Impact of Stone Terraces and Walls' Micro-environment on Biodiversity Conservation: A Case Study in the Mediterranean Island of Kythira-Greece

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Abstract. Agricultural terraces and terrace walls are a conspicuous feature of the Mediterranean Forest and agricultural landscapes, which are vital in relation to biodiversity. Aim of the study is to identify the contribution of agricultural terraces and terrace walls in the biodiversity conservation of the forest and agricultural landscapes on Kythira island. Literature review survey indicate that agricultural terraces and terrace walls provide various goods and services, which are vital, and they are potential and interesting resources for the development of this area. It is noteworthy that agricultural terraces and terrace walls are an important habitat for biodiversity. Also, stone terraces and walls create a suitable micro-environment for biodiversity conservation and enhancement. Consequently, these landscape elements should be preserved and exploited as they favor the components of biodiversity which are the source of our food and medicines, fibers, fuels and industrial products. The direct use of the components of biodiversity contribute substantially to the economy and tourism development.

Keywords: Biodiversity; Micro-environment; Conservation; Mediterranean island.

1 Introduction

The island of Kythira, also known as Cerigo, is located south of the southeastern tip of the Peloponnese. The area of Kythira is 277.28 km2 and the length of the coastline is 114.24 km, while taking into account the 22 islands around it, the total area is 278.65 km2. Its general geomorphologic picture is semi-mountainous, dominated by a low plateau of 200-300 meters, which is often interrupted by gorges and some valley-like configurations. This plateau leads to steep cliffs to the west and south, and to the east and north, to smoother and lower formations, with many beaches. There are several islands and islets around, with the most important being Dragonares in the east and

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Avgo or Hitra in the south (Aggelidis et al., 2016). Most of the Kythira area belongs to the category "forests and semi-natural areas" (63.35%), 36.38% of the total area belongs to the category "agricultural areas" and 0.27% to artificial areas (Fig. 1, 2).

Fig. 1. The Natural Environment of Kythira (Photo: Dr Alexandra Solomou).

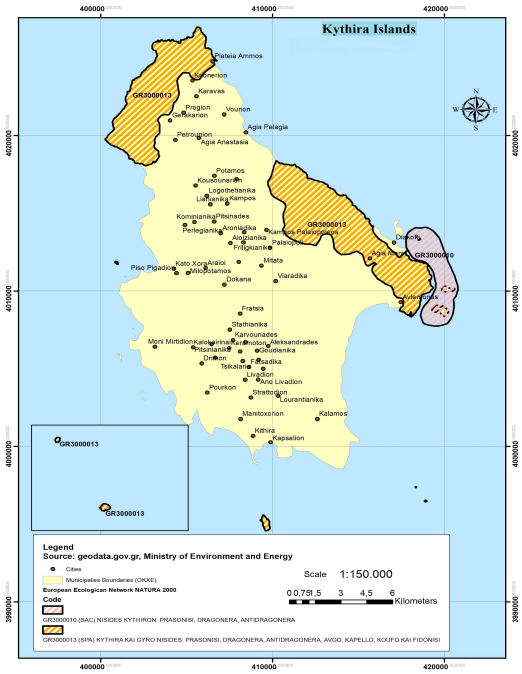

Fig. 2. Map of the Greek island Kythira.

Specifically, the SAC area (Special Areas of Conservation) GR3000010 - NISIDES KYTHIRON: PRASONISI, DRAGONERA, ANTIDRAGONERA (total area: 989.13

ha) are important for the flora [e.g. Allium gomphrenoides Boiss. & Heldr., Anthemis scopulorum Rech. f., Centaurea raphanina subsp. mixta (DC.) Runemark etc.], the birds (e.g. Anthus campestris, Falco eleonorae, Lanius senator etc.) and the mammals (e.g. Monachus monachus, etc.). Also, SPA GR3000013 - KYTHIRA KAI GYRO NISIDES: PRASONISI, DRAGONERA, ANTIDRAGONERA, AVGO, KAPELLO, KOUFO KAI FIDONISI (total area: 5392.46 ha) (Map 1) is important for breeding and marine species. It has been designated as SPA (Special Protection Areas) for the following birds: *Calonectris diomedea, Puffinus yelkouan, Phalacrocorax aristotelis, Falco eleonorae, Falco peregrinus, Larus audouinii* and *Emberiza caesia* (FILOTIS, 2018).

