LANDSCAPE ARCHAEOLOGY AND AERIAL PHOTOGRAPHY

IN THE CENTRAL IONIAN ISLANDS

GIAN PIERO C. G. MILANI

MERTON COLLEGE

SUPERVISED BY PROF. CATHERINE ANNE MORGAN, OBE, FBA

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To my family,

and to Emma and Leonardo, the Future thereof.

Aliusque et idem

“Te specchi nell'onde

del greco mar da cui vergine nacque

Venere, e fea quelle isole feconde

col suo primo sorriso”

“Regarding yourself in the waves

of the Greek sea, whence maiden was

born Venus, and made those islands bloom

with her first smile”

U. Foscolo, A Zacinto

Abstract

Landscape Archaeology and Aerial Photography in the Central Ionian Islands

Gian Piero Milani

Merton College

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This thesis presents a contribution to the study of settlement patterns on a regional scale in the Central Ionian archipelago, focussing on the input of remote sensing. For the first time, information from historical aerial photography is exploited and the potential of remote sensing for the study of the region explored. Chapter 2 focusses on the interpretation of small-scale features, which constitute the vast majority of the data retrieved from the interpretation of aerial imagery, providing possible interpretations in the absence of ground truthing. Chapters 3 and 4 focus instead on large scale interventions, often invisible on the ground. Both the investigation of the extension of the Early Hellenistic polis of Krane on Kephallonia (chapter 3), and the study of the extent of the centuriation associated to the Roman foundation of Nikopolis in Epirus (chapter 4) benefitted from the contribution of remote sensing, and in particular of archival material. These large-scale developments are analysed in the framework of regional settlement patterns. Chapters 3 and 4 also explore the potential of aerial photography to redress the

imbalance in the archaeological record of the region, which still reflects past attention to the search for Homeric *topoi*, resulting in a relative abundance of data of the Late Bronze and Early Iron Ages, showing the strategic importance of remote sensing for the study of the Classical and post-Classical landscape, given its tendency to display more superficial layers.

Finally, conclusions are drawn on the importance of aerial imagery for the study of the landscape archaeology of the region and possible future research developments are presented. The conclusions deal also with another case study, originally planned to be included in this thesis, whose completion was made impossible by the Covid 19 pandemic. Analysis of aerial photographic coverage for the area of Fiskardo revealed a number of interesting features on the northern peninsula. A small-scale survey of the peninsula was foreseen for the summer of 2020, to map in detail any structure visible on the ground, while picking up artefacts according to a survey grid.

Preface and acknowledgments

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1. INTRODUCTION

1.1 Aim and research questions

The aim of this thesis is to present a contribution to the study of settlement patterns on a regional scale in the Central Ionian archipelago, focussing on the input of remote sensing. For the first time, information from historical aerial photography is exploited and the potential of remote sensing for the study of the region explored. In particular, this thesis will detail how aerial archaeology allows us to look at major interventions and other features not readily visible from the ground.

The study begins from a solid evaluation of the physical environment of the archipelago and each island. Three-dimensional big-data analysis in a GIS environment is used to describe the geomorphology of each island, with an eye to the suitability of single areas for medium- and large-scale settlements, by which I mean village- or town-scale settlements. For example, smaller-scale structures such as isolated farmsteads would probably not be visible due to the scale of photographic material available and the nature of their archaeological visibility. They are thus best approached in the context of this thesis when part of a large-scale intervention such as a centuriation. Factors such as elevation, slope, erosion, and aspect are taken into account to evaluate the suitability of single areas for medium- and large-scale settlements. Water sources mapped by the Geographic Service of the Greek Army have also been interpolated to create a model of the availability of underground water. A multidisciplinary approach is used, integrating into the GIS database data from a variety of disciplines, such as seismology, mineralogy, and geology. The dataset is cumulatively analysed on top of a 3D raster digital elevation model derived from satellite data. This analysis results in the individuation of ‘target areas’ on each island, meaning areas suitable for medium- and large-scale settlements.

Aerial photographs providing detailed coverage of target areas (and of smaller islands due to their size) were obtained from the Geographic Service of the Hellenic Army and the Archive of the British School at Athens (World War II Allied Forces collection). Chapters 2, 3, and 4 detail the results of analysis of this aerial imagery. Two approaches are used. In chapter 2, a methodologically-focused case study of the island of Meganisi explores the use of aerial photography in conjunction with archaeological and ethnographic data from the intensive survey conducted by the Inner Ionian Archipelago project of the University of Crete and the Ephorate of Antiquities of Aetoloakarnania and Lefkada. This chapter addresses the challenges and potential of reconciling detailed ground data with medium scale remote sensing material not originally realised for archaeological purposes. Articulating the limitations of imagery generated by the armed forces provides a useful methodological case study to inform projects unable to generate their own coverage for economic or legal reasons (no fly zones near military and civilian airports being a typical example). Secondly, chapters 3 and 4 explore the potential of aerial photography to redress the imbalance in the archaeological record of the region, which still reflects past attention to the search for Homeric *topoi*, resulting in a relative abundance of data of the Late Bronze and Early Iron Ages. Two case studies (on the Hellenistic topography of the polis of Krane, Kephallonia, and a Roman system of land management in the area of Lefkada and the adjoining mainland) show the strategic importance of remote sensing for the study of the post-Classical landscape, given its tendency to display more superficial layers. These case studies reveal two large-scale developments, invisible on the ground, which are both discussed in the context of settlement history. Chapters 3 and 4 present also different approaches for the analysis of historical aerial imagery for archaeological research, with techniques ranging from stereoscopic analysis to digital extraction of features through skeletonization in a MatLab environment. The potentials and limitations of each methodology in connection to the nature of the spotted features are presented in each chapter. Finally, chapter 5 delineates settlement patterns and development trends (or their absence) on island and regional scales -as informed by the case studies presented in earlier chapters-, presents the answers to the research questions delineated in the introduction, and sketches further research developments in this field. Chapter 5 also includes data for an additional case study on the settlement of Panormos (modern Fiskardo) on Kephallonia, originally foreseen to be included in this thesis. This case studies could not be completed as the ground truthing scheduled for the summer of 2020 was cancelled to due the effects of the Covid 19 pandemic.

Data for the study of large-scale developments is obtained from a georeferenced database of archaeological finds populated from a literature review. This database was analysed over the aforementioned 3D digital elevation model obtained from satellite data, allowing a relational study of the archaeological material and the geophysical landscape.

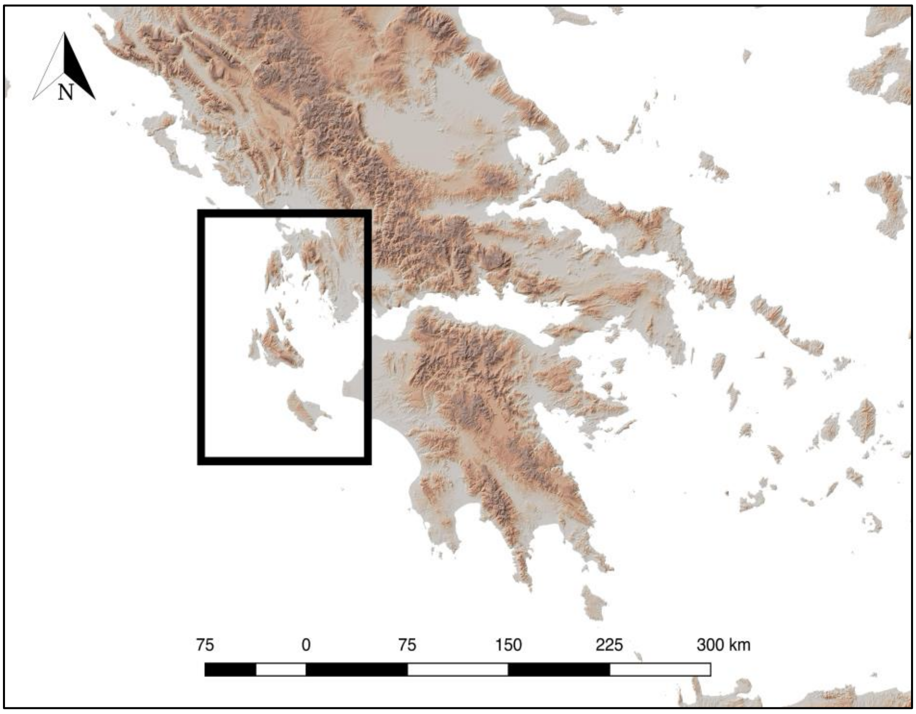

Figure 1: Location of the Central Ionian Archipelago, Greece. 3D shaded relief with superimposition of elevation data. Satellite data from ASTERGDEM, product of METI and NASA.

The archipelago consists in two chains. The outer, oriented north-south, comprises the larger islands of Lefkada ***(fig. 2, 1)***,[1] Ithaki ***(fig. 2, 2)***, Kephallonia ***(fig. 2, 3)***, and Zakynthos ***(fig. 2, 4)***. South-east of Lefkada, the inner chain of the Taphian islands comprises a number of smaller islands, including Meganisi ***(fig. 2, 5)***, Kalamos, and Kastos ***(fig. 2, 6)*** and the islets surrounding them: further south, off the coast by Astakos, lie the tiny islands of the Echinades ***(fig. 2, 7)***. The islands of the archipelago are located on crucial sea routes connecting the Aegean with the Italian and Adriatic worlds, and at

[1] Throughout the thesis, the name Lefkada refers to the island, while the colonial polis is Leukas; likewise, Ithaki is the island and Ithaka the polis. Toponyms are reported as given in the publication quoted, or by default as they appear on the maps produced by the Geographic Service of the Greek Army, series 1 : 50 000.

the same time are close to the mainland of Akarnania and the Western Peloponnese. They are therefore subject to a variety of external stimuli (ranging from trade contacts to seasonal migration to political connections), and are differentiated by their landforms, social and political development, and network of relations.

This study will address the following questions:

1. Can remote sensing make a contribution to the study of landscape archaeology in the Central Ionian Islands?
2. Can aerial photography contribute to redress the historical imbalance in the archaeological record, skewed towards the Late Bronze Age and Early Iron Age?
3. What sort of features of archaeological interest can be retrieved from the study of archival aerial imagery, and how is it possible to maximise the amount of data obtained from such study?
4. How may we provide possible interpretations for features retrieved exclusively from the analysis of aerial photographs and often not visible anymore on the ground?
5. What are the peculiar potentials and limitations of the archaeological use of archival aerial imagery made for military purposes?

As noted, these questions will be addressed through a cumulative and comparative analysis of geophysical, archaeological, and historical data. In keeping with scholarly practice in the field,[2] this study moves from investigation of the geographical features of each island to the identification of areas more suitable for settlement, analysing factors such as slope, aspect, soil erosion, access to water, and land capability (for example, the amount of land suitable for flat field agriculture and terracing). Resampling and modelling techniques are used to generate the various datasets on which these analyses rest. The entirety of the base material for the analyses comes from open source satellite data, with a resolution of 1 arcsec. These data, nowadays largely available through the ASTERDEM and EU DEM platforms, will likely be the mainstay of analyses for the foreseeable future, including for projects unable for whatever reason to acquire commercial satellite data or fly drones to obtain detailed coverage. The methodological implications (and limits) of such material for archaeological use are delineated with particular regard to potential issues arising from detailed resampling of vectorial datasets corresponding to sites over rasters.

Archaeological data, drawn mainly from published excavations, survey reports, and records of finds and rescue excavations not otherwise published, are collected in the Gazetteer (Appendix A) and plotted over a three-dimensional GIS model. This primary dataset is integrated with new features retrieved from the study of aerial photographs (Appendix B) and detailed in chapters 2, 3, and 4. The resulting new database is matched against the 3D model, linking archaeological and physical features. The aim is to study and describe the relations and interactions between the natural environment and documented human activity.[3]

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[2] As for example Farinetti 2009, pp. 15–26; Bevan and Conolly 2013, pp. 24–44.

[3] Farinetti 2011, pp. 11–14.

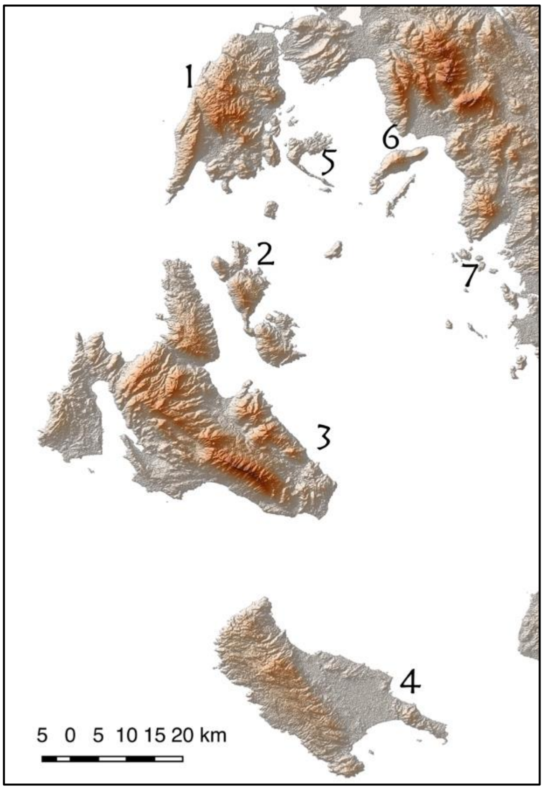

Figure 2: Location of the Central Ionian Archipelago. 3D shaded relief with superimposition of elevation data. Satellite data from ASTERGDEM, product of METI and NASA.

1.2 Approaches

i. Landscape archaeology and GIS

As Bevan and Connolly state in the introduction to their monograph on Antikythera, "the study of Mediterranean landscapes and of *longue durée* histories, island cultures and complex human ecologies have all developed into major research agendas over the past half-century, engaging large swathes of the social and natural sciences".[4] Farinetti distinguishes a geographical and an archaeological approach to landscapes.[5] On one side, geographers perceive the term landscape to have an eminently graphic connotation: *"a*

[4] Bevan and Conolly 2013, p. 1.
[5] Farinetti 2009, p. 4, with bibliography.

cultural image, a pictorial way of representing, structuring or symbolising surroundings".[6] With the development of a more complex approach, cultural features were integrated into this definition along with natural ones, focussing on the interaction between them and culminating in a holistic approach where "each component enfolds within its essence the totality of its relations with each and every other".[7] In Greek archaeology, an early interest in the correlation between physical and archaeological elements can be seen in the work of 19th century historical geographers.[8] For the Ionian islands, two important exponents of this *tempèrie* are William Gell,[9] with his book on Ithaka, and Joseph Partsch, with his work on Kephallonia and Ithaka,[10] where a geographical description of the islands includes a variety of details of the archaeological remains, some of which will be mentioned in chapter 3.

This approach has developed into a major research agenda in archaeology during the 20th century, promoting a rounded study of archaeological material along with a wealth of data from a range of social and natural sciences. Technological developments and the introduction of Geographic Information System (GIS) platforms provided a uniquely versatile tool for this approach, allowing digital comparison of archaeological and physiographical data, initially in a two-dimensional and more recently in a three-dimensional environment.[11] In Greek archaeology, the first studies using GIS for archaeological purposes date to the 1990s: examples include Romano and Tolba's work on Roman land management in the Corinthia.[12] In the early 2000s, important

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[6] Cosgrove and Daniels 1988, p. 1.
[7] Ingold 2000, p. 191, quoted in Farinetti 2009, p. 4.
[8] Farinetti 2009, p. 6, with bibliography.
[9] Gell 1807.
[10] Partsch 1890.
[11] Richards-Rissetto 2017.
[12] Romano and Tolba 1996.

methodological works on the use of GIS for landscape archaeology, such as the monograph by Henry Chapman,[13] established a solid theoretical framework for future research. Applications of GIS in Greek archaeology from the late 20th century have been a mainstay of the 'New Wave' surveys.[14] An important methodological contribution to the use of GIS for landscape archaeology on a regional scale is made by Emeri Farinetti's work on Boeotia,[15] which illustrated a way to analyse large regional datasets incorporating in a GIS environment a variety of data from cartographic, geological, geophysical and literary sources. Island studies are represented by Bevan and Connolly's works on Kythera[16] and Antitkythera.[17] This study follows in their footsteps, adopting the same methodology based on a joint reading of geomorphological and archaeological data. Material from geological,[18] environmental,[19] geophysical,[20] geoarchaeological,[21] climatological,[22] and seismological studies[23] is incorporated into a 3D GIS model along with settlements and finds retrieved from literature review, informing an understanding of the relationship between the natural environment and archaeological finds. This model has two different uses in this thesis:

1. It informs the choice of "target areas". Target areas are in the context of this thesis zones deemed particularly suitable for settlement (following analysis of the

[13] Chapman 2006.
[14] Farinetti 2009, pp. 6–8, with bibliography.
[15] Farinetti 2009; Farinetti 2011.
[16] Bevan and Conolly 2004.
[17] Bevan and Conolly 2013.
[18] Lekkas, Danamos, and Mavrikas 2001; Gournelos et al. 2010; Bourli et al. 2019.
[19] Baliousis 2015.
[20] Evelpidou 2012; Yiannouli 2016.
[21] Vött 2007; Tendürüs, van Wijngaarden, and Kars 2010; Vött et al. 2014.
[22] Nastos and Zerefos 2010.
[23] Papathanassiou, Pavlides, and Ganas 2005; Tendürüs, van Wijngaarden, and Kars 2010; Ganas et al. 2012; Valkaniotis et al. 2014.

physical environment datasets) or where archaeological settlements were known from literature review.

