.) by the animals, a fact that was reflected in our survey results: many respondents (20.4%; Table 6) claimed “uncontrolled grazing” as a reason for abandoning cultivation. Indeed, it seems that most of the available land on Nisyros is under constant grazing today, and that the competition for land use favors animal husbandry over agriculture. However, overall grazing pressure remains low on the island, with 0.29 AU/ha in 2001 (Tables 4 and 5), versus recommended limits in the Aegean islands of 1.0 AU/ha (KYA 568 2004).

These four developments have had significant repercussions at the landscape level. The most important is that formerly functional traditional landscape elements, such as terraces, enclosure walls, paved paths, and other structures, are no longer used in the current practices. Such elements require periodic maintenance, and when neglected they become unstable or damaged, especially in areas that are freely grazed by cattle, sheep, and goats, which damage the structures and accelerate their collapse. The resultant state of the stone terrace walls in the transformed landscape of Nisyros is shown in Fig. 3.

It would be very interesting to learn whether the process of field abandonment was affected by the distance from the main settlements or other topographic or landscape features such as accessibility and the type of terrace. However, although we tried to retrieve quantitative data by analyzing our GIS data and the survey results, this was not feasible within the present study for several reasons. First, most of the land owners, and especially those who had abandoned their terraces, have emigrated long ago (mainly to the United States, Athens, and Rhodes), which made recovery of this data impossible. In addition, the required level of detail was unavailable in the cadastres. Second, ownership patterns are complicated because farmers own fields at different

Table 5 Change in the number of animal units (AU) on Nisyros from 1971 to 2001

Settlements	1971			1991			2001			Change in AU from 1971 to 2001 (%)
	Cattle	Sheep – Goat	AU	Cattle	Sheep – Goat	AU	Cattle	Sheep – Goat	AU	
Mandraki	540	3520	997.6	109	1467	299.7	256	3205	672.7	–32.6
Emporios	399	1533	598.3	51	33	55.3	244	534	313.4	–47.6
Nikia	73	364	120.3	91	124	107.1	90	422	144.9	20.5
Total	1012	5417	1716.2	251	1624	462.1	590	4161	1130.9	–34.1

Sources: Calculated by the authors using data on livestock numbers from ESYE (1976, 1998, 2003)

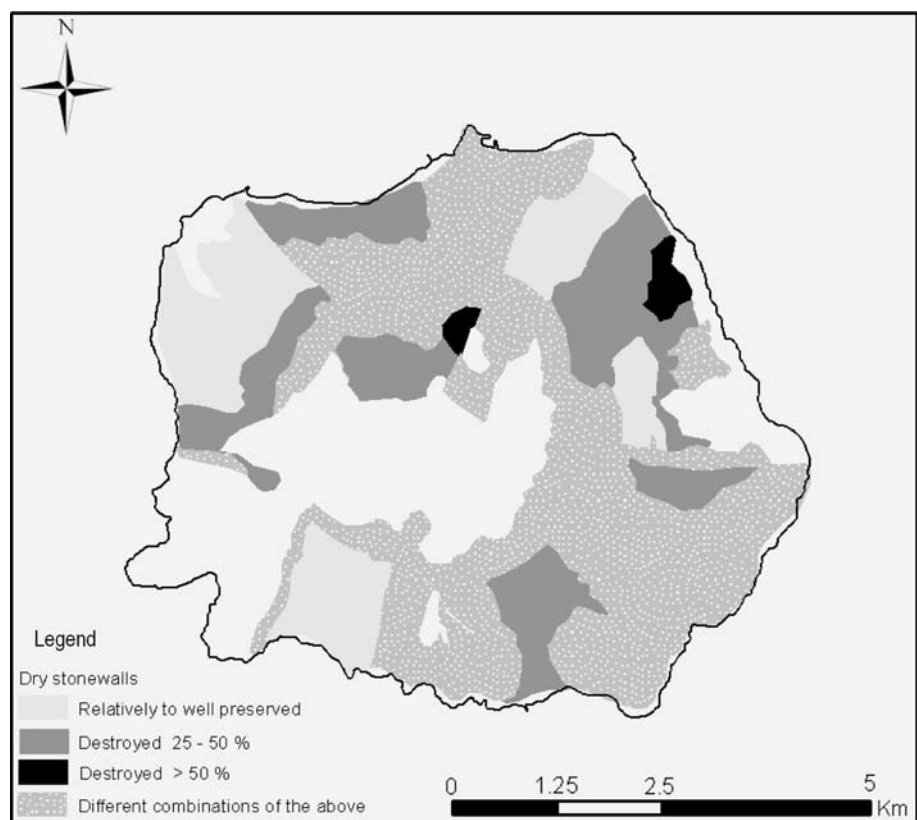
A cow or bull equals 1 AU, a calf equals 0.6 AU, and a sheep or a goat equals 0.15 AU (KYA 568 2004). % change in AU from 1971 to 2001 was calculated as: [(AU in 2001 – AU in 1971) x 100/ AU in 1971]