The aim of the present study is to identify the contribution of agricultural terraces and terrace walls in the biodiversity conservation of the forest and agricultural landscapes on Kythira island.

2 Climatic Characteristics

The island of Kythira is characterized by the Mediterranean climate with hot and dry summers and cold winters. Specifically, according to the Climatic Zone Classification of UNEP (1992), the area belongs to the sub-humid (SH) climate zone with Aridity Index (AI) values presented to decrease from 0.71 (for the period 1900-1930) to 0.59 (for the period 1960-1997), indicating that more arid conditions persist the recent years compared to the beginning of the century (Tsiros et al., 2020). According to the available meteorological data of the Hellenic National Meteorological Service, the annual precipitation in Kythira is low (about 495mm averaged for the period 1964-2016) and unevenly distributed between seasons, occurring mainly in winter (53%) and autumn (28%) and less in summer (only 2%) and spring (17%). In general, the summer months in Kythira are extremely dry, with July being the driest month. According to the pluvio diagram (Fig. 3), the dry season starts in April and ends at about late October.

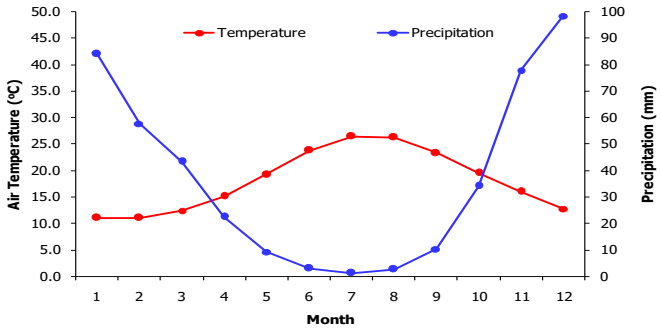

Fig. 3. The Pluvio Diagram for the island of Kythira derived from meteorological data of the period 1964-2016.

The annual average temperature is 18.0ºC, ranging seasonally between 11.6ºC in winter and 25.4ºC in summer, with intermediate values during the transitional seasons of spring and autumn (15.5ºC and 19.6ºC, respectively). July and August are the warmest months of the year with average temperatures 26.4°C and 26.2°C respectively, while coldest months are January and February with average temperatures around 11.0°C. The monthly changes of the temperature attributes are presented in Fig. 4, indicating that in the region, generally warm conditions persist during all seasons.

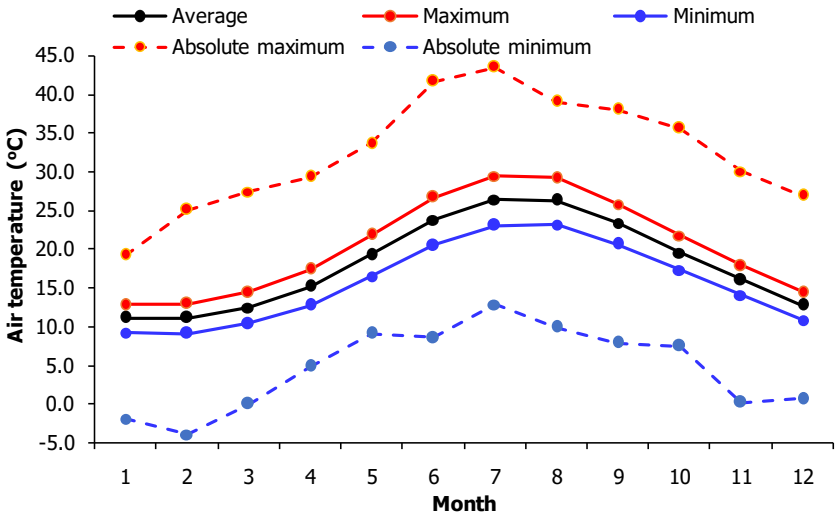

Fig. 4. Monthly values of temperature attributes in Kythira derived from meteorological data of the period 1964-2016.