2. The various datasets comprised in the model are used for the analysis of the case studies comprised in chapters 3 and 4.

ii. Aerial archaeology

This thesis concentrates on the potential of remote sensing, and of military aerial photography in particular, a topic perhaps less explored in Greece than in other Mediterranean countries. While the use of military aerial photography for archaeological purposes in Greece dates back to the middle of the 20th century and Chevallier's work on Roman land management systems,[24] aerial archaeology in Greece has never been as widely practiced as, for example, in Italy.[25] This is probably due to particularly restrictive laws on the availability of, and commerce in, aerial imagery, of a kind uncommon across the Mediterranean and Balkan regions. Important work on aerial archaeology has been done in Boeotia (though this is still not completely published),[26] and in the Corinthia.[27] Particularly important for this thesis, as a guide to possible available coverage, was Anke Stoker's work on Zakynthos,[28] not only because it featured an island included in this study, but also for the seminal survey of the available material, providing scholars with a clear guide to photographic material the location and availability of which was hitherto not widely known.

This thesis uses aerial imagery dating from the second half of the 20th century onwards, mainly from the historical archive of the Geographic Service of the Hellenic Army, but

[24] Chevallier 1958.
[25] On aerial archaeology in Italy, see: Guaitoli 2003.
[26] Donnellan 2017, p. 13.
[27] Romano and Tolba 1996.
[28] Stoker 2010.

also, for the first time, World War 2 aerial imagery kept at the British School at Athens. Photographic material from the 1940s remains of unique significance for the study of the Ionian Islands because it predates a major earthquake in 1953 (and several successive episodes) which caused important geomorphological alterations. The massive emigration, and abandonment of fields and pastures which followed gave rise in turn to a dramatic change in land cover, with progressive afforestation.[29] The Allied aerial images record landforms both before and after the earthquake. Because they were created for strategic military purposes, they provide a homogenous coverage of most of the islands at a scale suitable for archaeological interpretation, and their forward overlap allows 3D stereoscopic viewing, ideal for the identification of features and remains. These photographs were crucial in detecting the two large-scale developments described in chapters 3 and 4. In the case of the Hellenistic development of the polis of Krane, afforestation after the 1953 earthquake made the orthogonal grid practically invisible on the ground. For the Roman centuriations between Lefkada, Aktion, and the peninsula of Preveza, anthropogenic change (such as the installation of a military and subsequently civilian airport) through the second half of the 20th century covered the cropmarks recognised here. As an example of 20th century historical ecology, Chapter 2 contains an analysis of changes in land cover in Meganisi based on comparative study of post World War 2 coverage. The impact of these changes on the visibility of archaeological remains is also discussed.

Other possible sources of aerial imagery were explored in the early stages of this thesis. In particular, it was confirmed that the photographic archive of the German

[29] Grandazzi 1954.

Archaeological Institute in Athens contains no German aerial coverage of the areas of interest. Other possible sources of imagery, such as the National Archives and Records Administration (NARA, Washington, USA) and the Aerial Reconnaissance Archives (TARA, Edinburgh, UK) or other Departments of the Greek Government[30] could not be consulted for the following reasons:

1. Some collections are not organically catalogued, and the timeframe of a doctoral thesis did not permit me to undertake a large amount of cataloguing and mapping *ab initio.*
2. The Covid 19 pandemic constrained travel and access to resources located outside the UK.
3. The substantial costs involved in obtaining imagery, along with the time frame for the completion of a doctoral thesis, limited the quantity of material that could be acquired.

This thesis is therefore based on the two collections that were already catalogued: positives from the historical archive of the Geographic Service of the Hellenic Army and imagery from the British School at Athens.[31]

iii. Regional dynamics

Since the aim of this thesis is analysis of settlement patterns and development on a regional scale, it is important to clarify what is intended here as a 'region', and to justify the use of this approach in this context. Historically, the concept of region was based

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[30] For an overview of aerial imagery from these repositories available for Zakynthos, see Stoker 2010, pp. 34–36.

[31] Catalogued by the author over two years prior to the start of this thesis thanks to two grants by the Friends of the British School at Athens.

either on physical and natural characteristics or on the analysis of human activities.[32] The simplest solution in this thesis would be to adopt a definition based only on geography. In theory it would be possible to justify the need for a regional analysis of the Central Ionian Islands simply by saying that they all share an insular identity. They are in some ways separated from neighbouring lands by the sea channels that surround them, and it makes sense to study them together as they are (more or less) close to each other. Nevertheless, this argument has at least two flaws. First, Lefkada was not always an island: a navigable channel down its north-east coast was opened late in the 7th century by the Corinthian colonists of Leukas, and in later times a bridge capable of taking wheeled traffic joined the city to Aetoloakarnania.[33] Secondly, the 'geographical definition' is overly simplistic because it presupposes an unreasonably high level of generalization about the dynamics of connection. While it is true that the islands are close to each other, it is equally true that some of them (such as Kalamos) are closer to the mainland, and their insular identity alone would not justify a privileged relationship with other islands and the assumption of commonality. Even a preliminary glance at the composition of the archipelago reveals major differences in the size and resources of individual islands, thus implying the existence of thick textures of connection between them. In this respect, this thesis follows in the footsteps of recent studies such as the Antikythera Island Project[34] and the Small Cycladic Islands Project.[35] An approach which prioritised from the outset the analysis of human activities to ascertain some kind of commonality would effectively make assumptions about the significance of those human

[32] On this see Reger 2013, pp. 119–121. A wider history of the notion of the region and of its application in archaeology can be found in Farinetti 2011, pp. 3–14.
[33] Murray 1988.
[34] Bevan and Conolly 2013, pp. 1–7.
[35] Https://smallcycladicislandsproject.org.

activities before they were systematically studied. Furthermore, the only way to justify *a priori* some commonality of activity would be to resort to a geographical approach with all its limitations.

Vance and Henderson's definition of a region as 'a homogeneous area with physical and cultural characteristics distinct from those of neighbouring areas'[36] and Gary Reger's approach based on economic factors[37] both offer a possible way forward. The differentiation of the islands from the surrounding mainland is largely clear. Zakynthos lies in front of Elis but is clearly not part of it, although influences and relations are surely present. This might seem a cunning *escamotage* to sneak in by the back door the physical approach that we have just dismissed, but the case is saved by the first part of Vance and Henderson's definition, which stresses homogeneity. We can approach this archipelago as a region because of the density of the internal connections between islands, along with their shared position on certain sea routes. These joint factors, which characterise the archipelago as a 'near perfect laboratory of connectivity both in terms of its location and of its composition',[38] combined with the clear separation of almost all islands from the mainland, fit this definition of a region, and call for a global analysis.

Nevertheless, a multi-scale approach is needed to carry on this study. The same definition of a region can equally fit an island like Kephallonia, which had four different poleis in Archaic – Hellenistic times. As a single island, Kephallonia is certainly distinct from

[36] Vance and Henderson 1968, p. 377.
[37] Reger 2013.
[38] Morgan 2014, p. 25.

neighbouring areas, and its various city states interacted with each other in interesting and complex ways. Can this island be considered a region on its own? At the same time, the urban centre of the polis of Same on Kephallonia is considerably closer (by sea) to Ithaki than to the other Kephallonian poleis of Pale and Krane (either by sea or land), emphasizing again the importance of inter-island connectivity. Special attention will therefore be paid to the investigation and description of settlement patterns at island, inter-island, and archipelago level.

1.3 The Archipelago

i. Connections and 'borders'

The central Ionian Islands lie between the Calabrian and Hellenic arches and connect via different routes the old Greek and Aegean world with the Balkans and the Adriatic to the north, and Italy and Sicily to the west. Lefkada lies immediately in front of the coast of Aetoloakarnania, to which was it joined by marshlands until the opening of the Leukas channel late in the 7th century BC. Ithaki and Kephallonia are also aligned with this coast but are substantially further away. Southern Kephallonia lies right on the opening of the Gulf of Patras, which links with the Gulf of Corinth to create a vital east-west connection.[39] Zakynthos, at the southern end of the chain, lies before the coast of Elis and the Peloponnese.

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[39] Morgan 1988, pp. 315–316; Freitag 2000; Morgan 2003, pp. 218–220; Bonnier 2014.

The two principal routes via the islands are as follows. The first starts from the Saronic Gulf and the wider Aegean, crosses Cape Maleas and, passing along the Peloponnesian coast, enters the archipelago via Zakynthos and southern Kephallonia. It then proceeds through the Ithaki channel and around Lefkada, and then via Antipaxoi and Paxoi reaches Kerkyra. From Kerkyra it is possible either to cross the sea toward Cape Iapygia (and the coastal routes toward Italy and Sicily) or to continue northward toward Epidamnos and subsequently the northern Adriatic[40] (including, from the sixth century onwards, the trading settlements at Adria and Spina).[41] The second route starts from the Gulf of Corinth, continues through the Gulf of Patras, and then joins the first route at Kephallonia. After the opening of the *diolkos* early in the 6th century BC, traffic from the Saronic and Aegean could also follow this second route,[42] since the *diolkos* provided a safer alternative to the dangerous crossing of Cape Maleas, famous for its highly changeable weather and strong winds.[43]

The location of the Central Ionian Islands along those routes was of great strategic significance, and as a result, the archipelago from time to time emerged as a 'frontier-zone'. A brief summary of past approaches to the question of location highlights a number of general assumptions, based largely on external perceptions, which should now be called into question. During the Bronze Age, the islands have been described as the western periphery of the Aegean cultural area,[44] although this view is no longer

[40] Thiry 1998, p. 10.
[41] Zamboni 2016.
[42] Macdonald 1986 with bibliography. Recent discussion has cast doubt on the frequency of trans-isthmus portage in the pre-Roman period: see, Pettegrew 2016, pp. 113–124.
[43] Bevan and Conolly 2013, pp. 33–34 with bibliography.
[44] Souyoudzoglou-Haywood 1999, p. 131.

dominant.[45] Later, the foundation of colonies in southern Italy and Sicily transformed the pre-existing sea routes into the connections between continental Greece and what then became Magna Graecia.[46] During the Classical and Hellenistic periods, the connection that the islands afforded between the Ionian and Adriatic Sea; the Corinth Gulf and the coastal areas of Peloponnese became of geopolitical importance. As a result, they were at different times coveted by Corinth, Athens, Sparta, Macedonia, Syracuse, Carthage and Rome.[47] Subsequently they appeared to be the westernmost tip of the Eastern Roman Empire, and finally, under Venetian rule, they become the easternmost part of western Europe.[48] Yet such emphasis on frontiers and on the islands' position on the edge of the 'eastern' and 'western' Mediterranean world runs the risk of overshadowing the deep and continuous nature of connectivity in the area.

Today the islands belong to the wider administrative unit of the Ionian Islands, along with Kerkyra, Paxoi, and Antipaxoi to the north. Together with Kythera, they are still referred to as the Eptanese, following the Venetian name. Kerkyra, Paxoi, and Antipaxoi, however, belong to a different network (even if connected with the region of this study),[49] and Kythera belongs more to the cultural region of the Peloponnese and Aegean. By contrast, the Central islands, as pointed out above, make up a region in the sense of an 'area with physical and cultural characteristics distinct from those of neighbouring areas'.[50]

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[45] Souyoudzoglou-Haywood, Sotiriou, and Papafloratou 2017; Vikatou 2017; van Wijngaarden and Pieters 2017.
[46] Malkin 1998, pp. 74–81.
[47] Thiry 1998.
[48] Randsborg 2002, vol. 2, p. 13.
[49] Morgan 2014, p. 25.
[50] Vance and Henderson 1968, p. 377, quoted in Farinetti 2011, p. 3.

ii. Geography and geology

The islands are mainly constituted by secondary limestone formations[51] especially along the coasts,[52] which are the kind of permeable rocks directly connected to karstic phenomena. A feature of the area is the high level of rainfall, which is two to three times greater than in continental Greece.[53] Despite this remarkable level of precipitation, the availability of water is strongly influenced by the karstic environment. Souyoudzoglou-Haywood rightly notes the presence of springs emerging directly into the sea or too close to the shore to avoid contamination with brackish or salt water. A further problem concerns the quality of the water accessible in a karstic landscape, where underground caves are filled by precipitated water subject to limited filtration and accessed mainly through sink-holes (*katavothrai).* Perennial streams are extremely rare.[54] The interpolation of water sources plotted by the Greek Army into a 3D GIS environment derived from satellite data allows us to build a model of areas with direct access to water **(pl. 1)**.[55]

The islands are relatively close together, separated by channels only 8 to 15 km wide (the same distance that divides them from the coasts of the Greek mainland). Nonetheless, their environments and geomorphologies differ. Lefkada and Ithaki are mountainous

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[51] Thiry 1998, p. 5.

[52] Evelpidou 2012, pp. 295–296.

[53] The highest peak of rainfall is on the island of Kerkyra: Branigan and Jarrett 1975, p. 336, quoted in Souyoudzoglou-Haywood 1999, p. 5. For more recent studies of precipitation in the Ionian Islands, see Nastos and Zerefos 2010 with bibliography.

[54] Souyoudzoglou-Haywood 1999, pp. 4–5.

[55] For ease of visualisation and because of their scale, certain images are included as full page plates.

while Zakynthos is mostly plain.[56] Kephallonia combines these two aspects, with rich and fertile plains in the southern part of the island and the Paliki, and a central mountainous zone. The short distances between single islands and between the islands and the mainland, along with the good number of natural ports and the absence of *meltemia* (the northern winds characteristic of the Aegean during the summer),[57] made these islands ideal for short-distance maritime and coastal navigation. In the Mediterranean it is possible to observe a general pattern of anticlockwise, cyclonic currents. Nevertheless, on a smaller scale, currents are influenced by a variety of phenomena such as prevailing wind directions, intermixing of waterbodies with various depths, and the meeting of distinct water masses with different levels of salinity.[58] There is evidence of human habitation dating back to 110 ka BP and of seafaring at least from 35 ka BP.[59] A detailed presentation of the geomorphological characteristics of each island is provided later in this introduction.

The islands lie at the meeting point of the Adriatic, Eurasian, Hellenic, and African plates. Located exactly along the Hellenic Trench, this area shows the greatest seismicity in the entire Mediterranean region,[60] with recurring events of high magnitude due to the subduction of the African plate towards the northeast and the continental collision of the Apulian platform with the Eurasian plate.[61] Recent studies on Lefkada and Kephallonia

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[56] Although the plain areas are distributed between a large coastal plain and a plateau, as it will be detailed later on.
[57] Souyoudzoglou-Haywood 1999, p. 5. In the Ionian sea mainly westerlies tend to be prevailing winds: Bevan and Conolly 2013, p. 31.
[58] Bevan and Conolly 2013, p. 32.
[59] Ferentinos et al. 2012.
[60] Papathanassiou, Pavlides, and Ganas 2005, p. 13.
[61] Vött 2007, pp. 895–897.

have demonstrated how soil liquefaction during earthquakes enhances the destructive potential of seismic events.[62] Frequent tectonic movements also contribute to a constant modification of landforms,[63] generating slow but continuous changes (subsidence and uplift) in the environment. The relevance of these phenomena must be carefully weighed in studies of the archaeological landscape. A recent study in Zakynthos dealt with displacement and burial of archaeological remains,[64] while effects on the shoreline were investigated by the A.Sho.Re project on southeast Kephallonia.[65]

The position of the archipelago over the points of contact and subduction of four plates is reflected in fundamental landforms typical of areas of tectonic collision: land elevation and bathymetric data combine to reveal rocky, mountainous islands with deep sea bays.[66] **(pl. 2)**.

iii. An uneven set of records

For the past two centuries, investigation of the central Ionian archipelago has been often intense but uneven. An understanding of the dynamics of study is therefore crucial in order to weigh the archaeological records available. The picture of the history of investigation in Ithaki presented by Gerasimos Livitsanis[67] is in many ways applicable to the rest of the archipelago, as is clear from a review of the bibliography. As Livitsanis suggests, archaeological interest can be divided chronologically into three periods: the period of the *Pioneers* (chiefly travellers), that of the *Patrons*, and the *Modern* period.