Table 6 Numbers of abandoned cultivated fields on Nisyros in different years, as a function of the motives for abandonment, and the situation in 2003

Decade	Number of abandoned cultivated areas, by category of motive					Total
	Death	Migration	Uncontrolled grazing	Distance – accessibility	Change of profession	
1940s	11	0	0	0	0	11
1950s	14	0	1	1	9	25
1960s	0	13	13	1	11	38
1970s	10	10	8	12	18	58
1980s	33	10	34	9	20	106
1990s	2	2	8	1	7	20
Still cultivated (2003)						55
Total	70	35	64	24	65	313

Source: Results of surveys conducted in the present study

Fig. 3 Distribution of terraces on the island of Nisyros, illustrating the current condition of their supporting dry stone walls (year 2000). White areas are not terraced



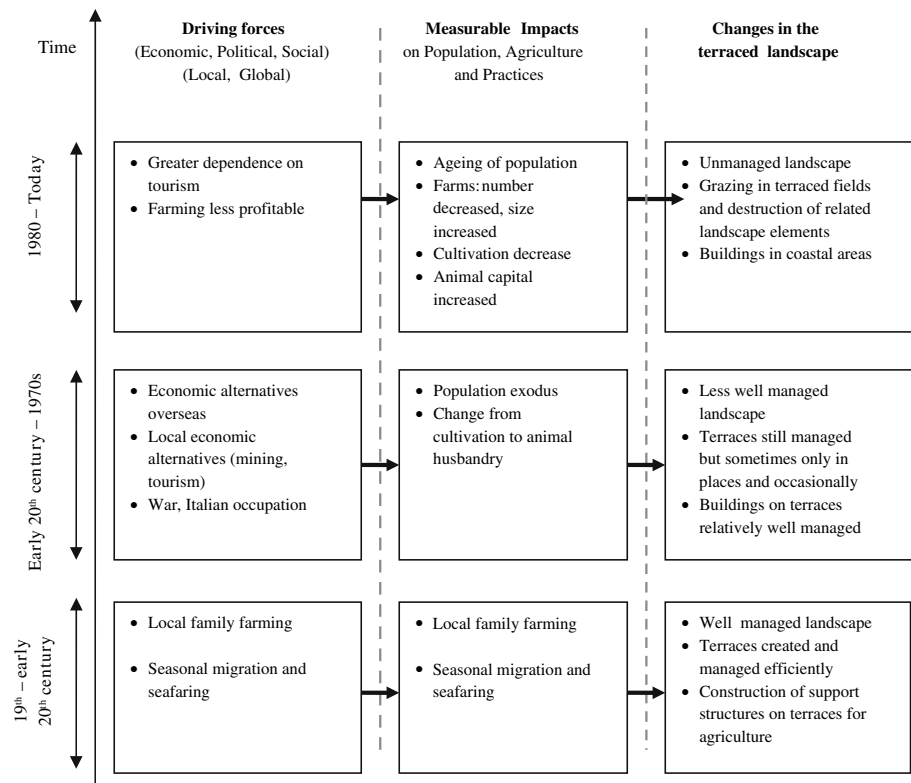
locations around the island. When emigration, death, or a change in profession occurred, such owners normally abandoned all their fields simultaneously, regardless of a field's quality and size. Moreover, even current farmers occasionally abandon one or more of their fields. As a result of these factors, modeling the process of terrace abandonment as a function of topographic factors and landscape elements seems particularly difficult for Nisyros. Such an effort may be more rewarding on larger islands with larger populations of farmers, such as Samos or Lesbos (A. Dalaka

and T. Petanidou, unpublished data, University of the Aegean).

The Socioeconomic and Political Background as a Driving Force for Land-Use Change

The highest population levels on Nisyros occurred at the beginning of the 20th century, but lasted for only a brief period (Table 1). Nonetheless, the subsequent changes in

Fig. 4 Illustration of the driving forces that have led to dramatic changes in the terraced landscape of Nisyros during the 20th century



population were important in terms of landscape change after the period of maximal terrace use on the island. Various significant socioeconomic and political developments during the 20th century resulted in a major population exodus, with dramatic repercussions for terrace abandonment (Table 1, Fig. 4).