The region's climate has become significantly hotter the last decades compared to the past as clearly depicted in Fig. 5. The temperature attributes' trend analysis was performed by employing the widely used Mann-Kendall test (Mann, 1945, Kendall, 1975) and the Sen-slope method (Sen 1968), by applying the MAKESENS 1.0 software (Salmi et al., 2002). On an annual basis, the average temperature appears to have increased by a rate of +0.37ºC/decade since 1964. The specific rate becomes maximum (0.67ºC/decade) in summer and minimum, though positive, in winter, indicating that all seasons became much warmer compared to the past. The greatest changes, on a monthly basis, is identified for August which presents a warming rate on the order of 0.74ºC/decade.

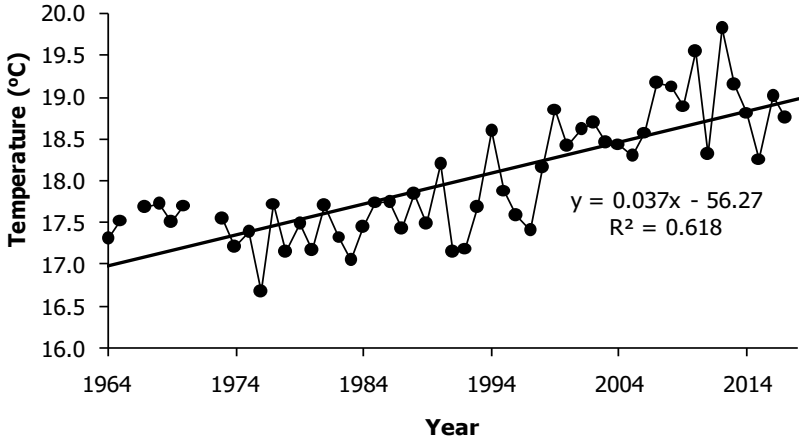

Fig. 5. Mean Temperature annual values for the period 1964-2016 in Kythira.

3 Materials and Methods

Data for the current study were taken from a previously published work and, to safeguard the credibility, only indexed and peer-reviewed articles were used. The following databases were included: Scopus, Google Scholar, PubMed, Science Direct, and MEDLINE.

4 Dynamics of Stone Terraces and Walls in the Natural Environment

The island of Kythira is the crossroad of Mediterranean cultures. The fire occurred in 2017 exposed the stone terraces and walls (Fig. 6), works that span hundreds of years, whose maintenance and extension continued until the 1960s, as they are elements of the Greek landscape and its features. According to Koulouri (2004) terraces are, historically, one of the most important and characteristic human interventions in shaping the Mediterranean landscape. They are a very important element of the historical and cultural heritage of the Mediterranean peoples and at the same time of great aesthetic and environmental value.

The idea of the stone terraces and stone walls (Fig. 6) is very likely to have been conceived by the island's inhabitants in ancient times so that they can cultivate the land, mainly due to the steep slope of the soil, and to some extent ensure their survival. Traditionally, the art of tiering has been passed down from generation to generation, among members of each family. Such terrestrial farming has largely been abandoned due to the mechanization of agriculture, intensive farming and the reduction in the share of human labor in agricultural production (Crhysanthaki, 2005).