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[62] Papathanassiou, Pavlides, and Ganas 2005; Valkaniotis et al. 2014, with bibliographies.
[63] Ganas et al. 2012.
[64] Tendürüs, van Wijngaarden, and Kars 2010.
[65] Yannouli 2016.
[66] For the phenomena of orogenesis in the region: Aliaj 2006; Doutsos, Koukouvelas, and Xypolias 2006; Ganas et al. 2012; Avramidis et al. 2017.
[67] Livitsanis 2013, p. 96.

The interests of the Pioneers and Patrons[68] focused mainly on the significance of the islands in Homer,[69] and this in turn shaped the direction of investigation and thus the archaeological records available. Research into the mythical kingdom of Odysseus[70] drew significant attention to Ithaki,[71] and in turn gave rise to extensive research on Kephallonia[72] and Lefkada.[73] By contrast, Zakynthos received much less attention perhaps because it is easily identified in the Homeric poems.[74]

While much has changed since the time of the 19th-century travellers and early excavators, the orientation of archaeological interest in the islands still reflects the strength of past attention to the search for Homeric *topoi*, with a relative abundance of data for the Late Bronze and Early Iron Ages[75] and significant gaps in our knowledge of later periods. To a significant extent, this reflects the lack of publication of post-Archaic data from past excavations, which hampers attempts to gain a wider and more complex understanding. During the last decades, however, a significant amount of new data has emerged from excavations and surveys carried out on Lefkada,[76] Kephallonia,[77] Ithaki,[78] Zakynthos[79] and Meganisi with the inner Ionian archipelago,[80] while the rescue

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[68] The term ‘Patrons’ here refers to the great sponsors of expeditions, such as Rennell Rodd on Ithaki or the Goekoop family on Kephallonia and Lefkada.
[69] Steinhart and Wirbelauer 2002.
[70] Waterhouse 1996, pp. 314–317.
[71] Paizis-Danias 2001, pp. 413–472.
[72] Marinatos 1921; Marinatos 1932; Marinatos 1933.
[73] Dörpfeld and Goessler 1927.
[74] van Wijngaarden 2012.
[75] Souyoudzoglou-Haywood 1999.
[76] Andreou 1998.
[77] Randsborg 2002.
[78] Morgan 2004; Livitsanis 2013; Morgan 2014.
[79] van Wijngaarden, Kourtessi-Philippakis, and Pieters 2013, along with the annual reports published in Pharos from 2005 onwards.
[80] Galanidou 2002.

excavations of the Greek Archaeological Service have made a noteworthy contribution to our understanding.[81] The region emerges from these studies as a palimpsest, in all its richness and complexity, the most recent layers of which still have not received sufficient attention.

A number of studies of the geological[82] and geomorphological features of the region have shed new light on the dynamics of the formation and transformation of the islands,[83] but have also addressed the influence of these factors upon the archaeological record. Three examples may be noted. First, geoarchaeological studies on Kephallonia have examined the relationship between the natural and cultural components of the coastal zone.[84] Second, a pilot study on Zakynthos has examined the effect of seismic events upon the preservation of both architectural structures and pottery finds in the long term.[85] Third, again on Zakynthos, the dramatic impact of geological alterations has been showcased, with previously documented archaeological sites almost disappearing due to the effects of coastal erosion in just fifty years.[86] All in all, a new inter-disciplinary approach has shown how to make effective links between finds, sites, and a territory affected by continuous variation, and to take into account the influence of constant landform changes upon the preservation and distribution of ancient artifacts. Today, the general progress of research, along with this holistic approach, enables new readings and reinterpretations of

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[81] *Passim* in Wijngaarden and Sotiriou 2013. Andreou 1998 for Lefkada.
[82] Evelpidou 2012.
[83] Geraga et al. 2008; Gkioni et al. 2013; Avramidis et al. 2017.
[84] Yiannouli 2016.
[85] Gouma, van Wijngaarden, and Soetens 2011.
[86] Stein and van Wijngaarden 2012.

previous studies - for example challenging[87] the assumption that the basic landforms of the islands have remained essentially the same since the end of the Ice Age.[88]

1.4 Datasets

While studies have been made of the archaeological and historical records of the prehistoric,[89] Archaic-Classical and Roman[90] periods, and of the epigraphy of the region,[91] systematic compilation of the available data and its diachronic analysis for the purpose of landscape studies across the entire region has not yet been undertaken. This thesis fills the gap via the construction of three separate datasets and their comparative analysis in a GIS. These datasets concern the physical environment, previously known sites, and newly identified sites.

Analysis is based on assessment of different aspects of the land- and seascapes of single islands. It is focused on the investigation of how such aspects inform understanding of networks of communication amongst the islands themselves and with the mainland.[92] Particular attention will be paid to comparative reading of transformations in settlement in the islands and in surrounding areas as elucidated by the case studies, to clarify whether and how the islands formed part of wider regional dynamics, and how they reacted to

[87] Avramidis et al. 2017.
[88] Souyoudzoglou-Haywood 1999, p. 3.
[89] Souyoudzoglou-Haywood 1999.
[90] For a historical overview, see Thiry 1998.
[91] *IG* IX.2.
[92] Westerdahl 2011, pp. 746–747. In the Mediterranean context, see Horden and Purcell 2000, pp. 53–54.

significant changes in contiguous zones, such as the foundation and eventual decline of Nikopolis.[93]

The ultimate objective is to contribute to understanding of how the islands participated in a complex network of relations and interactions on three levels: between single islands, inside the archipelago, and with the mainland. Also implicated is the impact upon insular identities and character of their location on 'frontier-zones' and across crucial trade-routes. Thus, one might consider whether this resulted in a tendency to isolation or rejection of outside elements, or whether it encouraged participation in wider networks at a cultural level, beyond simple trade; and if outside elements were adopted, how they were then adapted to fit pre-existing identities? Understanding of these dynamics, and how they changed over time, is crucial if we are to assess the network of relations with surrounding areas and responses to cultural stimuli.[94]

For example, chapter 3 investigates the incomplete large-scale orthogonally planned urban centre of Nea Krane, belonging to the polis of Krane (Kephallonia) and dating to the Hellenistic period. Discussion explores two levels of connection. First, on an island level, the development of a planned city is analysed along with the cases of two other Kephallonian cities (Same and Poros) which underwent planned redevelopment at various stages from the early fourth to the third century BC. Second, the possible link between this incomplete large-scale development at Nea Krane and the wider context of the

[93] Veikou 2012, pp. 331–360.
[94] Souyoudzoglou-Haywood 1999, p. 131.

politics of the New Corinthian League (of which the central Ionian islands were part) is explored.

Chapter 4 links the traces of a Roman land management system in Lefkada with the wider settlement and landscape dynamics of the Early Imperial Period. The grid retrieved from the study of remote sensing material is linked with another grid in the peninsula of Aktion, and with the previously known centuriation of Nikopolis, shedding new light on the dynamics of the synoecism of the Roman colony.[95] The analysis then proceeds to include wider settlement trends, including the foundation of the Roman colony of Patrae and the establishment of centurial grids in the northern Peloponnese, framing the centuriation of Lefkada and Aktion in the wider framework of the urban policy of Augustus in Greece after his naval victory against Antony at Actium in 31 BC.[96]

i. Datasets concerning the physical environment.

The physical environment should be understood as the global sum of data related to landforms, geology, and hydrology. Study is crucial to assess the potential of given areas for settlement, dynamics of movement, and spatial relations between sites. This dataset is divided into BASE data and DERIVED data. The former includes ‘raw’ data and sources. The latter is made up of data obtained from the BASE group either through geospatial analysis or through a process of critical interpretation.

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[95] Purcell 1987; Samsaris 1994.
[96] Riginos 2007.

Table 1: BASE (raw) data included in the GIS database			
Data type	**Source**	**Scale or resolution**	**Notes**
Elevation data	ASTERDEM[97]	Raster. Ground resolution: 1 arc second per pixel	
Topographical maps	Geographical Office of the Hellenic Army	1:50 000	Sheets used (1984 series): Vonitsa, Levkas, Astakos, Kalamos, Ayos Petros, Ekhinadhes, Nisos Atokos, Ithaki, Atheras, Nea Manolas, Ayia Irini, Argostolion, Amalias, Vartholomion, Zakynthos,

[97] ASTERGDEM is a product of METI and NASA.

			Volimai, Pyrgos.
Bathymetric data	EMODnet	1 : 150 000	
Vertical Aerial Photographs	BSA	Various	List of flights and photographs is provided in table 2
Vertical Aerial Photographs	Geographical Office of the Hellenic Army	Various	List of flights and photographs is provided in table 2
Georectified Aerial Photographs	National Cadastrial Agency of Greece, online WMS[98]	Various	
Geological Maps of Greece	Athens Institute of Geology and Mineral Exploration	1 : 50 000	Sheets used: Echinades (1989), Paxi (1969), Ithaki and Atokos Islands (1991),

[98] Ελληνικό Εθνικό Κτηματολόγιο: www.ktimanet.gr

			Astakos (1986), Nea Manolas (1977), Vartholomion (1969), Arta (1969), Vonitsa (1996), Amalias (1993), Cephalonia Island Northern Part (1985), Messolonghion (1996), Kalamos (1994), Zakynthos Island (1980) Cephalonia Island Southern Part

			(1985), Lefkas Island (1963).
Admiralty Charts (2010 edition)	United Kingdom Hydrographic Office (UKHO)	Various: 1 : 50 000 to 1 : 300 000	Sheets used: 189 - Nisos Sapientza to Nisos Paxoi (1 : 300 000); 203 - Nisos Zakynthos to Nisos Antipaxoi (1 : 150 000); 1676 - Prokolpos Patron to entrance of Korinthiakos Kolpos (1 : 100 000); 2405 - Ports in Western Greece (1 : 50 000).

Historical Admiralty Charts, from the Map Room of the British School at Athens	United Kingdom Hydrographic Office (UKHO)	Various scales	Sheets used: 203 - Anti Paxos island to Cape Glarenza including Levkas, Ithaca and Cephalonia islands (1867 edition, scale 1 : 154 000); 207 - West coast of Morea, from Kastro Tornese to Venetiko with the island of Zante (1867 edition, scale 1 : 205 000); 1557 - Port Argostoli (1896 edition,

			scale 1 : 19 800); 1609 - Levkas road and Port Drepano (1914 edition, scale 1:29 300); 1620 - Harbours in the Ionian islands (1866 edition, various scales).
SHOM Charts (2008 edition)	Le Service Hydrographique et Océanographique de la Marine (SHOM)	1:250 000	Sheets used: 7195 L - Côte Ouest du Peloponnèse, De Nísos Zákinthos à Ákra Taínaro; 7272L - Iles Ioniennes (Iónioi Nísoi) - De Nísos Othonoi à

			Nísos Zákinthos.
Clipping polygon for the archipelago	Manually drawn	Vector - polygon	
Clipping polygons for each island	Manually drawn	Vector - polygon	
Map of geographical distribution of susceptibility to erosion factor	Raster	1:150 000 c.	Evelpidou 2012, p. 304, fig.6.
Map of geographical distribution of erosion risk.	Raster	1:150 000 c.	Evelpidou 2012, p. 307, fig. 9.
Survey grid for the Inner Ionian Archipelago Project.			
Survey data from the Inner Ionian Archipelago Project.	Prof. Nena Galanidou	XLSX spreadsheet	The following datasets were imported: Late Bronze Age, Early Iron Age,

			8th to 7th century BC, Archaic, Archaic to Classical, Archaic to Hellenistic, Classical, Classical to Hellenistic, Hellenistic, Hellenistic to Roman, Early to Middle Roman, Late Roman, Modern Pottery, Iron Slugs.

Table 2: List of Aerial photographs included in the database. BSA stands for British School at Athens, Collection of Allied Aerial Imagery. GYS stands for Geographic Service of the Hellenic Army, Aerial Photographs Fund.			
Collection and ID	**Date**	**Scale of print positives**	**Frame numbers**
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Table 3: DERIVED data included in the GIS database			
Data type	Derived from	Scale or resolution	Notes
Digital Elevation Model A	Elevation data (stitched together)	Raster. Ground resolution: 1 arc second per pixel	Coordinate reference system used for the DEM was EPSG : 4326 - WGS 84. The geographical extent of the raster was: 20.26125, 37.61125: 21.18652, 38.90347.
Digital Elevation Model B	Digital Elevation Model A	Raster. Ground resolution: 1 arc second per pixel	Pixels corresponding to sea level were labelled with a NULL value.

Digital Elevation Model C	Digital Elevation Model B	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygon covering the entire area of the archipelago.
Individual DEMs for each island	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The Echinades are treated as a unique entity for the sake of the analysis.
DEM classified	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	Classification of elevation data obtained through raster calculation. Class 1: < 200

			m asl; class 2: ≥ 200 and < 600 m asl; class 3: ≥ 600 m asl.[99]
Individual classified DEMs for each island	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The Echinades are treated as a unique entity for the sake of the analysis.
Hillshade shaded relief	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	
SLOPE archipelago	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	Methodology and formula are provided further ahead in

[99] After Farinetti 2009, p. 17.

			the introduction.
Individual slope rasters for each island.	SLOPE archipelago	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The Echinades are treated as a unique entity for the sake of the analysis.
SLOPE classified	SLOPE archipelago	Raster. Ground resolution: 1 arc second per pixel	Methodology and formula are provided further ahead in the introduction.
Individual classified slope rasters for each island.	SLOPE classified	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single

			islands. The Echinades are treated as a unique entity for the sake of the analysis.
Physiographical classes	DEM classified and SLOPE classified	Raster. Ground resolution: 1 arc second per pixel	Methodology and formula are provided further ahead in the introduction.
Individual physiographical classes rasters for each island.	Physiographical classes	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The Echinades are treated as a unique entity for the sake of the analysis.

Aspect	Elevation data	Raster. Ground resolution: 1 arc second per pixel	**Pl. 3**
Individual aspect rasters for each island.	Elevation data	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The Echinades are treated as a unique entity for the sake of the analysis.
Contour lines	Elevation data	Vector	**Pl. 2**. Data sampled at a 100 m interval.
Slope Classes A	Slope Classification	Vector	Sampled at intervals of five degrees.
Slope Classes B	Slope Classification	Raster. Ground resolution: 1 arc second per pixel	Sampled at intervals of five degrees.

Water Sources	Topographical maps, Geographical Office of the Hellenic Army, series 1:50 000	Vector - points	
Model of water availability	Water Sources	1:50 000	**Pl. 1**. 1 km of catchment area around a given source estimated, which includes potential underground availability around a point and anthropic movement.
Contour lines			**Pl. 2**. Data sampled at 100 m intervals.
Field boundaries	Aerial photographs	Vector	For target areas, when relevant for case studies.

Terraced areas	Aerial photographs	Vector	For target areas, when relevant for case studies.
Vectorialised map of geographical distribution of susceptibility to erosion factor.	Raster map of geographical distribution of susceptibility to erosion factor.	Vector	Evelpidou 2012, p. 304, fig. 6.
Vectorialised map of geographical distribution of erosion risk.	Raster map of geographical distribution of erosion risk.		Evelpidou 2012, p. 307, fig. 9.
Basin drainage	Digital Elevation Model C	Raster. Ground resolution: 1 arc second per pixel	Realised with Multiple Triangular Flow Direction method.
Individual basin drainage rasters for each island.	Basin drainage	Raster. Ground resolution: 1 arc second per pixel	Clipped with vectorial polygons corresponding to single islands. The

			Echinades are treated as a unique entity for the sake of the analysis.
Finds retrieved during the land survey of the Inner Ionian Archipelago Project.	Survey data and grid polygons from the Inner Ionian Archipelago Project.	Vector - points	The following datasets were generated: Late Bronze Age, Early Iron Age, 8^{th} to 7^{th} century BC, Archaic, Archaic to Classical, Archaic to Hellenistic, Classical, Classical to Hellenistic, Hellenistic, Hellenistic to Roman, Early to Middle

			Roman, Late Roman, Modern Pottery, Iron Slugs.

ii. The first archaeological dataset.

The first archaeological dataset consists of the georeferenced sites and finds from published excavations and survey reports collected in the Gazetteer (Appendix A). The rationale behind the structure of this database and its categories is to reconnect the entries to certain components of the terrestrial and maritime landscapes of the archipelago,[100] taking also into account that features can have multiple purposes:

1. The *economic landscape* is based on trade, fishing, herding, cultivation, and the exploitation of natural resources. It includes the exploitation of resources both internal to an island (including the creation of infrastructure such as terracing and land divisions) and external (in the sense of being located beyond the island, such as, for example, cash cropping on the mainland).[101] Investigation here also aims at the understanding of trade models, i.e. whether islands generate the surplus necessary for export, or need constant imports, or tend to be self-sufficient, and if this changes when the region appears to be part of a wider economic system.[102]

[100] Adapted from Westerdahl 2011.
[101] Bevan and Conolly 2013, pp. 196–204.
[102] Bevan and Connolly 2013, pp. 79–84.