Developments before World War II included:

- Political changes, with the Dodecanese islands being annexed from the Ottoman Empire to the Italian State in 1912 (Savorianakis 2000). Communication with the continental coast of Asia Minor gradually became more difficult, and ceased in 1947, the year in which the Dodecanese islands were annexed by the Greek State. This was a major blow for the seasonal migration towards Asia Minor that used to provide important income to Nisyrians, as it did for other islanders in the area. As political changes complicated migration towards the Eastern Mediterranean basin, migratory pressure became directed towards the United States, Rhodes, and Athens (Bournova and Progoulakis 1999).
- Changes in permanent or semi-permanent migration opportunities, such as the emigration towards the United States, which practically stopped in the 1920s due to changes in the U.S. immigration policy (Bournova and Progoulakis 1999). Emigrants to the United States played a key role in the development of the

island by sending money to their family members who stayed behind. Migrants within Greece, although unable to contribute financially to the same extent, created a strong union and a cultural league, the “Society for Nisyrian Studies” in Athens, which remains operational today (Chartofyllis 2000).

- Transportation changes, with bigger and more modern ships replacing small-scale transports and reducing the use of smaller vessels.

Developments after World War II included:

- Continuous transportation changes: public transportation using ferry boats marginalized the island, with Nisyros connected to Piraeus (i.e., the Greek mainland) only via Kos or Rhodes, a situation that continues today. Furthermore, these transportation changes opened small island markets to commerce with major trade centers (e.g., Athens) during this period, which marginalized local producers and rendered them unprofitable, as was the case in many other areas of the Mediterranean basin (Pratt and Funell 1997).
- Social changes, with the traditional peasant society gradually being transformed into a modern one, in which agricultural employment was socially devalued and jobs in the service sector became more appreciated and sought after. Such changes were fuelled and accelerated by rapid tourism development in the larger,

nearby islands, starting with Rhodes and continuing with Kos, which provided more attractive jobs and enhanced emigration from smaller islands. Survey respondents on Nisyros confirmed the existence of these developments during the past 50 years. In the 1950s “death” was reported as the main reason for abandoning agriculture, whereas after the 1960s, low profitability became more important, with “distance,” “accessibility,” “change of profession”, and “migration” becoming the main reasons cited by the respondents (Table 6). Given that our survey did not include emigrants, who accounted for most of the population decrease from 2499 in 1947 to 779 in 1991, abandonment due to emigration must be considered a primary motivation, although part of the emigrants’ land was cultivated by the farmers remaining on the island until the early 1970s, a practice that declined thereafter. In 2003, the year of our survey, fields were cultivated mainly to provide animal fodder, and even this form of cultivation was only carried out in 55 of the total of 313 areas in which the 30 survey respondents owned fields (Table 6).

- General post-war changes in agriculture and livestock management practices included the intensification of agriculture and animal husbandry by means of mechanization, irrigation, chemical inputs to improve soil fertility and combat pests, increased numbers of livestock, and imported fodder for animals (see also Pratt and Funell 1997). The adoption of such mechanized and industrialized management systems in more fertile areas permitted increased production for wider markets, and increasingly marginalized most island producers due to their low productivity. Along with the change in management practices, most traditional collection activities were also abandoned on Nisyros,

including those related to forests (e.g., oak and terebinth products). Combined with the general rise of industry in urban areas, these changes reinforced the urbanization process and caused a widespread exodus from rural areas. The resulting land-use changes were important, and included a reduction in the area of cultivated land, an increase in the area of grazing land, and the expansion of settlements, especially on tourist islands and in coastal areas of all Aegean islands (Kizos 2005). In some cases, these socioeconomic changes and the abandonment of agriculture led to a recovery in natural vegetation, which had nearly disappeared for many centuries both in the islands and on the mainland (Petanidou and others 2001; Grove and Rackham 2002; J. Pantis, Aristotle University of Thessaloniki, personal communication).