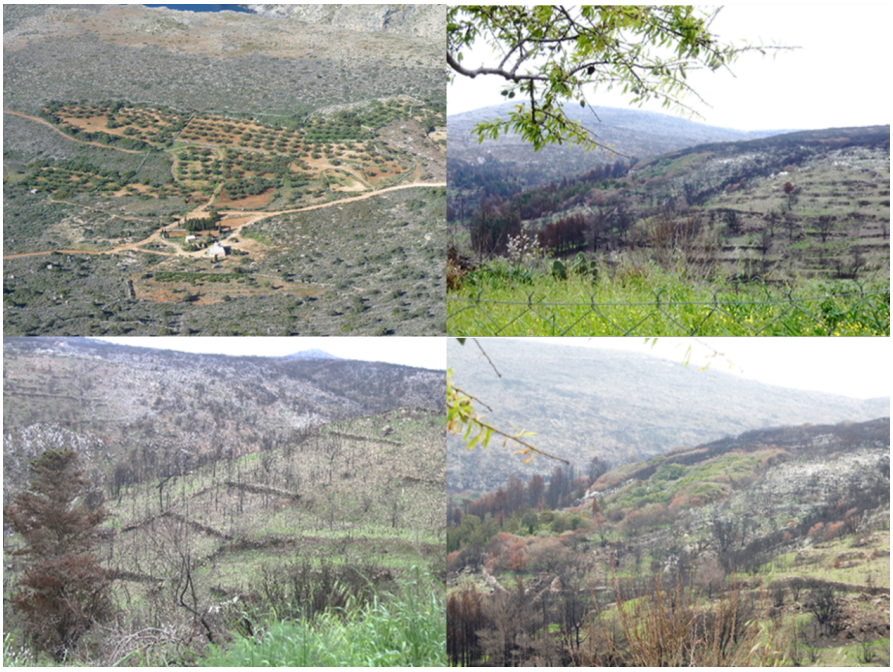

Fig. 6. Stone terraces and walls in the Kythira landscape (Photo: Dr Alexandra Solomou).

We should also consider the fact that the systems of stone terraces and walls (Fig. 6) provide a multitude of benefits for both the environment and human societies. They provide Ecosystem Services that are vital, especially on island regions. More specifically, the most important benefits of maintaining stone terraces and walls are:

- Prevention of soil erosion, both by the action of water and air,
- Protection during extreme weather, preventing floods and contributing to the creation of a local microclimate,
- Production, under specific conditions, of high-quality products,
- The creation of suitable micro-habitats for the conservation, protection and enhancement of biodiversity,
- Maintenance of the high aesthetic and cultural value of the Mediterranean landscape (Koulouri, 2004).

5 Contribution of Stone Terraces and Walls to Biodiversity Conservation

Stone terraces and walls are an integral part of the Mediterranean landscape (Fig. 7). In many cases, they create ecological seals/habitats/nests offering a permanent or temporary refuge to various biodiversity components, e.g. invertebrates, reptiles, birds, etc. Indeed, the orientation of the terraces to the south creates a fire hazard, but on the other hand "retaining walls during the day store solar energy, which is released at night, thereby creating local microclimate" suitable for many organisms, which in turn leads to an increase in biodiversity (Vernikos et al., 2001). In essence, they create an artificial habitat and organism shelter that is enhanced by the increase in landscape mosaics.

The micro-environment at the base of stone terraces and walls are characterized by high humidity and increased primary productivity (dense vegetation), factors which are important for invertebrate populations (e.g. spiders, phalanx, Carabidae, Staphylinida, etc.) (Arnett et al., 2002, Dajoz 2002). During the summer months the slits and openings of the stone terraces and walls accommodate large numbers of other invertebrates (e.g. snails) that pass the breeding period in a protected microclimate. This is probably due both to the high humidity of the stone terraces and walls, and to the increased calcium requirements for the construction of snail shells, factors that make them ideal environments for organisms.

Fig. 6. Stone terraces and walls as an important source of biodiversity (Photo: Dr Alexandra Solomou).

As regards the reptiles, their exothermic condition plays a decisive role in the selection of "good" calorie sites where there is rich food and protection from predators (Adolph, 1990). Stone terraces and walls are such places; thus, they are attractive to reptiles. Therefore, these areas of the island's rural landscape are very important for wildlife, because they are an important refuge for a large number of species (e.g. reptiles, smallpox and insects) that constitute important food for many bird species.

Stone terraces and walls are also an important habitat for flora diversity and habitat for dry or shady plants as they find a safe retreat site there, a haven of life. The flora that grows in these areas hosts species that are scattered by the natural flora of neighboring areas. Plant species vary greatly from place to place depending on the micro geographical conditions (microclimate, altitude, etc.) (Petanidou, 2001). Other factors have to do with the growth of herbaceous plants are the age of the construction, the moisture retention at least once a year, the north orientation and the shading, which indirectly regulate the amount of moisture and its duration (Pafilis, 2014).

6 Conclusion

Stone terraces and walls are part of the island's cultural tradition and heritage and the can contribute to the financial development of the local communities. Under the environmental view, they create suitable micro-environments for biodiversity conservation. It is essential to be preserved as a measure for the protection of the local flora and fauna, for strengthening ecosystems adaptation mechanisms in order to cope with climate change.

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