2. The *landscape of transport* may be divided into internal- and external - facing features; to the former category belong features such as roads and pathways, and to the latter, sea routes[103] and harbours.[104]
3. The *landscape of power and defence* includes fortifications and towers intended to control channels, strategic areas, and ports, with an emphasis on visual communication between islands.[105]

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[103] Horden and Purcell 2000, pp. 722–740.
[104] See Yannouli 2016 for the study of seascapes in Kephallonia.
[105] Veikou 2012, pp. 336–346 carries out a similar analysis for fortifications in Epirus during Byzantine times.

Table 4: Structure of the first archaeological dataset: sites retrieved from literature review		
Field	**Options**	**Notes**
ID	Island.LR.Serial Number (KEF.LR.1) Island identifiers are the following: LEF: Lefkada MEG: Meganisi KAL: Kalamos KAS: Kastos ECH: Echinades ARK: Arkoudi ATO: Atokos ITH: Ithaki KEF: Kephallonia ZAK: Zakynthos AKT: Peninsula of Aktion	
Toponym	Open field	Toponyms whenever possible are spelled as reported in the original publication, with as default the

		usage on the Greek Army Maps, 1: 50 000 series.
Typology (and sub-type)	Settlement Cave Cult Temple Sanctuary Cave Sanctuary Early Christian Church Church Monastery … Burial Necropolis Graves (generic) Tumulus Tholos Chamber tomb Cist grave Pit grave Cairn Burial Monument	

	… Harbour Landing place Defence Tower Castle Fortification Excavated structures House Public building Theatre Walls Mosaic Special activity Agriculture Quarrying Shipbuilding Extraction of salt Storage …	

	Concentration of finds Spolia Figurines Metal Pottery Inscriptions Seals Beads Architectural fragments Single find Sporadic find Architectural fragment Imported object Inscription Metal Coin …	
Description	Open field	
Chronology 1	Ancient (generic) Stone Age Prehistoric Neolithic	It is possible to use multiple values in combination (Classical OR Hellenistic) or to add a dubitative symbol: Geometric?

	EH MH Mycenean LH LH I LH II LH IIIA LH IIIB LH IIIC PG Geometric Archaic Classical Hellenistic Roman Late Roman Byzantine Frankish Venetian	
Chronology 2	Century	If more precise than precedent field
Chronology 3	Date	If more precise than precedent fields
Record nature	Excavation *Archaeological project*	

	Rescue excavation Survey *Extensive* *Intensive* Accounts Communication Literary Sources Standing structure	
Precision of location	GPS point Digital Orthophotographs Satellite imagery Georeferenced map < 1:25 000 Georeferenced map < 1:100 000 Georeferenced map > 1:100 000 Island wide Village Scattered Exact location unknown Location unknown	
Spatial extension of entry	Open field	To be matched with preceding field to assess overall spatial accuracy
Relation with other entry	Open field	

Bibliography	Open field	

iii. A second archaeological dataset

The second dataset contains the features individuated in the stereoscopic analysis of aerial photographs **(**Appendix B**)**. This study is based on a holistic and diachronic approach, which aims to elicit an understanding of different layers of transformation across time. To this end, it is first necessary to fill gaps in the study of the region, noting especially the substantial lack of medieval and early modern records and of systematic study of the remains available.

While knowledge of the Late Antique to early modern periods is uneven and often slight, good potential sources of information exist. This study integrates previously known data with information newly retrieved from aerial photographs and archival documents. Aerial photography appears to be particularly important for the study of the Classical and post-Classical landscape, given its tendency to display more superficial layers.

As mentioned above, the principal source of aerial imagery used in this thesis is the photographs made by the Allied forces during World War 2 and now held in the archive of the British School at Athens, along with photographic material obtained from the Archive of the Geographic Office of the Greek Army. Because these photographs were created for strategic military purposes, they usually provide a homogenous coverage of most islands at a scale suitable for archaeological interpretation, and their forward overlap allows 3D stereoscopic viewing, ideal for the identification of features and remains. These two sources proved to be interesting for different reasons, shedding light on their peculiar potential for the study of the region:

1. Aerial imagery dating from the second half of the 20th century onwards (mainly from the historical archive of the Geographic Service of the Hellenic Army) illustrates the significant changes in land cover due to new urbanisation and development;
2. World War 2 aerial imagery proves to be of unique significance for the study of the Ionian Islands, as it predates a major earthquake in 1953 (and several successive episodes) which caused significant geomorphological alterations. The massive emigration, and abandonment of fields and pastures, which followed gave rise in turn to a dramatic change in land cover, with progressive afforestation.[106] The Allied aerial photographs record landforms prior to the earthquake and its aftermath.

Aerial imagery has been sought and acquired in two different ways. A general coverage of the islands was first obtained, with photographs on scales ranging from 1:15 000 to 1: 20 000. For areas where ancient settlements were already known, and for the 'target areas' deemed particularly suitable for settlement (following analysis of the physical environment datasets) previously investigated or not, all available imagery suitable for archaeological interpretation was then acquired. The photographs display a range of features of archaeological and ethnographic interest, which are presented and discussed

[106] Grandazzi 1954.

in Chapters 2 to 4. Two different approaches are used, based on the different scale of features. Chapter 2 presents the reading of several small features from the island of Meganisi, which are presented and compared with similar ones displayed across the archipelago. Their analysis and interpretation hinges on anthropological and ethnographic studies carried out in the framework of the Inner Ionian Sea Archipelago Survey, and matches data known from other studies carried out across Greece. Chapters 3 and 4 present two large scale developments from the Hellenistic and Roman periods invisible from the ground, which are discussed in detail, along with methodological issues relating to their interpretation.

Table 5: Structure of the second archaeological dataset: features retrieved from analysis of aerial photographs

Field	**Definition**
ID	Identifying number of the feature. Island . PH . Serial Number (KEF . PH . 1) Island identifiers are the following: LEF: Lefkada

	MEG: Meganisi KAL: Kalamos KAS: Kastos ECH: Echinades ARK: Arkoudi ATO: Atokos ITH: Ithaki KEF: Kephallonia ZAK: Zakynthos AKT: Peninsula of Aktion
Photos	Number of the frame or frames in which the feature has been seen.
Description	Objective, without interpretation. Example: 'circular white negative cropmark'.
Dimensions	Length and width or diameter. Calculated from the photograph with a micrometric lens or retrieved from satellite imagery if the feature is visible.
Elevation	Presence of elevation or micro-elevation in stereoscopic view. Yes or no; slight if micro-elevation can be detected only by joining two photographs which are not an immediate stereoscopic pair (example: BSA P 18, 4100 and BSA P 18, 4102, skipping BSA P 18, 4101).

Visible on Google Maps	With a record of the date of the satellite image.
Visible on Ethniko Ktimatologio	
Feature recorded in maps	Refers to the photographic interpretation reported on the maps of the Geographic Service of the Hellenic Army, series 1 : 50 000.
Preliminary interpretation	Example: threshing floor. Including chronology.
Link to other features	For example, for proximity or similarity
Link to site from Literature Review	Example: see KEF.LR.1

iv. Bringing the data together

The last step is to match the three datasets in a 3D GIS model and to interpret the relationship between them. This 3D model, based on satellite-generated elevation data from NASA, has a resolution of 1 arc-sec (approximately 30 meters per pixel), thus permitting us to read together geological, topographical, and archaeological data.

Practical steps following from this fall into three main areas: studies of distribution, postdictive analysis, and landscape modelling. Studies of distribution rely upon the effective plotting of sites, finds, and data across a long span of time in order to create maps of specific periods or specific activities across different periods. These include statistical studies of archaeological densities, and provide an immediate visual understanding of certain dynamics of change,[107] such as shifts from lowlands to uplands. Postdictive analysis is aimed at understanding the function of an already known site or feature; for example, the calculation of the view-shed of defensive structures and their inter-visibility.[108] Landscape modelling using specific algorithms permits us to understand how landscapes change under particular circumstances, or to investigate specific aspects. These might include the study of erosion or the distribution of humidity, both particularly important in the islands, given the high rate of rainfall in the region, in order to assess areas potentially suitable for settlement and cultivation.[109]

Digital modelling also allows us to manipulate the landscape virtually, for example systematically to delete certain features (such an action of terracing linked to a particular period) or to generate a reverse calculation of erosion. Landscape modelling aims to create a digital stratigraphy of the territory which is crucial for the comprehension of sites, finds, and features in context.[110]

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[107] Gouma, van Wijngaarden, and Soetens 2011.
[108] Bevan and Conolly 2013, pp. 159–161. For a critical approach and the limits of visibility analysis, Gillings 2017.
[109] Richards-Rissetto 2017.
[110] Keay, Parcak, and Strutt 2014.

1.5 Geomorphology and land classification

i. Rationale and methodology

Dividing the landscape into physiographical classes informs the study of the basic characters of the islands, and allows us to compare the human activities attested in the archaeological record with the physical environment. For the purposes of this thesis, geomorphological analysis informs the choice of 'target areas' as zones demonstrating potential for medium and large-scale developments, often matched by the presence of significant settlements and finds (as evidenced by Database A).

In her study of archaeological landscapes in Boeotia, Emeri Farinetti has proposed a methodology for the classification of landforms suitable for this purpose.[111] Farinetti's method consists in an integrated study of elevation, slope, soil erosion, and land capability (in relation to agriculture). More recent development of GIS technologies now make it possible to expand Farinetti's methodology through the input of data related to aspect (the compass direction that a slope faces, also known as exposure) and hydrological distribution of rainfall. Furthermore, the detailed rendering of underground water sources in the relevant sheets of the 1: 50 000 series of topographical maps of Greece drawn by the Geographic Service of the Hellenic Army allows to generate a model of water availability across the islands. It must, however, be stressed that methodologically, the lack of mapped underground water sources does not preclude the existence of such springs, given the degree of accuracy of land survey which was not primarily aimed at

[111] Farinetti 2009, pp. 16–17.

mapping such features. For present purposes, therefore, the proven presence of underground water in an area adds strengthens the potential for medium and large-scale developments, while its absence is not necessarily considered detrimental. This results in a positive weighting for presence but no negative weighting for absence. All these factors clearly fall within the remit of the assessment of land capability.

ii. Elevation

Preliminary steps: preparation of a digital elevation model

The relevant tiles of the satellite generated digital elevation model (DEM) were stitched together to form a singular DEM (Digital Elevation Model A).[112] The coordinate reference system used for the digital elevation model was EPSG: 4326 – WGS 84. Maps are printed, for purely aesthetic reasons, with EPSG: 3857 – WGS 84 (pseudo Mercator). 'On the fly' reprojection was enabled in QGIS to avoid coordinate mismatches across the two different coordinate reference systems.

Pixels corresponding to sea level were labelled as NULL, obtaining a new raster (Digital Elevation Model B). This raster was then manually checked to ensure that no terrain coverage with an elevation of 0 m asl had been marked as NULL and lost.

‘Digital Elevation Model B’ was then clipped with a vector polygon corresponding to the entire area of the archipelago, eliminating the mainland and generating a new DEM

[112] The geographical coverage of the raster was: *20.26125, 37.61125 : 21.186528, 38.90347* (EPSG: 4326 – WGS 84).

(Digital Elevation Model C), corresponding to the islands only, without the sea. 'Digital Elevation Model C' constitutes the base for subsequent analyses.

Classification of elevation ranges and generation of specific rasters

Emeri Farinetti distinguishes three elevation ranges:

P: plain or valley, below 200 m asl;

H: hill, above 200 and below 600 m asl;

M: mountain, above 600 m asl.[113]

For the sake of this study, and to facilitate automated GIS processing of the data, numerical fields were preferred. Plains and valleys have been assigned the value '1', hills the value '2', and mountains the value '3'.

A new raster was calculated from 'Digital Elevation Model C' to create this new classification, assigning to each pixel a value corresponding to its elevation range. The coding formula used in the raster calculator was the following:

((" Digital Elevation Model C @ 1 "   > = 0) AND

*(" Digital Elevation Model C @ 1 " < 200)) * 1 +*

((" Digital Elevation Model C @ 1 "   > = 200) AND

*(" Digital Elevation Model C @ 1 " < 600)) * 2 +*

*((" Digital Elevation Model C @ 1 "   > = 600)) * 3*

[113] Farinetti 2009, p. 17.

The Geotiff raster obtained was named ‘DEM Classified’.

Analysis of elevation classes

‘DEM Classified’ was at this point analysed with the *r stats* processing tool of GRASS GIS to ascertain the percentage of land covered by each elevation class.

The results were as follows:

Class 1, plains and valleys (< 200 m asl): 45.48 %;

Class 2, hills (≥ 200 and < 600 m asl): 40.87 %;

Class 3, mountains (≥ 600 m asl): 13.65 %.

At this stage, the raster files ‘Digital Elevation Model C’ and ‘DEM Classified’ were clipped with specific vectorial polygons corresponding to each island. For the sake of this analysis, the islets of Sparti, Madouri, and Skorpios were included in the polygon of Lefkada. Thilia and Kythros were included in the polygon of Meganisi. Provati was included in the polygon of Kastos. Fermikoula was included in the polygon of Kalamos. The Echinades were treated as a single entity.

The raster files obtained from the clipping of ‘DEM Classified’ were run individually through the the *r stats* processing tool of GRASS GIS for the purpose mentioned above. Results were as follows:

Table 6: Comparison of elevation classes for each island or group.

Unit	Class 1, plains and valleys (< 200 m asl)	Class 2, hills (≥ 200 < 600 m asl)	Class 3, mountains (≥ 600 m asl)
Arkoudi	100 %	-	-
Atokos	79.23 %	20.77 %	-
Echinades	94.70 %	5.30 %	-
Ithaki	53.59 %	42.64 %	3.77 %
Kalamos	54.89 %	40.15 %	4.96 %
Kastos	100 %	-	-
Kephallonia	40.51 %	38.34 %	21.15 %
Lefkada	46.18 %	37.69 %	16.13 %
Meganisi	92.51 %	7.49 %	-
Zakynthos	51.57 %	46.23 %	2.20 %

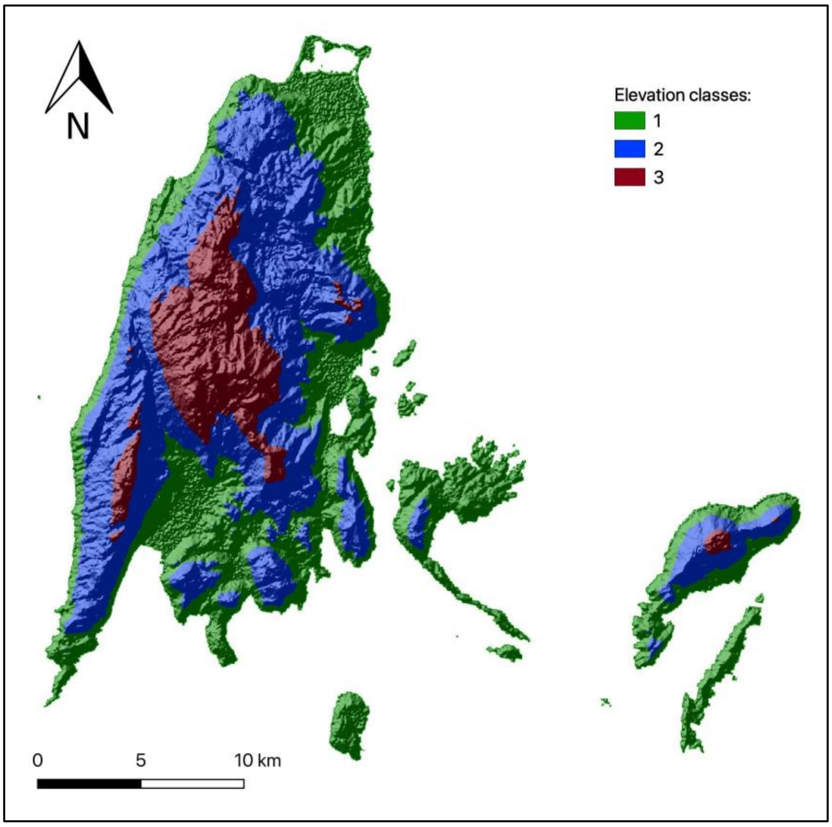

Figure 3: Elevation classes, detail. Superimposed over shaded relief.