After the 1980s, a decade marking the end of the exodus, the population of Nisyros appeared to stabilize at approximately 1000 inhabitants (Table 1). Such a population level, together with other indices, suggests that the economic activities occurring on the island (e.g., animal husbandry, mining on the small nearby island of Yiali under the administrative authority of Nisyros, as well as tourism and other services — in any case, not agriculture) continue to sustain a considerable number of permanent, relatively young and active inhabitants compared with other Aegean islands of similar size (Table 7). The 2001 census (although of questionable credibility concerning the winter population, which may be 20% smaller than the value indicated by the official census, estimated based on our experience) suggests that this population is not elderly (23% are younger than 20, compared with the Greek average of 21%), which contrasts with the situation on other similar islands (Table 7; ESYE 2001).

Table 7 Selected population, spatial, and social indicators for six selected islands in the Aegean region

Island	Area (km ²)	Population in 2001	Population change (%)		Employment in agriculture (% of total employed in 2001)	Non- active/ active ^a	Ageing index ^b
			1991– 2001	1951– 1991			
Aghios Efstratios	43.23	371	29.7	−92.6	44.1	1.65	2.08
Nisyros	40.92	948	3.8	−60.8	5.8	1.67	0.92
Sikinos	41.03	238	−10.9	−54.7	27.0	2.09	3.00
Psara	39.77	422	−3.7	−37.4	14.6	3.23	2.05
Anafi	38.35	273	4.6	−50.9	43.8	1.54	1.40
Kimolos	35.71	769	5.6	−52.6	16.6	3.19	3.24
Aegean Islands average		10 570	19.6	−25.1	20.0	1.88	1.04

Source: Calculated by the authors using data from ESYE (2001)

^a According to the official statistics on employment by the EU, “active” represents all persons between 15 and 65 years old who are either employed or unemployed but actively seeking employment

^b Inhabitants older than 65 or inhabitants younger than 15

Epitome

Cultivation terraces supported by dry stone walls are among the most significant landscape elements of the Aegean archipelago. Using them as a model for changing land use, we explored the changes since the end of the 19th century on one Aegean island (Nisyros), with a particular focus on the socioeconomic driving forces responsible for these changes in the landscape. Based on a diverse array of data, we were able to draw several important conclusions:

(i) Population, economic, and societal changes have been strong driving forces that produced obvious effects on the landscape of the Aegean. On the island of Nisyros, as has been the case with other islands and areas considered today as disadvantaged or “less-favored” compared to more populous or more fertile areas, the population increase at the end of the 19th century and beginning of the 20th century created an extended cultural landscape. The social and economic changes that occurred during the first half of the 20th century marginalized the economic structures of these disadvantaged areas and caused a major population exodus that led to the abandonment of agriculture and changes in the form of agriculture (from crop cultivation to animal husbandry) that produced corresponding changes in the landscape. These changes can be evaluated in terms of productivity (reduced cultivated areas and fewer agricultural products) and management (fewer but bigger farms that are difficult to manage in the traditional way by the few remaining farmers), and changes in both parameters reflected a major loss of cultural capital and local knowledge (e.g., craftsmanship and knowledge of how to create the dry stone walls). In this sense, the example of Nisyros is typical of many similar cases in Greece and the Mediterranean basin.

Although the case of Nisyros is unique because of the scale and intensity of the driving forces that have brought about abrupt changes within the period covered by our study, the intensification and abatement of various forms of land use are recurring, long-existing phenomena within the Mediterranean basin (Horden and Purcell 2000). Molinillo and others (1997) and Lasanta and others (2005, 2006) discuss the abandonment of mountain farms and its impacts in the Spanish central Pyrenees, where, as on Nisyros, farmers have emigrated and abandoned densely cultivated and managed landscapes since the middle of the 20th century. Plieninger (2006) discusses a similar case in a mountainous part of western Spain, where demographic changes and changing land use resulted in rural depopulation, abandonment of traditional agricultural activities, and a sharp increase in livestock husbandry, finally resulting in a loss of *dehesa* as a result of shrub encroachment or conversion to open grassland. Pinto-Correia and Vos (2004) compared three mountain systems in Spain, Italy, and

France that were all characterized by population emigration, and the abandonment of farming and traditional management systems, in all three cases resulting in recovery of the area’s original forest vegetation. Similarly, cultivation terraces that have been abandoned on many islands of the south-eastern Aegean have been invaded by shrubs, turning farmland into shrubland (Petanidou and others 2001). Kizos and Koulouri (2005) found that on the island of Lesbos, rural depopulation resulted in the abandonment of many terraces that were formerly covered by olive plantations, and the terraces have now been taken over by Mediterranean shrubs and forest vegetation. Many similar cases of recent landscape change, with particular emphasis on terraces due to the abandonment of former management systems throughout the Mediterranean basin, have been summarized and discussed by Grove and Rackham (2002). All these approaches, ranging from landscape ecology to historical geography, revealed that although recent changes may be part of a historical cycle, the changes brought about seem deeper today compared to previous periods, and seem to be having dramatic and potentially irreversible effects on the landscape.

(ii) The landscape changes resulting from the abandonment of terrace cultivation on Nisyros are so sufficiently dramatic that they appear to be irreversible in many cases, given the current social and economic conditions. These changes encompass both the landscape elements and the practices and social functions of the society that created this landscape. Although this trend is not unique to Nisyros, but rather is a common tendency within the Mediterranean basin, the fact that Nisyros is a small and remote island makes the problem and its consequences more dramatic. Actions should be taken to preserve the cultural, productive, and ecological qualities of this landscape, but it’s important to note that this will be difficult given the amount of practical knowledge that has been lost over the past century, and such actions could probably only reconstruct the former morphology and not all of its functions. The diminishing number of farmers undoubtedly leaves little space for optimism regarding a large-scale conservation project that would encompass the parts of the terraced landscape that have been well maintained due to their vital role in supporting the island’s subsistence economy. The uniqueness of Nisyros among other islands that have been studied in the south-eastern Aegean (see the section “Sources and Methods”; Petanidou and others 2001) may qualify the island to become an archive or repository of old agricultural management techniques that can be referenced and used by future generations as a living resource for sustainable management. Although this seems to be easier said than done, it is the only way to keep the existing terraces in place.

Acknowledgments The study was supported by the Ministry of the Aegean (INTERREG II Program, Project entitled “Terraces in the islands of the Aegean: Role in the past and importance for their future in relation to economy, ecology and culture”, 1999–2001), and by the Municipality of Nisyros. We thank all collaborators and students who participated in the fieldwork and laboratory work (K. Karystinakis, P. Spastra, H. Dahm, D. Arabatzoglou, P. Tserpelis, V. Gkelou, and T. Kontos), for their invaluable contribution to the terrace mapping; G. Nikolakakis and T. Iosifidis for their advice on issues related to cultural and social documentation; and all local residents who responded to our questionnaires and participated in our interviews, and particularly D. Papadelias, A. Kaloudis, G. Sakellariadis, and A. Katsimatidi. We gratefully acknowledge Y. Mahairidis, P. Katsimatidis, and K. Hartofyllis for offering logistical support and providing background documents. The article benefited from a critical reading by E. Lamborn, M. Koulouri, B. Morehouse, G. Hart, and three anonymous reviewers.