ASTERGDEM is a product of METI and NASA

iii. Slope

Algorithms for the calculation of slope factor in a GIS environment

There is a vast literature on the effects of slope algorithms on slope estimates in a GIS environment[114] and on the potential errors arising from the use of some of them, especially on certain terrains.[115] Tang and Pilesjö analysed the effects of eight different algorithms using pair-wise statistical tests to detect significant differences between the methods in

[114] Skidmore 1989; Jones 1998; Dunn and Hickey 1998.
[115] Zhou and Liu 2004.

general, and between flat, undulating, and steep terrain.[116] Due to the rocky and mountainous nature of some islands, one of the conclusions of Tang and Pilesjö assumes particular importance: “all eight algorithms show much greater differences between each other in steep terrain. […] In other words, algorithm choice becomes critically important when the terrain is fluctuating”.[117]

Intrinsic limitations of slope calculation

Another factor to be taken into account is the general ‘smoothing effects’ created by the averaging techniques of such algorithms, which as Dunn and Hickey report do “not consider the centre cell, and have inherent problems associated with peaks, pits, ridges, and valleys”.[118] Smoothing is an intrinsic effect of any slope calculation, due to the fact that every algorithm compares elevation values in neighbouring cells,[119] automatically generating an average of data in the comparison. The same authors nevertheless, remark how “the smoothing effects may be entirely appropriate when DEM accuracy is suspect and a general impression may be more valuable than local variations”.[120] This is definitely the case in this study, where the resolution of the satellite data of 1 arcsec (corresponding to c. 30 m on the ground, or a scale of c. 1 : 97 000) does not permit detailed analysis of the morphology of a single parcel of land,[121] yet can support the study of landscapes and landforms on a regional scale. It is nevertheless crucial to clarify here the methodological implications of the resolution of the data, and of the methodology used to extrapolate

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[116] Tang and Pilesjö 2011.
[117] Tang and Pilesjö 2011, p. 153, n. 4.
[118] Dunn and Hickey 1998, p. 14.
[119] Tang and Pilesjö 2011, p. 146.
[120] Dunn and Hickey 1998, p. 14.
[121] On the limits and properties of DEMs with 30 x 30 m resolution see Farinetti 2009, p. 17.

slope data. In particular, this study does not use techniques of detailed and individual resampling of point vectors corresponding to sites over rasters, and in particular over the rasters corresponding to slope values. 'Detailed resampling' here is meant to correspond to the automated attribution of data to a vector (such as a point), based on the value(s) of the cell of a raster corresponding to the location of the vector.[122] The standard resolution of the raster does not allow any detailed resampling due to the high possibility of cumulating various intrinsic errors and imprecisions, due for example to the georeferencing of a site in the database.[123] In some cases, a sampling could be possible in theory,[124] but the 'smoothing effect' would by itself generate an additional 'projected displacement' through the averaging of the values of cell 5 (central cell in the 3 x 3 DEM sampling kernel defined below) with those of neighbouring cells. Furthermore, only a minority of database entries would satisfy the technical requirements needed to ensure a minimum degree of accuracy. Their individual analysis would create an *a posteriori* imbalance in the analysis through the arbitrary use of a technical aspect to filter data to be analysed.

Therefore, slope data is used only to inform medium- and large-scale analyses. This strikes a balance between the two extremes delineated by Dunn and Hickey: "*at what point are improvements in DEM resolution irrelevant? At the other end of the scale, at what resolution are calculations of slope too general to be meaningful?*".[125]

[122] E.g. point *A* (vector), with coordinates *x* and *y*, would assume as additional fields the slope or height value of the cell with coordinates *x* and *y* of a given raster.
[123] Especially when the 'precision of location' field value is: georeferenced map > 1:100 000; island wide; village; scattered; exact location unknown; location unknown.
[124] For example with the following 'precision of location' field values: GPS point; digital orthophotographs; satellite imagery; georeferenced map < 1:25 000; georeferenced map < 1:100 000. Possibly even in the case of georeferenced map > 1:100 000.
[125] Dunn and Hickey 1998, p. 15.

Medium- and large-scale analyses comprehend for example:

1. Classification of slope ranges.[126] The categorisation of slope values in pre-defined intervals is not deemed to be subject to issues derived from smoothing effects, due to the division into specific but sufficiently wide classes.
2. Estimate of land suitable for flat field agriculture, based on a threshold of 12° to 13° for terracing.[127]
3. Visual study of the location of features inside specific slope ranges, when the area corresponding to a given range is comfortably large around the feature. An area of c. 300 m around a given site *de facto* eliminates any intrinsic error or imprecision due to georeferencing, and removes the impact of smoothing effects, with 300 m corresponding to approximately ten cells.

Algorithms comparison and choice

Tang and Pilesjö identified a substantial homogeneity of mean and median estimated slope values obtained in different terrains with six algorithms:

1. Fleming and Hoffer's 'second order finite difference' (2 F D);[128]
2. Unwin's 'three order finite difference weighted by reciprocal of distance' (3 F D W R D);[129]

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[126] After Farinetti 2009, p. 17.
[127] Bevan and Conolly 2004, p. 127 and fig. 5.
[128] Fleming and Hoffer 1979.
[129] Unwin 1981.

3. Sharpnack and Akins's 'three order finite difference linear regression plan' (3 F D);[130]
4. Horn's 'three order finite difference weighted by reciprocal of squared distance' (3 F D W R S D);[131]
5. Chu and Tsai's 'frame finite difference' (F F D);[132]
6. Jones' 'simple difference' (Simple D).[133]

The reported potential of Simple D to generate slightly higher values led to its exclusion from consideration.[134] Among the remaining five algorithms, Horn's 'three order finite difference weighted by reciprocal of squared distance' (3 F D W R S D) was chosen. The reason behind the choice was the fact that this algorithm is one of those incorporated in GDAL through QGIS, making possible the generation of two rasters, one manually and the other automatically through GDAL. The generation of two rasters, subsequently compared against each other, adds another layer of verification to the process of generation of an important dataset, crucial for further analyses.

A new raster was calculated from 'Digital Elevation Model C' using Horn's algorithms: the formulas used were the following ones:

General slope definition:[135]

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[130] Sharpnack and Akin 1969.
[131] Horn 1981.
[132] Chu and Tsai 1995.
[133] Jones 1998.
[134] Tang and Pilesjö 2011, p. 152, n. 6.1.
[135] Tang and Pilesjö 2011, p. 146, n. 3.

$$Slope = \arctan \sqrt{[(fx)^2 + (fy)^2]}$$

Horn's formula:[136]

$$Fx = (z3 - z1 + 2 (z6 - z4) + z9 - z7) / 8g (8)$$

$$Fy = (z7 - z1 + 2 (z8 - z2) + z9 - z3) / 8g$$

Where: zi (i = 1, 2, …9) is the elevation value in cell i; i (1, 2 ,…9) is the number of the cells in a 3 × 3 DEM sampling kernel (with 1 being at the bottom right); g is the cell size (spatial resolution), in our case 1 arcsec / c. 30 m.[137]

The generated raster was named 'SLOPE archipelago', which was clipped with the aforementioned specific vectorial polygons corresponding to each island, generating new individual rasters. Data for 'SLOPE archipelago' and individual rasters was express as percentages rather than degrees.

Classification of slope ranges

Emeri Farinetti individuates four classes of slope values, applicable to the elevation classes defined above:

> *"The following is the list of physiographical classes used for the characterisation of the Boeotian landscape:*

[136] Horn 1981, quoted in Tang and Pilesjö 2011, p. 147, n. 4.
[137] Tang and Pilesjö 2011, p. 146.

- uneven: hillside steep or very steep (between 20 % and 35 % or more than 35 %)

- hilly: hillside moderately steep (10 - 20 %), sometimes steeper, but low in altitude

- undulating plateau: moderate inclination (3 - 10 %), sometimes almost flat

- plain: < 5 %

Those four classes can be applied to the three main elevation ranges: mountain (upper), hills, plain (lower) areas".[138]

For the purposes of this study, the partial overlap between plain and undulating plateau (in the 3 to 5 % range of values) was rationalised. The class of data called 'uneven', which effectively includes two ranges of data (≥ 20 % to < 35 % ; ≥ 35 %), was divided into classes. As for elevation classes, to facilitate automated GIS processing of the data, numerical fields were preferred. Classes were therefore defined as follows:

Class 1, plain: slope factor < 5 %;

Class 2, undulating plateau: slope factor ≥ 5 % and < 10 %;

Class 3, hilly: slope factor ≥ 10 % and < 20 %;

Class 4, hillside – steep: slope factor ≥ 20 % and < 35 %;

Class 5, hillside – very steep: slope factor ≥ 35 %.

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[138] Farinetti 2009, p. 17.

A new raster was calculated from ‘SLOPE archipelago’ to create this new classification, assigning to each pixel a value corresponding to its slope range. The coding formula used in the raster calculator was the following:

((" SLOPE archipelago @ 1" > 0) AND (“ SLOPE archipelago @ 1 “ <
_5)) * 1 +_
((" SLOPE archipelago @ 1" > = 5) AND (“ SLOPE archipelago @ 1
_“ < 10)) * 2 +_
((“ SLOPE archipelago @ 1 “ > = 10) AND (“ SLOPE archipelago @
1 “ < 20)) * 3 + ((“ SLOPE archipelago @ 1 “ > = 20) AND (“
SLOPE archipelago @ 1 “ < 35)) * 4 + ((“ SLOPE archipelago @ 1 “
_> = 35)) * 5_

The resulting raster was named ‘SLOPE classified’.

Analysis of slope classes

‘SLOPE classified’ was at this point analysed with the *r stats* processing tool of GRASS GIS to ascertain the percentage of land covered by each slope class. The results were as follows:

- Class 1, plain, slope factor < 5 %: 9.69 %.
- Class 2, undulating plateau, slope factor ≥ 5 % and < 10 %: 12.56 %.
- Class 3, hilly, slope factor ≥ 10 % and < 20 %: 21.94 %.
- Class 4, hillside – steep, slope factor ≥ 20 % and < 35 %: 24.55 %.
- Class 5, hillside – very steep, slope factor ≥ 35 %: 31.26 %.

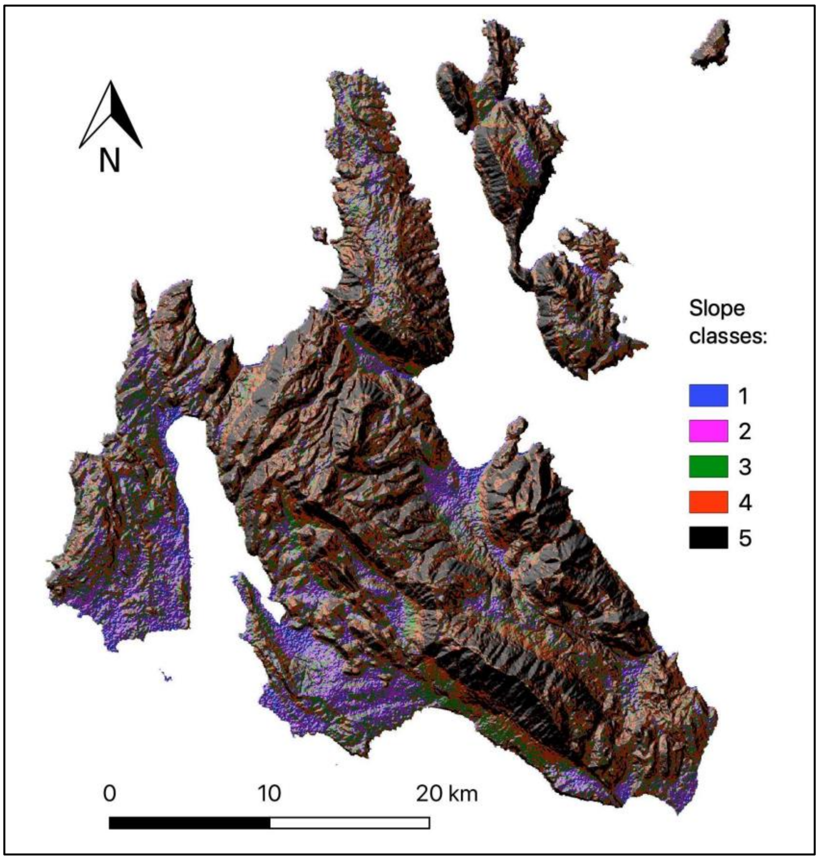

Figure 4: Slope classes, detail: Kephallonia, Ithaki, and Atokos. Superimposed over shaded relief.

ASTERGDEM is a product of METI and NASA

As for previous rasters, this one too was clipped with the specific vectorial polygons corresponding to each island, generating new individual rasters. These rasters were run individually through the *r stats* processing tool of GRASS GIS for the purpose mentioned above. Results were as follows:

Table 7: Comparison of slope classes for each island or group					
Unit	Class 1, plain (< 5 %)	Class 2, undulating plateau ≥ 5 % and < 10 %)	Class 3, hilly (≥ 10 % and < 20 %)	Class 4, hillside – steep: (≥ 20 % and < 35 %)	Class 5, hillside – very steep: (≥ 35 %)
Arkoudi	11.52 %	21.64 %	31.94 %	24.62 %	10.28 %
Atokos	2.46 %	4.42 %	9.40 %	20.64 %	63.08 %
Echinades	7.70 %	11.99 %	21.89 %	22.81 %	35.61 %
Ithaki	3.48 %	6.60 %	16.53 %	25.07 %	48.32 %
Kalamos	3.97 %	4.65 %	8.95 %	18.60 %	63.83 %
Kastos	7.08 %	13.55 %	25.63 %	26.10 %	27.64 %
Kephallonia	6.86 %	11.91 %	21.94 %	25.20 %	34.09 %
Lefkada	8.16 %	9.33 %	18.14 %	27.9 %	36.47 %
Meganisi	7.87 %	12.52 %	22.89 %	27.81 %	28.91 %
Zakynthos	18.41 %	18.14 %	26.10 %	21.34 %	16.01 %

iv. Physiographical classes

From slope and elevation to physiographical classes

Emeri Farinetti proposed a classification of ‘physiographical positions’ obtained from the combination of slope and elevation data.[139] As for elevation and slope classes, to facilitate automated GIS processing of the data, numerical fields were preferred. Classes were therefore defined as follows:[140]

Table 8: Physiographical classes derived from the combination of slope and elevation data

Code	**Slope**	**Definition**
Valley below 200 m asl (< 200)		
1	< 5 %	Valley or basin
2	≥ 5 % and < 10 %	Gentle slope
3	≥ 10 % and < 20 %	Foothill, moderate slope
4	≥ 20 % and < 35 %	Foothill, severe slope
5	≥ 35 %	Foothill, very severe slope
Hill below 600 m asl (≥ 200 < 600)		
6	< 5 %	Plateau
7	≥ 5 % and < 10 %	Gentle slope
8	≥ 10 % and < 20 %	Moderate slope
9	≥ 20 % and < 35 %	Severe slope

[139] Farinetti 2011, p. 17. The slope values for the M 4 and M 5 categories are meant to be respectively < 35% and ≥ 35 % to match the ‘uneven’ physiographical class as defined on the same page.
[140] The number of categories is slightly expanded compared to the classification proposed by Farinetti, for the sake of homogeneity and completeness. In particular, Farinetti’s P 4 category (elevation < 200 m asl and slope ≥ 10% is divided into classes 3, 4, and 5.

10	≥ 35 %	Very severe slope
Mountain above 600 m asl (≥ 600)		
11	< 5 %	Plateau
12	≥ 5 % and < 10 %	Plateau, gentle slope
13	≥ 10 % and < 20 %	Moderate slope
14	≥ 20 % and < 35 %	Severe slope
15	≥ 35 %	Very severe slope

A new raster was calculated from 'DEM classified' and 'SLOPE classified' to create this new classification, assigning to each pixel a value corresponding to its physiographical class. The coding formula used in the raster calculator was the following:

((" DEM Classified @ 1 " = 1) AND (" SLOPE Classified @ 1 " = 1))

* 1 +

((" DEM Classified @ 1 " = 1) AND (" SLOPE Classified @ 1 " = 2))

* 2 +

((" DEM Classified @ 1 " = 1) AND (" SLOPE Classified @ 1 " = 3))

* 3 +

((" DEM Classified @ 1 " = 1) AND (" SLOPE Classified @ 1 " = 4))

* 4 +

((" DEM Classified @ 1 " = 1) AND (" SLOPE Classified @ 1 " = 5))

* 5 +

((" DEM Classified @ 1 " = 2) AND (" SLOPE Classified @ 1 " = 1))

* 6 +

((" DEM Classified @ 1 " = 2) AND (" SLOPE Classified @ 1 " = 2))

** 7 +*

((" DEM Classified @ 1 " = 2) AND (" SLOPE Classified @ 1 " = 3))

** 8 +*

((" DEM Classified @ 1 " = 2) AND (" SLOPE Classified @ 1 " = 4))

** 9 +*

((" DEM Classified @ 1 " = 2) AND (" SLOPE Classified @ 1 " = 5))

** 10 +*

((" DEM Classified @ 1 " = 3) AND (" SLOPE Classified @ 1 " = 1))

** 11 +*

((" DEM Classified @ 1 " = 3) AND (" SLOPE Classified @ 1 " = 2))

** 12 +*

((" DEM Classified @ 1 " = 3) AND (" SLOPE Classified @ 1 " = 3))

** 13 +*

((" DEM Classified @ 1 " = 3) AND (" SLOPE Classified @ 1 " = 4))

** 14 +*

((" DEM Classified @ 1 " = 3) AND (" SLOPE Classified @ 1 " = 5))

** 15*

The raster obtained was named ‘Physiographical classes’.