References

- Agapitidis SI (1969) O plithismos tis Dodekanisou. *Nisyriaka* 3:5–22 (in Greek)
- Anonymous. 1956. Statistika stoiheia Nisyrou. *Nisyriaka Hronika* 2:49–50 (in Greek)
- Antrop M (2005) Why landscapes of the past are important for the future. *Landscape and Urban Planning* 70:21–34
- Argyris P (2001) Historical–geographical coordinates of Dodecanese: from the sea to the countryside. In: Petanidou T, Dahm H, Soulakellis N (eds) The role of terraces for the future of the islands in relation to economy, ecology and civilization – Unpublished Final Technical Report to the Ministry of the Aegean. University of the Aegean, Mytilene (in Greek). pp. 39–54
- Asdrahas S, Karapidaki NE, Katsiardi-Hering O, Liata E, Matthaiou A, Sivignon M, Stoianovich T (2003) Elliniki Oikonomiki Istoría, 15–19os aionas. Cultural Foundation of Peiraios Bank, Athens (in Greek)
- Barker G, Hodges R, Clark G (1995) A Mediterranean Valley: Landscape Archaeology and Annales history in the Biferno Valley. Leicester University Press, London
- Bournova E, Progoulakis G (1999) O Agrotikos Kosmos 1830–1940. In: Kremmydas V (ed), *Eisagogi sti Neoelliniki Oikonomiki Istoría (18–20os aionas)*. Typothito Press, Athens. (in Greek). pp. 45–104
- Brunet M (1990) Terrasses de culture antiques: l'exemple de Délos, Cyclades. *Méditerranée* 71:5–11
- Cammeraat E, van Beek R, Kooijman A (2005) Vegetation succession and its consequences for slope stability in SE Spain. *Plant and Soil* 278:135–147
- Chartofyllis KM (2000) *Eisagogi*. *Nisyriaka* 14:5–7 (in Greek)
- CEC (Commission of the European Communities) (2000) From land cover to landscape diversity in the European Union. Report from EC DG VI, EUROSTAT, Joint Research Center, EEA
- Doukellis P (1998) Versants pierreux et champs de culture à Ceos. In: Mendoni LG, Mazarakis-Ainian AJ (eds), *Kythnos: History and Archaeology – Proceedings of an International Symposium*. Meletimata 27, Centre for Greek and Roman Antiquity. National Hellenic Research Foundation, Athens. pp 309–330
- Duiker SW, Flanagan DC, Lal R (2001) Erodibility and infiltration characteristics of five major soils of southwest Spain. *Catena* 45:103–121
- Ekonomakis R, de Vries C (2001) *Nisyros: History and Architecture*. Melissa, Athens
- ESYE. (1965) Katanomi ektaseos tis Ellados kata vasikes katigories hriseos (Proapografika stoiheia apografis georgias – ktinotrofias tou etous 1961). Athens (in Greek)
- ESYE. (1976) Apotelesmata apografis georgias – ktinotrofias tou etous 1971. Athens (in Greek)
- ESYE. (1991) Stoiheia apografis plithismou 1991, available at <http://www.statistics.gr/StatMenu.asp> (in Greek)
- ESYE. (1995) Katanomi ektaseos tis Ellados kata vasikes katigories hriseos (Proapografika stoiheia apografis georgias – ktinotrofias tou etous 1991). Athens (in Greek)
- ESYE. (1998) Apotelesmata apografis georgias – ktinotrofias tis 7 Martiou 1991. Athens (in Greek)
- ESYE. (2001) Stoiheia apografis plithismou 2001, available at <http://www.statistics.gr/StatMenu.asp> (in Greek)
- ESYE (2003) Apotelesmata apografis georgias – ktinotrofias 2000–2001. Athens (in Greek)
- Fittschen K (1998) Archaeologia kai prostasia tou fysikou topiou – To paradeigma tis Arhaias Karthaias (in Greek). In: Mendoni LG, Mazarakis AJ-Ainian (eds), *Kea – Kythnos: History and Archaeology – Proceedings of an International Symposium*, Kea – Kythnos, 22–25 June 1994. Meletimata 27, Research Centre for Greek and Roman Antiquity. National Hellenic Research Foundation, Athens. pp. 539–545
- Forman RTT, Godron M (1986) *Landscape Ecology*. John Wiley & Sons, New York
- French CAI, Whitelaw TM (1999) Soil erosion, agricultural terracing and site formation processes at Markiani, Amorgos, Greece: The micromorphological perspective. *Geoarchaeology* 14:151–189
- Gasparis H (1997) I gi kai oi agrotis sti mesaioniki Kriti: 13–14os aionas. National Research Foundation, Athens (in Greek)
- Gebremedhin B, Swinton SM, Tilahun Y (1999) Effects of stone terraces on crop yields and farm profitability: Results of on-farm research in Tigray, northern Ethiopia. *Journal of Soil and Water Conservation* 54:568–573
- Gerozisis TA, (ed). (1998) *Dodekanisa: Synthikes – Nomoi – Statistikes – Hartes 1947–1997*. Vouli ton Ellinon, Athens (in Greek)
- Grenon M, Batisse M (1989) *Futures for the Mediterranean Basin: The Blue Plan*. UNEP, Paris
- Grove AT, Rackham O (2002) *The nature of Mediterranean Europe: an ecological history*. Yale University Press, New Haven
- Haber W (1990) Using Landscape Ecology in Planning and Management. In: Zonneveld IS, Forman RTT (eds), *Changing Landscapes: An Ecological Perspective*. Springer, New York. pp. 217–232
- Hammad AA, Borresen T (2006) Socioeconomic factors affecting farmers' perceptions of land degradation and stonewall terraces in central Palestine. *Environmental Management* 37:380–394
- Horden P, Purcell N (2000) *The corrupting sea: A study of Mediterranean history*. Blackwell, London
- Inbar M, Llerena CA (2000) Erosion processes in high mountain agricultural terraces in Peru. *Mountain Research and Development* 20:72–79
- Jameson MH, Runnels CN, van Andel TH (1994) *A Greek countryside: The southern Argolid from Prehistory to the present day*. Stanford University Press, Stanford
- Jongman RHG (ed) (1997) Ecological and landscape consequences of land use change in Europe – Proceedings of the first ECNC seminar on land use change and its ecological consequences. European Centre for Nature Conservation, Tilburg
- Kayhko N, Skanes H (2006) Change trajectories and key biotopes – Assessing landscape dynamics and sustainability. *Landscape and Urban Planning* 75:300–321
- Kizos T 2005. Politiki anaptyxis tis ypaithrou kai agrotiko topio stania tou Aigaiou. In: Tsalts G (ed), *Aeiforia kai perivallon:*

- o nisiotikos horos ston 21o aiona. Sideris, Athens (in Greek). pp. 347–362
- Kizos T, Koulouri M (2005) Economy, demographic changes and morphological transformation of the agricultural landscape of Lesvos, Greece. *Human Ecology Review* 12:183–192
- Kizos T, Spilanis I (2004) The transformation of landscape: modeling policy and social impacts on the agricultural landscape of Lesvos. *Natural Resource Modeling* 17:321–358
- Kostis K (1987) Agrotiki oikonomia kai Agrotiki Trapeza. Opseis tis ellinikis oikonomias sto mesopolemo. National Bank Foundation, Athens (in Greek)
- Koulouri M, Giourga C (2007) Land abandonment and slope gradient as key factors of soil erosion in Mediterranean terraced lands. *Catena* 69:274–281
- KYA 568. 2004. Greek Common Ministerial Decision 568/201/04 (Ministry of Economics and Finance, Ministry of Public Services and Ministry of Agriculture) for “Good Agricultural Practices,” available at <http://www.minagric.gr/greek/EPAA/INDEX%201/INDEX%201.HTM> accessed 18/04/2007
- Lasanta T, Gonzalez-Hidalgo J, Vicente-Serrano S, Sferi E (2006) Using landscape ecology to evaluate an alternative management scenario in abandoned Mediterranean mountain areas. *Landscape and Urban Planning* 78:101–114
- Lasanta T, Vicente-Serrano S, Cuadrat JM (2005) Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: A study of the Spanish Central Pyrenees. *Applied Geography* 25:47–65
- Liata ED (1987) I Serifos kata tin Tourkokratia (17–19os aionas): symvoli sti meleti ton koinonikon kai oikonomikon domon kai tou koinotikou systimatos. Idryma Erevnas kai Paideias, Foundation of the Commercial Bank of Greece, Athens (in Greek)
- Lock P (1995) *The Franks in the Aegean: 1204–1500*. Longman, London
- Logothetis M (1963) *Tourismos kai oikonomia tis nisou Nisyrou*. Nisyriaka 1:51–117 (in Greek)
- Logothetis M (1987) Ta ktimatologia tis Nisyrou kata ta hronia tis douleias (1785–1945). Nisyriaka 10:197–386 (in Greek)
- Lohmann H (1992) Agriculture and country life in classical Attica. In: B. Wells (ed), *Agriculture in Ancient Greece – Proceedings of the seventh International Symposium at the Swedish Institute at Athens, 16–17 May, 1990*. Paul Åströms Förlag, Stockholm. pp. 29–60
- Lowry HW (2002) Fifteenth century Ottoman realities: Christian peasant life on the Aegean island of Limnos. Eren Press, Istanbul
- Mander U, Palang H, Ihse M (2005) Development of European landscapes. *Landscape and Urban Planning* 67:1–8
- Margaris NS (1992) Primary sector and environment in the Aegean islands, Greece. *Environmental Management* 16:569–574
- Molinillo M, Lasanta T, Garcia-Ruiz JM (1997) Managing mountainous degraded landscapes after farmland abandonment in the Central Spanish Pyrenees. *Environmental Management* 21:587–598
- Muir R (2003) On change in the landscape. *Landscape Research* 28:383–404
- Netting RM (1993) *Smallholders, householders: farm families and the ecology of intensive, sustainable agriculture*. Stanford University Press, Stanford
- Nicod J (1990) Murettes et terrasses de culture dans les régions karstiques méditerranéennes. *Méditerranée* 71:34–54
- Palang H, Antrop M, Alumae H (2005) Rural landscapes: past processes and future strategies. *Landscape and Urban Planning* 70:3–8
- Papahristodoulou HI (1969) Toponymiko Nisyrou. Nisyriaka 3:230–268 (in Greek)
- Petanidou T (2005) *Vastadia kai tavles – Sculpturing the landscape of Nisyros*. Nisyriaka 15:212–255 (in Greek)
- Petanidou T, Dahm N, Soulakellis N (2001) O rolos ton anavathmidon sto parelthon kai i simasia tous gia to mellon ton nision se shesi me tin oikonomia, tin oikologia kai ton politismo. Final Report to the Ministry of the Aegean, Vols. 1–2, University of the Aegean, Mytilene (in Greek)