Analysis of physiographical classes

‘Physiographical classes’ was at this point analysed with the *r stats* processing tool of GRASS GIS to ascertain the percentage of land covered by each slope class. The results were as follows:

Class 1: 7.70 %

Class 2: 7.88 %

Class 3: 10.39 %

Class 4: 9.07 %

Class 5: 9.34 %

Class 6: 1.65 %

Class 7: 3.89 %

Class 8: 9.34 %

Class 9: 11.73 %

Class 10: 15.09 %

Class 11: 0.34 %

Class 12: 0.78 %

Class 13: 2.21 %

Class 14: 3.75 %

Class 15: 6.84 %

As for previous rasters, also this one was clipped with the specific vectorial polygons corresponding to each island, generating new individual rasters. These rasters were run individually through the *r stats* processing tool of GRASS GIS for the purpose mentioned above. The results were as follows:

Table 9: Comparison of physiographical classes for each island or group

Class	Arkoudi	Atokos	Echinades	Ithaki	Kalamos
1	11.52 %	2.18 %	7.53 %	2.14 %	3.31 %
2	21.64 %	3.58 %	11.79 %	3.52 %	3.12 %
3	31.94 %	6.77 %	21.24 %	9.14 %	5.43 %
4	24.62 %	13.77 %	21.51 %	13.93 %	12.26 %
5	10.28 %	51.18 %	31.64 %	23.10 %	28.70 %
6	-	0.29 %	0.18 %	1.31 %	0.50 %
7	-	0.84 %	0.20 %	3.00 %	1.12 %
8	-	2.64 %	0.66 %	6.96 %	2.37 %
9	-	6.69 %	1.33 %	9.67 %	5.07 %
10	-	12.06 %	3.92 %	23.33 %	32.98 %
11	-	-	-	0.03 %	0.16 %
12	-	-	-	0.08 %	0.41 %
13	-	-	-	0.43 %	1.16 %

14	-	-	-	1.46 %	1.26 %
15	-	-	-	1.90 %	2.15 %
Class	**Kastos**	**Kephallonia**	**Lefkada**	**Meganisi**	**Zakynthos**
1	7.08 %	5.38 %	6.08 %	7.63 %	15.05 %
2	13.55 %	8.11 %	4.75 %	11.84 %	10.61 %
3	25.63 %	11.08 %	6.59 %	25.36 %	10.93 %
4	26.12 %	8.18 %	8.47 %	25.60 %	8.12 %
5	27.62 %	7.03 %	10.67 %	21.37 %	6.12 %
6	-	1.11 %	1.50 %	0.24 %	3.13 %
7	-	2.82 %	3.43 %	0.69 %	7.11 %
8	-	7.79 %	9.19 %	2.45 %	14.42 %
9	-	11.38 %	14.14 %	3.30 %	12.66 %
10	-	15.70 %	18.75 %	1.52 %	9.62 %
11	-	0.37 %	0.58 %	-	0.21 %
12	-	0.98 %	1.15 %	-	0.43 %
13	-	3.07 %	2.97 %	-	0.74 %
14	-	5.64 %	4.68 %	-	0.57 %
15	-	11.36 %	7.05 %	-	0.27 %

v. Erosion

Erosion is here meant to represent two distinct but comparable phenomena: soil erosion and coastal erosion. Soil erosion is the natural process of removal and transport of superficial strata of the soil, with natural and anthropogenic causes.[141] Coastal erosion affects sediments and rocks on the coastline and is due to the action of waves, currents, and wind.

Soil erosion

Soil erosion is the process of detachment of soil from an original location, either because of natural phenomena (rain, water flow, wind etc.) or human activity.

Bevan and Connolly list a number of characteristics which make certain Mediterranean landscapes particularly vulnerable to soil loss, all particularly important for the region under study here:[142]

1. Seasonally skewed distribution of rainfall (particularly relevant in this case as a feature of the region is the high level of rainfall, two to three times more than in continental Greece),[143] leading to rapid soil loss.
2. Active tectonic history. The islands lie at the meeting point of the Adriatic, Eurasian, Hellenic, and African plates, exactly along the Hellenic Trench, in the area with the greatest seismicity in the entire Mediterranean.[144]

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[141] Farinetti 2009, p. 17, with bibliography.
[142] Bevan and Conolly 2013, pp. 38–41.
[143] Branigan and Jarrett 1975, p. 336, quoted in Souyoudzoglou-Haywood 1999, p. 5. For more recent studies of precipitation in the Ionian Islands, see Nastos and Zerefos 2010 with bibliography.
[144] Papathanassiou, Pavlides, and Ganas 2005, p. 13.

3. Grazing animals resulting in low scrub cover, surely relevant prior the abandonment of fields and pastures, and dramatic change in land cover, with progressive afforestation in the aftermath of the 1953 seismic events.[145]
4. Karstic landscape, allowing concentrations of sediment flow.

Soil erosion has been widely connected to soil loss, and to damage to the agricultural potential of a certain area through the reduction of arable and fertile strata. This is particularly true in the case of these islands. While Farinetti mentions the possibility of eroded soil sliding towards plains and valleys where it can be used for cultivation,[146] in the Ionian islands many of the fertile plains slope gently towards the sea, resulting in the probable transport, and loss at sea, of eroded soil during flash floods.

Coastal erosion

Coastal erosion does not affect only the superficial layers of land cover, but rather the entirety of the landforms exposed to marine action and atmospheric agents.[147] Evelpidou reports that Ionian Neogene coasts are very steep, making them particularly vulnerable to wave action.[148] The slow but continous erosion of landforms can be also accelerated by seismic events. A clear -and extreme- example of coastal erosion is Cape Kaloyeros (Zakynthos), an elevated peninsula made of sandstone and marl, whose erosion by the sea has been documented.[149]

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[145] Grandazzi 1954.
[146] Farinetti 2009, p. 19, n. II.
[147] Farinetti 2009, p. 49.
[148] Evelpidou 2012, p. 298.
[149] Stein and van Wijngaarden 2012.

Methodologies for the study of soil erosion

In the context of landscape archaeology in Greece, different approaches have been proposed for the evaluation of erosion. Farinetti uses a methodology based on the relation between erosion and slope defining the percentage of subsurface exposed.[150] Bevan and Connolly use more complex parameters, based on the holistic study of rainfall erosivity, soil erodability, slope steepness and length, land cover (forests, vegetation, etc.), and support practices (such as terracing).[151]

Data for the Central Ionian islands

In the case of Central Ionian Islands, an excellent model of erosional processes has been developed by Niki Evelpidou, based on a complex study of lithology, micro and macro-tectonic structures, land use, vegetation and soil cover.[152] Evelpidou divided the Ionian Islands (from Kerkyra to Zakynthos) in three classes of susceptibility to erosion factor (0 – 0.3; 0.3 – 0.5; 0.5 – 1). The map[153] of the classes was incorporated into the database as a raster, and the three classes were manually vectorialised. From analysis of this map, Evelpidou drew a second map displaying the erosion risk in the region,[154] divided into four classes (very low, low, medium, high). This map was also incorporated into the database as a raster, and the four classes vectorialised. At this point, data from the

[150] Farinetti 2009, p. 18.
[151] Bevan and Conolly 2013, p. 39, table 3.1.
[152] Evelpidou 2012.
[153] Evelpidou 2012, p. 304, fig. 6.
[154] Evelpidou 2012, p. 307, fig. 9.

Geological Maps of Greece produced by the Hellenic Institute of Geology and Mineral Exploration were added to the dataset,[155] and the respective classes vectorised.[156]

vi. Land capability

Amount of land suitable for flat face agriculture

Of primary importance to the assessment of land capability, and the agricultural potential of an area, is understanding the amount of land suitable for flat face agriculture, without the need to invest resources into terracing. Bevan and Conolly, looking at the Kytheran evidence, agree with the traditional assumptions that field management strategies are likely to change with a slope value of approximately 10 – 15°, and establish a threshold at 12 to 13°.[157] Considering that a slope with a 13° angle equals a grade of 23.1 % (simplified here to 23 %), a new raster was generated from 'SLOPE archipelago' to isolate values accordingly. The obtained raster was named 'Slope 23 % threshold'. The formula was as follows:

((" SLOPE archipelago @ 1 " > 0) AND (" SLOPE archipelago @ 1 "

*< = 23)) * 1 +*

*((" SLOPE archipelago @ 1 " > 23)) * 2*

---

[155] After the metholodogy of Farinetti 2009, pp. 19–20.

[156] Series 1:50000. Sheets used: Echinades (1989), Paxi (1969), Ithaki and Atokos Islands (1991), Astakos (1986), Nea Manolas (1977), Vartholomion (1969), Arta (1969), Vonitsa (1996), Amalias (1993), Cephalonia Island Northern Part (1985), Messolonghion (1996), Kalamos (1994), Zakynthos Island (1980), Cephalonia Island Southern Part (1985), Lefkas Island (1963).

[157] Bevan and Conolly 2004, p. 127 and fig. 5.

‘Slope 23 % threshold’ was at this point analysed with the *r stats* processing tool of GRASS GIS to ascertain the percentage of land covered by each slope class. The results were as follows:

Land suitable for flat face agriculture: 49.89 %.

Land with a slope factor > 23 %: 50.11 %.

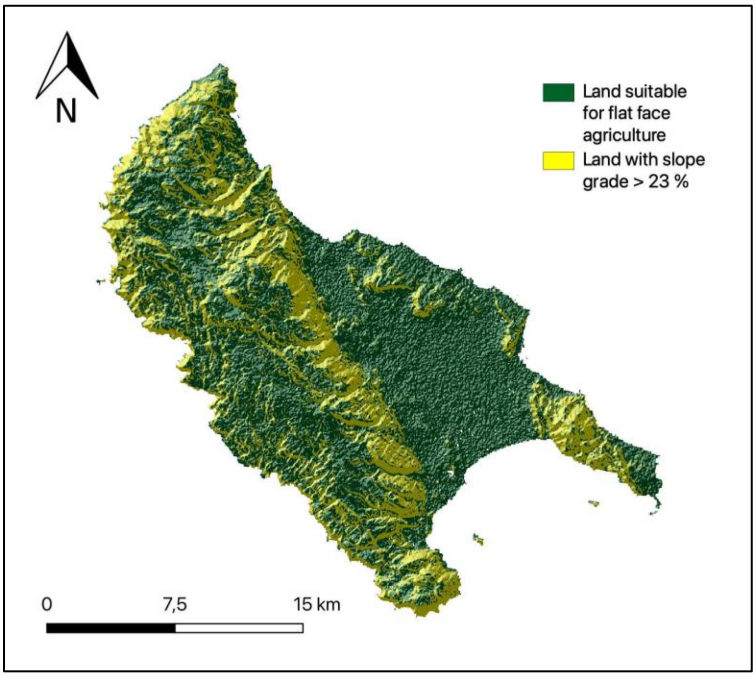

Figure 5: Analysis of land suitable for flat face agriculture, detail: Zakynthos. Superimposed over shaded relief. ASTERGDEM is a product of METI and NASA.

As for previous rasters, this one too was clipped with the specific vectorial polygons corresponding to each island, generating new individual rasters. These rasters were run individually through the *r stats* processing tool of GRASS GIS for the purpose mentioned above. The results were as follows:

Table 10: Comparison of amount of land suitable for flat face agriculture

Unit	**Land with slope grade ≤ 23 %**	**Land with slope grade > 23 %**
Arkoudi	71.60 %	28.40 %
Atokos	20.25 %	79.75 %
Echinades	46.82 %	53.28 %
Ithaki	31.97 %	68.03 %
Kalamos	20.85 %	79.15 %
Kastos	52.47 %	47.53 %
Kephallonia	46.47 %	53.53 %
Lefkada	42.06 %	57.94 %
Meganisi	55.56 %	44.47 %
Zakynthos	68.31 %	31.69 %

At this point, raster files for the computation of the aspect (compass direction faced by slopes, also known as exposure) of the archipelago and each island were generated.

vii. Underground water

The topographical maps drawn by the Geographic Service of the Hellenic Army (series 1 : 50 000), display with great detail a high number of underground water sources (wells, springs, etc.). These data are particularly important for a region where perennial streams are extremely rare. These sources were georeferenced as vectors (points), and subsequently interpolated. The catchment area around a given source for interpolation purposes was estimated to be 1 km, which includes potential underground availability around a given point and anthropic movement.

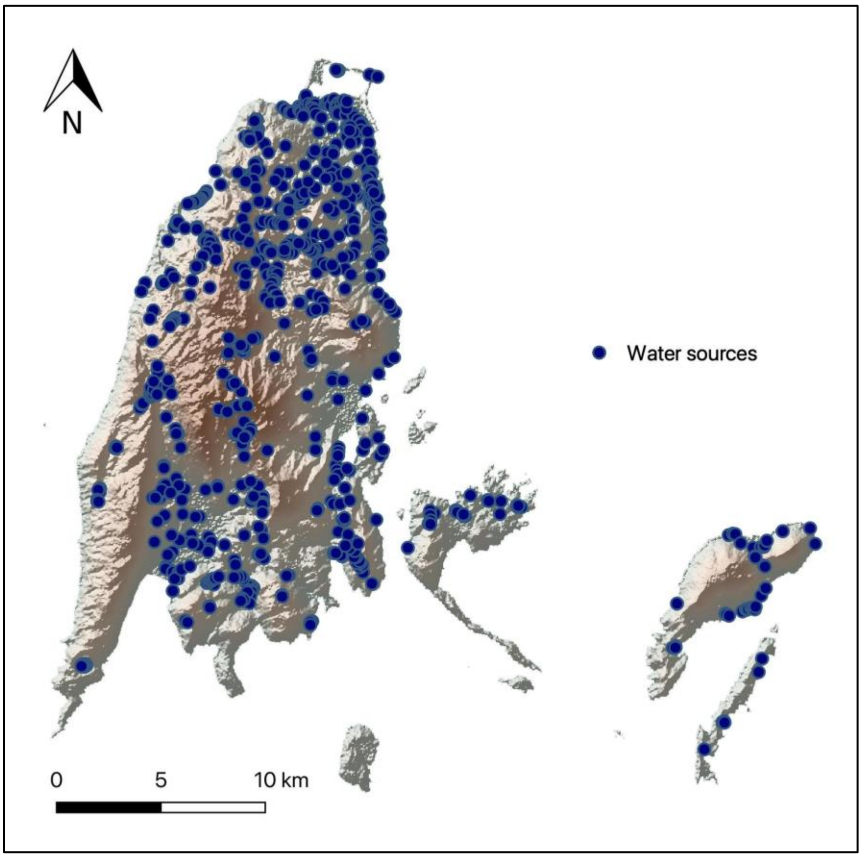

Figure 6: Water sources mapped by the Greek Army, detail: Lefkada, Meganisi, Kalamos, Kastos, and Arkoudi. Superimposed over shaded relief. ASTERGDEM is a product of METI and NASA.

The obtained raster 'Water sources 1 km', is displayed in **plate 1**. It must be stressed at this point that the lack of guarantee of the accuracy of the Greek Army land survey (which was not primarily aimed at mapping such features) needs to be taken into account. Furthermore, Souyoudzoglou-Haywood rightly notes that some of these springs emerge directly into the sea or too close to the shore to avoid contamination with brackish or salt water.[158] A further problem concerns the quality of the water accessible in a karstic landscape, where underground caves are filled by precipitated water subject to limited filtration and accessed mainly through sink-holes (*katavothrai).* Therefore, the absence of springs and wells does not necessarily exclude the existence of such sources. Therefore, in this study the proven presence of underground water in an area adds strength to the potential for medium and large-scale developments, while its absence is not necessarily considered detrimental. This results in a positive weighting for presence but no negative weighting for absence.

viii. Basin drainage

The last raster to be generated was a modelling of basin drainage over the archipelago, aimed at generating a map of the distribution of precipitation water. Distribution of rainfall is important for three reasons. First, for irrigation purposes, especially when such water generates seasonal streams. Secondly, as we have seen above, seasonal rains can accelerate soil loss. Thirdly, the same seasonally skewed distribution of rains can result in flash floods, impacting the suitability of an area for development. The scale and resolution of satellite data does not allow detailed analyses for the reasons articulated

[158] Souyoudzoglou-Haywood 1999, pp. 4–5.

above in relation to slope computation, especially since basin drainage and hydrology models are primarily based on slope data. Four models were used through the SAGA GIS suite:

1. Rho 8, stochastic eight-neighbours method;[159]
2. Braunschweiger Reliefmodell;[160]
3. Multiple flow direction;[161]
4. Multiple triangular flow direction.[162]

[159] Fairfield and Leymarie 1991.
[160] Bauer, Rohdenburg, and Bork 1985.
[161] Freeman 1991.
[162] Seibert and McGlynn 2007.