- Petanidou T, Soulakellis N, Karystinakis K, Spastra P (2004) The Mediterranean terraced landscapes in change: estimating the efforts to build it up and the reasons to downturn it. In: Arianoutsou M, and V. Papanastasis. (eds), *Proceedings 10th MEDECOS Conference CD*, Rhodes, Millpress, Rotterdam
- Pinto-Correia T, Vos W (2004) Multifunctionality in Mediterranean landscapes – past and future. In: Jongman R (ed), *The new dimensions of the European landscape*. Wageningen UR Frontis Series nr. 4, Springer, Berlin. pp. 155–184
- Plieninger T (2006) Habitat loss, fragmentation and alteration – quantifying the impact of land use changes on a Spanish dehesa landscape by use of aerial photography and GIS. *Landscape Ecology* 21:91–105
- Pratt J, Funell D (1997) The modernization of Mediterranean agriculture. In: King R, Proudfoot L, Smith B (eds), *The Mediterranean: environment and society*. Arnold, London. pp. 194–207
- Price C, Nixon L (2005) Ancient Greek agricultural terraces: Evidence from texts and archaeological survey. *American Journal of Archaeology* 109:665–694
- Psihogios DK (1995) Proikes, foroi, stafida kai psomi: oikonomia kai oikogeneia stin agrotiki Ellada tou 19ou aiona. EKKE, Athens (in Greek)
- Rackham O, Moody JA (1992) Terraces. In: Wells B (ed), *Agriculture in Ancient Greece – Proceedings of the seventh International Symposium at the Swedish Institute at Athens, 16–17 May, 1990*. Paul Åströms Förlag, Stockholm. pp. 123–130
- Rackham O, Moody JA (1996) *The making of the Cretan landscape*. Manchester University Press, Manchester
- Robson C (2002) *Real world research*. Blackwell, Oxford
- Savorianakis P (2000) Nisiotikes koinonies sto Aigaio prin kai meta tis othomanikes metarythmises: I periptosi ton Ellinon tis Rodou kai tis Ko (18–19os aionas). Athens, Trohalia – Dimos Rodou, Athens (in Greek)
- Steiner FR (1991) *The Living Landscape: An Ecological Approach to Landscape Planning*. McGraw-Hill, New York
- Stobbelaar DJ, van Mansvelt JD (2000) The process of landscape evaluation: introduction to the 2nd special AGEE issue of the concerted action: “The landscape and nature production capacity of organic/sustainable types of agriculture”. *Agriculture, Ecosystems and Environment* 77:1–15
- Tarsouli A (1950) *Dodekanisa, Volume 3*. Alpha I.M. Skazikis Publisher, Athens (in Greek)
- Turner MG, Gardner RH, O’Neill RV (2003) *Landscape Ecology in theory and practice: pattern and process*. Springer, Berlin
- Vagen TG, Tilahun Y, Esser KB (1999) Effects of stone terracing on available phosphorus and yields on highly eroded slopes in Tigray, Ethiopia. *Journal of Sustainable Agriculture* 15:61–74
- Veeck G, Zhou L, Ling G (1995) Terrace construction and productivity on Loessal soils in Zhongyang County, Shanxi Province. *Proceedings of the Association of American Geographers* 85:450–467
- Wascher DM (1999) *Agri-environmental indicators for sustainable agriculture in Europe*. European Centre for Nature Conservation, Tilburg
- Wascher DM, (ed). (2000a) *The face of Europe: policy perspectives for European landscapes*. Technical Report series, European Centre for Nature Conservation, Tilburg
- Wascher DM, (ed). (2000b) *Landscapes and sustainability – Proceedings of the European workshop on landscape assessment as*

- a policy tool. European Centre for Nature Conservation, The Countryside Agency, Tilburg
- Wascher DM (2006) European Landscape Character Areas – Typologies, Cartography and indicators for the assessment of sustainable landscapes. Final Project Report of the European Landscape Character Assessment Initiative. Available at <http://www.elcai.org/brochure.html> accessed 18/04/2007
- Whitelaw TM (1994) An ethnoarchaeological study of rural land-use in north-west Keos: insights and implications for the study of past Aegean landscapes. In: Doukellis PN and Mendoni LG (eds), Structures rurales et sociétés antiques – Actes du Colloque de Corfu (14–16 Mai 1992). Annales Littéraires de l'Université de Besançon, Paris. pp. 163–186