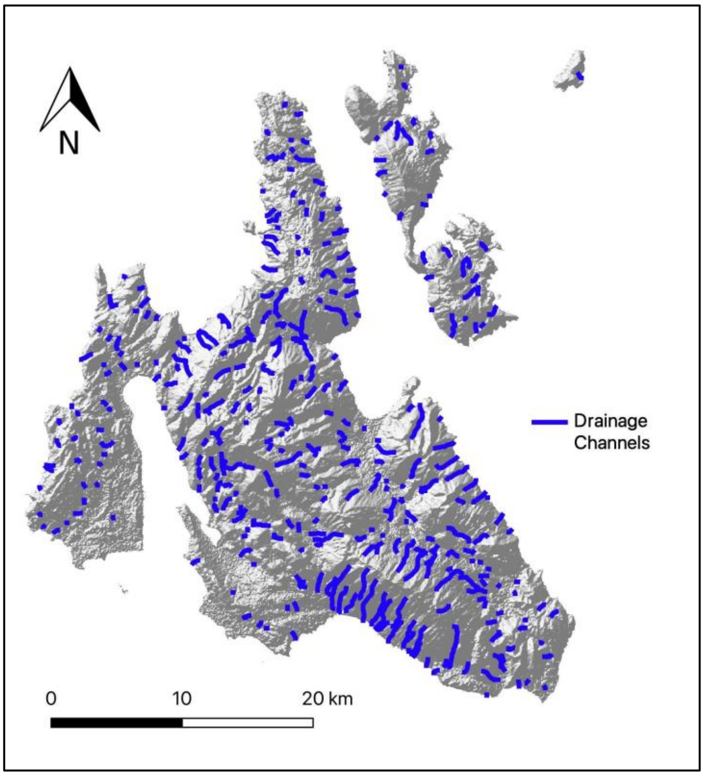

Figure 7: Basin drainage channels, detail: Kephallonia, Ithaki, and Atokos. Superimposed over shaded relief. ASTERGDEM is a product of METI and NASA.

The four models produced comparable results. The raster generated with Multiple Triangular Flow Directon was therefore saved as ‘Basin drainage’ and clipped with the specific vectorial polygons corresponding to each island, generating new individual rasters. A vectorialised version of the basins was elaborated as well.

1.6 The islands

In this section, the basic physiological characteristics of the major islands are delineated, building on the various datasets previously elaborated. Evidence for Meganisi is presented at length in chapter 2.

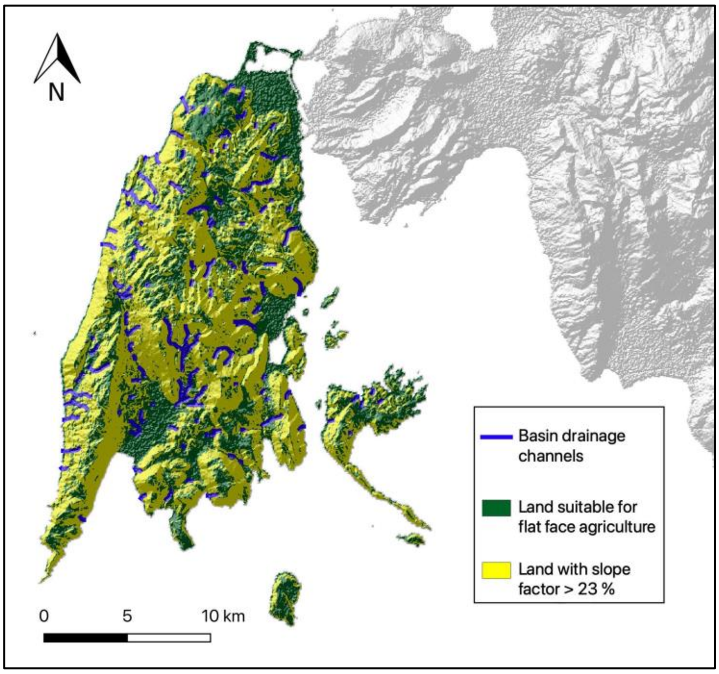

Figure 8: Classification of slope factor (threshold at 23 %) for Lefkada, Meganisi, and Arkoudi, with basin drainage channels, superimposed over shaded relief. ASTERGDEM is a product of METI and NASA.

Lefkada

Geomorphology

Lefkada is roughly triangular, extending 30 km north-south, and 18 km east-west, with an area of 295 km^2. The central mountainous area rises to the peak of Mt Elati (1158 m asl). Evelpidou reports the island to be mainly composed by limestones, granulated, microbreccian or in alternation with schists and dolomites. Outcrops of flysch, marl, or molasse, and alluvial depositions can also be found. The plain of Vassiliki and the Lagada Gria valley have been formed by the fault lines that delimit them. More than one third of the island is covered by quaternary formations.[163] Recent studies have demonstrated how the soil is subject to liquefaction during seismic events, enhancing their destructive potential.[164] Today, Lefkada is joined to Aetoloakarnania by a causeway. In antiquity, as we have seen, it was separated from the mainland only late in the 7th century BC, when the Corinthian colonists of Leukas opened a narrow canal, the *dioryctos*,[165] to provide a safer north-south route for seafarers than the circuit around Cape Doukaton (the south-west tip of the island) which was particularly dangerous due to remarkably shallow waters[166] and exposure to south winds. Some 60 % of Lefkada is hilly and mountainous, with reliefs concentrated in the central and western parts of the island. Large plains are concentrated in the north (right in front of mainland), in the east near the Gulf of Vlykos, and in the south, over the Gulf of Vasilikì. Plateaux (physiographical classes 6 and 7) of good dimension (over 1 km in width) are also present around the central massif, as those of Livadi and Livadia.

[163] Evelpidou 2012, p. 296.
[164] Papathanassiou, Pavlides, and Ganas 2005; Valkaniotis et al. 2014, with bibliographies.
[165] Strabo, 10. 451.
[166] GYS bathymetric data record a depth of 9 meters at about 400 meters from the coastline of Cape Doukaton.

Table 11: Elevation and physiographical classes for Lefkada, including the islets of Sparti, Madouri, and Skorpios.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	46.18 %	**1**	< 5 %	Valley or basin	6.08 %
		2	≥ 5 % and < 10 %	Gentle slope	4.75 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	6.59 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	8.47 %
		5	≥ 35 %	Foothill, very severe slope	10.67 %
Hill below 600 m asl (≥ 200 < 600)	37.69 %	**6**	< 5 %	Plateau	1.50 %
		7	≥ 5 % and < 10 %	Gentle slope	3.43 %
		8	≥ 10 % and < 20 %	Moderate slope	9.19 %
		9	≥ 20 % and < 35 %	Severe slope	14.14 %
		10	≥ 35 %	Very severe slope	18.75 %
Mountain above	16.13 %	**11**	< 5 %	Plateau	0.58 %
		12	≥ 5 % and < 10 %	Plateau, gentle slope	1.15 %
		13	≥ 10 % and < 20 %	Moderate slope	2.97 %
		14	≥ 20 % and < 35 %	Severe slope	4.68 %

600 m asl (≥ 600)		**15**	≥ 35 %	Very severe slope	7.05 %

Harbours and hydrology

The island presents a number of suitable anchorages. The three main ones are: in the north-east of the island, corresponding to the area protected by the ancient mole; the Gulf of Vlykos in the south east (well sheltered from winds by hills on all sides); the harbour of Vasiliki in the South. A number of smaller gulfs suitable for anchorage are present in the south, such as the harbours of Desimi, Rouda, Kastri, and Sivota (the last offering a good degree of shelter from winds). Underground water seems to be present across the entire island, with the exception of the south-western massif and peninsula. Among the main plains, only the area of Vasiliki seems to be intersected by basin drainage channels (Figure 8).

Target areas

1. Northern plain;
2. Vasiliki plain;
3. Gulf of Vlykos.

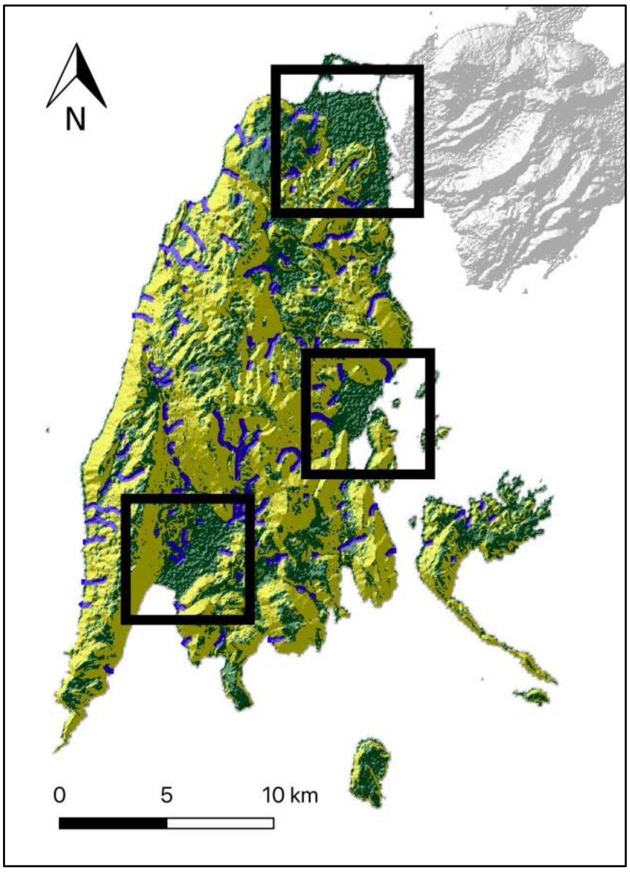

Figure 9: Target areas for Lefkada, superimposed over a detail of Figure 8.

ASTERGDEM is a product of METI and NASA.

i. Meganisi

Evidence for the island of Meganisi is extensively presented at the start of Chapter 2.

Table 12: Elevation and physiographical classes for Meganisi, including Thilia and Kythros.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**

Valley below 200 m asl (< 200)	92.51 %	**1**	< 5 %	Valley or basin	7.63 %
		2	≥ 5 % and < 10 %	Gentle slope	11.84 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	25.36 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	25.60 %
		5	≥ 35 %	Foothill, very severe slope	21.37 %
Hill below 600 m asl (≥ 200 < 600)	7.49 %	**6**	< 5 %	Plateau	0.24 %
		7	≥ 5 % and < 10 %	Gentle slope	0.69 %
		8	≥ 10 % and < 20 %	Moderate slope	2.45 %
		9	≥ 20 % and < 35 %	Severe slope	3.30 %
		10	≥ 35 %	Very severe slope	1.52 %
Mountain above 600 m asl (≥ 600)	-	**11**	< 5 %	Plateau	-
		12	≥ 5 % and < 10 %	Plateau, gentle slope	-
		13	≥ 10 % and < 20 %	Moderate slope	-
		14	≥ 20 % and < 35 %	Severe slope	-

		15	≥ 35 %	Very severe slope	-
Land with slope grade ≤ 23 %					55.56 %
Land with slope grade > 23 %					44.47 %

ii. Kalamos

Geomorphology

Kalamos is triangular in shape, with an area of c. 25 km^2. The island is mainly hilly, with more than 80 % of the land presenting a slope factor ≥ 20 %. The highest peak is Mount Vouni, with an altitude of 745 m asl. Baliousis reports the island as being mainly constituted by limestones. Old talus cones, scree and marine deposits with brackish intercalations are present in the eastern part of the island.[167] The island has been deemed to have a very low risk of soil erosion.[168] Narrow plains (with a width ranging between 200 and 300 m) are present along the northern coastlines, but due to their aspect do not receive any substantial amount of direct sunlight. A plateau more than 2 km-wide is present in the centre of the island, on the slopes of Mt Vouni. A pocket (c. 1500 x 500 m) of plain land is present in the south-east of the island, around the modern village.

[167] Baliousis 2015, p. 307.
[168] Evelpidou 2012, pp. 307, fig. 9.

Table 13: Elevation and physiographical classes for Kalamos, including the islet of Fermikoula.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	54.89 %	**1**	< 5 %	Valley or basin	3.31 %
		2	≥ 5 % and < 10 %	Gentle slope	3.12 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	5.43 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	12.26 %
		5	≥ 35 %	Foothill, very severe slope	28.70 %
Hill below 600 m asl (≥ 200 < 600)	40.15 %	**6**	< 5 %	Plateau	0.50 %
		7	≥ 5 % and < 10 %	Gentle slope	1.12 %
		8	≥ 10 % and < 20 %	Moderate slope	2.37 %
		9	≥ 20 % and < 35 %	Severe slope	5.07 %
		10	≥ 35 %	Very severe slope	32.98 %
Mountain above 600 m asl (≥ 600)	4.96 %	**11**	< 5 %	Plateau	0.16 %
		12	≥ 5 % and < 10 %	Plateau, gentle slope	0.41 %
		13	≥ 10 % and < 20 %	Moderate slope	1.16 %
		14	≥ 20 % and < 35 %	Severe slope	1.26 %
		15	≥ 35 %	Very severe slope	2.15 %

Harbours and hydrology

Good anchorages, along with the modern harbour, are present in the gulfs of Gerolimnionas and Vathy Limioni. Water is uniformly present, with the exception of the peak of Mount Vouni and certain coastal areas in the north and west. The plains do not appear to be affected by basin drainage channels.

Target areas

1. Area of the village of Kalamos;
2. Slopes of Mount Vouni.

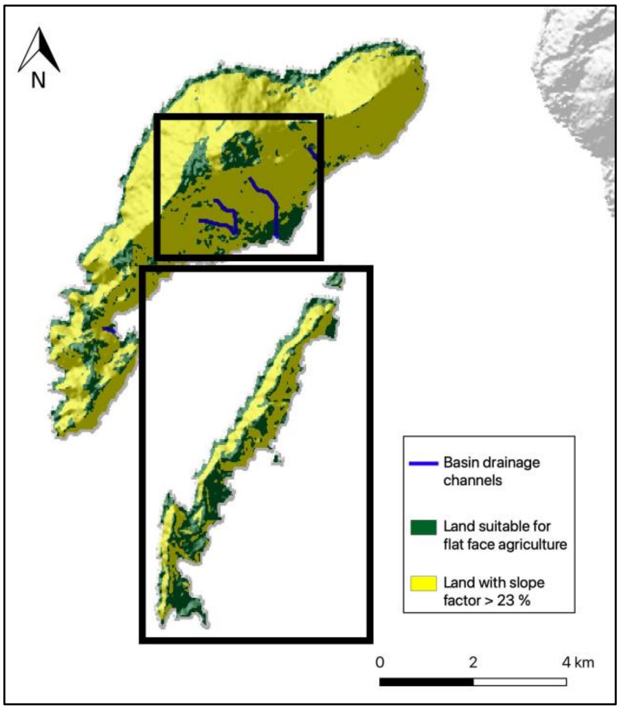

Figure 10: Classification of slope factor (threshold at 23 %) for Kalamos and Kastos, with basin drainage channels, superimposed over shaded relief. Black squares correspond to target areas. ASTERGDEM is a product of METI and NASA.

iii. Kastos

Geomorphology

Kastos is elongated in shape, measuring c. 7 km from north to south, with a width of c. 800 m. The area is c. 6 km^2. Kastos is separated by Kalamos by a narrow (c. 2.5 km) but deep channel, with depths of over 125 m recorded by the Geographical Service of the Greek Army. Kastos is entirely constituted by limestones.[169] The island is gently sloped, rising to hills up to c. 100 m asl. Kalamos has been deemed to have a very low risk of soil erosion.[170] Plains are present along the western coast and in the south. Plateaux are present in the central spine.

[169] Bourli et al. 2019, fig. 4.
[170] Evelpidou 2012, pp. 307, fig. 9.

Table 14: Elevation and physiographical classes for Kastos, including the islet of Provata.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	100 %	**1**	< 5 %	Valley or basin	7.08 %
		2	≥ 5 % and < 10 %	Gentle slope	13.55 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	25.63 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	26.12 %
		5	≥ 35 %	Foothill, very severe slope	27.62 %
Hill below 600 m asl (≥ 200 < 600)	-	**6**	< 5 %	Plateau	-
		7	≥ 5 % and < 10 %	Gentle slope	-
		8	≥ 10 % and < 20 %	Moderate slope	-
		9	≥ 20 % and < 35 %	Severe slope	-
		10	≥ 35 %	Very severe slope	-
Mountain above 600 m asl (≥ 600)	-	**11**	< 5 %	Plateau	-
		12	≥ 5 % and < 10 %	Plateau, gentle slope	-
		13	≥ 10 % and < 20 %	Moderate slope	-
		14	≥ 20 % and < 35 %	Severe slope	-
		15	≥ 35 %	Very severe slope	-

Harbours and hydrology

The island has a number of natural harbours, including the Gulfs of Sarakiniko, Vathy Vali, and Tourkovigla. Water is uniformly present. The plains do not appear to be affected by basin drainage channels.

Target areas

1. Entire island.

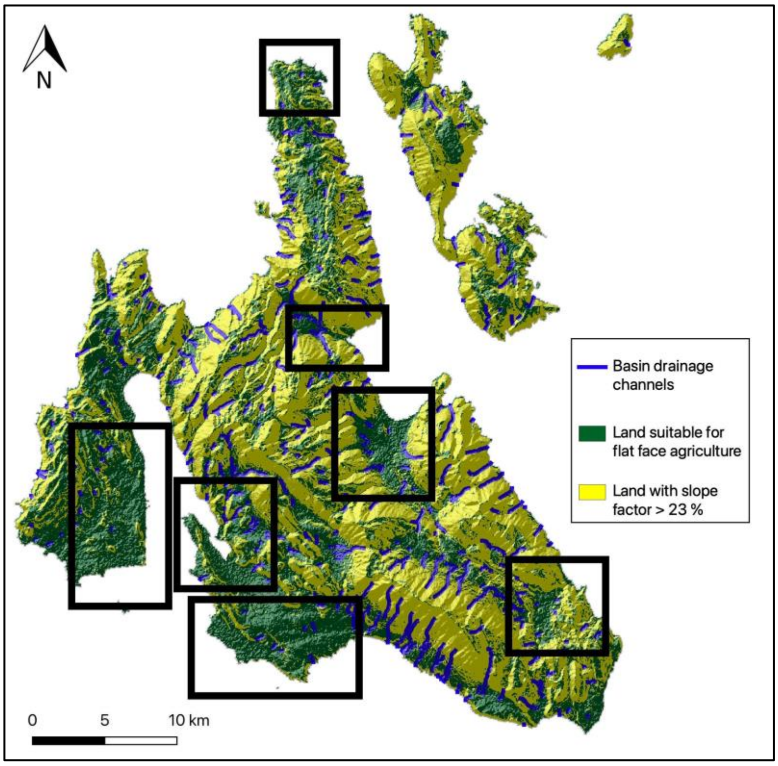

Figure 11: Classification of slope factor (threshold at 23 %) for Kephallonia, with basin drainage channels, superimposed over shaded relief. Black squares correspond to target areas. ASTERGDEM is a product of METI and NASA.

iv. Kephallonia

Geomorphology

Kephallonia is roughly rectangular, with two appendanges to the north and west. It extends for 46 km north-south and 53 km east-west, with an area of 760 km^2. In the south, the peak of Mount Ainos (1628 m asl) is the highest in the region. The island is mainly constituted by limestone, but sandstone, marls, breccia, alluvial deposits, and gypsum are also present.[171] There are extensive plains in most coastal areas, but also around the Gulf of Argostoli (where some 60 % of the fertile Paliki peninsula consists of plain), in the north around Agia Efthymia, inland from Sami, and in several parts of the south. The island has been deemed to have a generally low erosion risk, albeit with areas presenting medium and high risk in the south and in the Paliki region.

[171] Stratouli and Melfos 2008, p. 382.

Table 15: Elevation and physiographical classes for Kephallonia.

Elevation class		Physiographical classes			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	40.51 %	**1**	< 5 %	Valley or basin	5.38 %
		2	≥ 5 % and < 10 %	Gentle slope	8.11 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	11.08 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	8.18 %
		5	≥ 35 %	Foothill, very severe slope	7.03 %
Hill below 600 m asl (≥ 200 < 600)	38.34 %	**6**	< 5 %	Plateau	1.11 %
		7	≥ 5 % and < 10 %	Gentle slope	2.82 %
		8	≥ 10 % and < 20 %	Moderate slope	7.79 %
		9	≥ 20 % and < 35 %	Severe slope	11.38 %
		10	≥ 35 %	Very severe slope	15.70 %
Mountain above 600 m asl (≥ 600)	21.15 %	**11**	< 5 %	Plateau	0.37 %
		12	≥ 5 % and < 10 %	Plateau, gentle slope	0.98 %
		13	≥ 10 % and < 20 %	Moderate slope	3.07 %
		14	≥ 20 % and < 35 %	Severe slope	5.64 %
		15	≥ 35 %	Very severe slope	11.36 %

Harbours and hydrology

Kephallonia has a number of excellent natural harbours, among them the Koutavos lagoon, the terminal part of which is nowadays divided from the open sea by a bridge built in 1813. Other anchorages are in the gulfs of Lixouri, Sami, Poros and Fiskardo, along with a number of smaller inlets along the northern and eastern coastlines. Water tends to be available in most coastal areas, while the slopes of the Ainos range have some of the few streams in the entire region. The plains do not appear to be affected by important basin drainage channels.

Target areas

1. Paliki.
2. Peninsula of Fiskardo.
3. Koutavos lagoon.
4. Area of Agia Efthymia.
5. Area of Minias and the site of the modern airport.
6. Area of Poros.
7. Area of Sami.

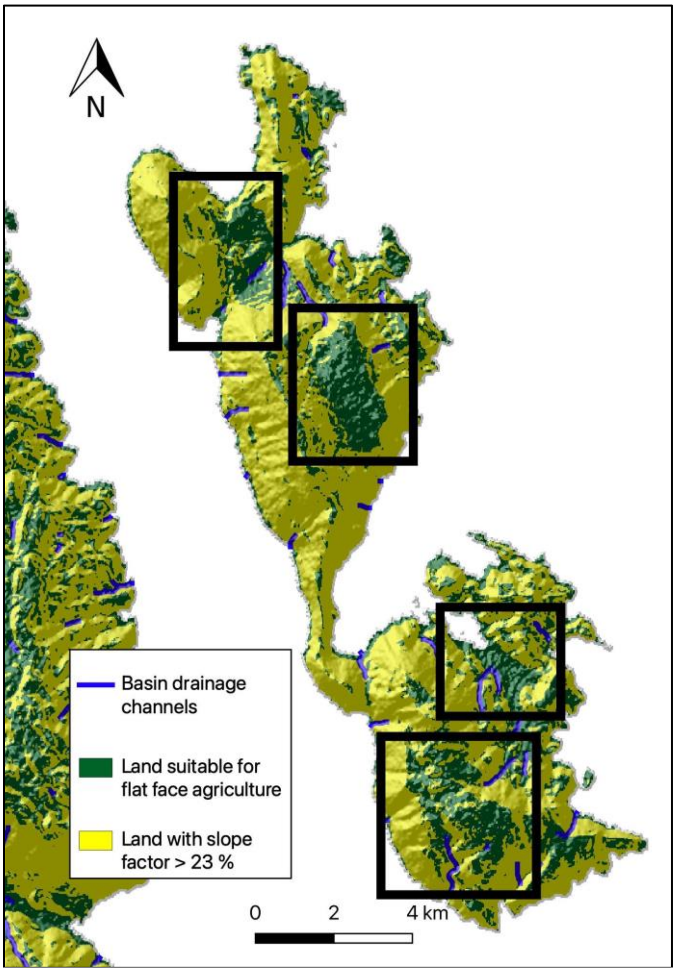

Figure 12: Classification of slope factor (threshold at 23 %) for Ithaki, with basin drainage channels, superimposed over shaded relief. Black squares correspond to target areas. ASTERGDEM is a product of METI and NASA.

v. Ithaki

Geomorphology

Ithaki consists of two land masses joined by the narrow (600 m-wide) isthmus of Aetos. With a total area of 95 km^2, Ithaki extends for 22 km north-south: while the distance from the westernmost cape to the easternmost is 17 km, the land itself is never wider than 7 km. Both landmasses have coastal plains and mountainous interiors rising to central plateaux. The island is mainly constituted by limestone, with breccias and alluvial deposits present as well.[172] The island was deemed to have a very low risk of erosion, with areas of medium and high risk in the north (Afales, Polis) and in the southern plateau.[173]

Table 16: Elevation and physiographical classes for Ithaki.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	53.59 %	**1**	< 5 %	Valley or basin	2.14 %
		2	≥ 5 % and < 10 %	Gentle slope	3.52 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	9.14 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	13.93 %
		5	≥ 35 %	Foothill, very severe slope	23.10 %
Hill below 600 m asl (≥ 200	42.64 %	**6**	< 5 %	Plateau	1.31 %
		7	≥ 5 % and < 10 %	Gentle slope	3.00 %
		8	≥ 10 % and < 20 %	Moderate slope	6.96 %
		9	≥ 20 % and < 35 %	Severe slope	9.67 %
		10	≥ 35 %	Very severe slope	23.33 %

[172] Lekkas, Danamos, and Mavrikas 2001, p. 12.
[173] Evelpidou 2012, p. 307, figure 9.

< 600)					
Mountain above 600 m asl (≥ 600)	3.77 %	**11**	< 5 %	Plateau	0.03 %
		12	≥ 5 % and < 10 %	Plateau, gentle slope	0.08 %
		13	≥ 10 % and < 20 %	Moderate slope	0.43 %
		14	≥ 20 % and < 35 %	Severe slope	1.46 %
		15	≥ 35 %	Very severe slope	1.90 %

Harbours and hydrology

Good harbours exist in the gulfs of Afales, Frikes, Kioni, Vathy, Sarakiniko, Aetos, and Polis. Access to water is limited: water resources seem to concentrate in the northern parts of both areas.

Target areas

1. Northern plateau;
2. Area of Afales;
3. Valley of Polis;
4. Area of Vathy;
5. Southern plateau.

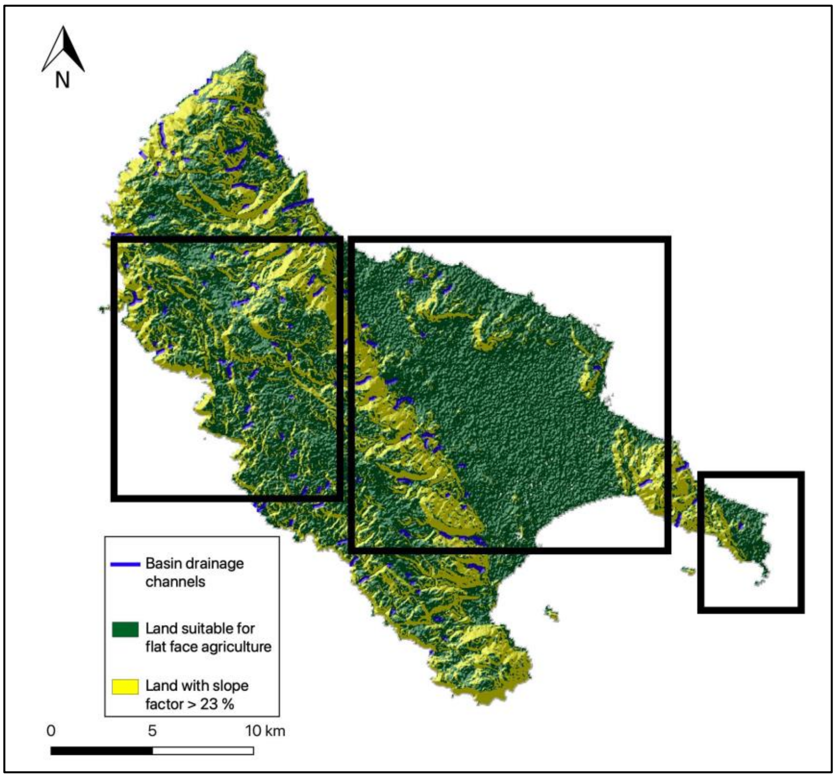

Figure 13: Classification of slope factor (threshold at 23 %) for Zakynthos, with basin drainage channels, superimposed over shaded relief. Black squares correspond to target areas. ASTERGDEM is a product of METI and NASA

vi. Zakynthos

Geomorphology

Zakynthos is also triangular, extending for 32 km north-south and 40 km east-west, with an area of 402 km^2. As all the other large islands, it has a central mountainous area, rising to the peak of the Vrachionas (758 m asl), though only 2% of the island has an elevation ≥ 600 m asl. This central mountainous area is made of calcareous marl and limestone. The entire western part is a hilly plateau composed of lime and dolomitic mudstone, representing the majority of land with elevation class 2 (≥ 200 and < 600 m asl). The east of the island is today the largest plain in the entire archipelago, and is mostly composed of alluvium.[174] Recent studies on the paleogeography of Zakynthos conclude that in antiquity at least one third of the area of this plain was occupied by a lagoon which separated the Vasiliki peninsula from the rest of the island.[175] The island was deemed to have a low risk of erosion, with areas of medium risk in the western plateau, and an area of high risk on the central ridge.[176]

Table 17: Elevation and physiographical classes for Zakynthos.

Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	51.57 %	**1**	< 5 %	Valley or basin	15.05 %
		2	≥ 5 % and < 10 %	Gentle slope	10.61 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	10.93 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	8.12 %
		5	≥ 35 %	Foothill, very severe slope	6.12 %
Hill below 600 m asl (≥ 200	46.23 %	**6**	< 5 %	Plateau	3.13 %
		7	≥ 5 % and < 10 %	Gentle slope	7.11 %
		8	≥ 10 % and < 20 %	Moderate slope	14.42 %

[174] Carlo et al. 2010.
[175] Avramidis et al. 2017.
[176] Evelpidou 2012, p. 307, figure 9.

< 600)		**9**	≥ 20 % and < 35 %	Severe slope	12.66 %
		10	≥ 35 %	Very severe slope	9.62 %
Mountain above 600 m asl (≥ 600)	2.20 %	**11**	< 5 %	Plateau	0.21 %
		12	≥ 5 % and < 10 %	Plateau, gentle slope	0.43 %
		13	≥ 10 % and < 20 %	Moderate slope	0.74 %
		14	≥ 20 % and < 35 %	Severe slope	0.57 %
		15	≥ 35 %	Very severe slope	0.27 %

Harbours and hydrology

Water is found mainly in the eastern part of the island, although a good number of sources are recorded in the central part of the western plateau. A number of good anchorages is present around the island, especially along the eastern coast.

Target areas

1. Eastern plain;
2. Western plateau;
3. Peninsula of Vasiliki.

1.7 Target areas

Study of the datasets described above has resulted in the establishment of the following target areas.

Lefkada:

1. Northern plain.
2. Vasiliki plain.
3. Gulf of Vlykos.

Meganisi:

3. Entire island.

Kalamos:

4. Area of the village of Kalamos.
5. Slopes of mount Vouni.

Kastos:

6. Entire island.

Kephallonia:

8. Paliki.
9. Peninsula of Fiskardo.
10. Koutavos lagoon.
11. Area of Agia Efthymia.
12. Area of Minias and site of modern airport.
13. Area of Poros.
14. Area of Sami.

Ithaki:

6. Northern plateau.
7. Area of Afales.
8. Valley of Polis.
9. Area of Vathy.
10. Southern plateau.

Zakynthos:

4. Eastern plain.
5. Western plateau.
6. Peninsula of Vasiliki.

Detailed coverage was obtained (where available and not classified) of these areas, and of the entire island of Meganisi, from the archive of the Geographic Service of the Hellenic Army. Available material, of sufficient quality, was purchased and investigated. The study of the coverage resulted in the individuation of the two large scale developments described in chapters 2, 3, and 4. A number of additional features retrieved from target areas are included in Appendix B.

Three case studies will be presented in the following chapters to illustrate the contribution of aerial imagery to the understanding of the *longue durée* history of the islands. Chapter 2 focusses on the interpretation of small scale features, which constitute the vast majority of the data retrieved from the interpretation of aerial imagery, providing possible interpretations in the absence of direct ground truthing (as for example when features are no longer visible) or when data from survey are limited. Chapters 3 and 4 focus instead on large scale interventions, often invisible on the ground. Both the investigation of the extension of the Early Hellenistic polis of Krane on Kephallonia, and the study of the extent of the centuriation associated to the Roman foundation of Nikopolis in Epirus benefitted from the contribution of remote sensing, and in particular of archival material. Chapters 3 and 4 also explore the potential of aerial photography to redress the imbalance in the archaeological record of the region, which still reflects past attention to the search for Homeric *topoi*, resulting in a relative abundance of data of the Late Bronze and Early Iron Ages, showing the strategic importance of remote sensing for the study of the Classical and post-Classical landscape, given its tendency to display more superficial layers. These large scale developments will be analysed in the framework of regional settlement patterns.

2. MEGANISI

This chapter presents the datasets for the island of Meganisi, for which a detailed study of the aerial coverage has been carried out. After a general discussion of the geomorphology of the island, data from the analysis of aerial photographs are illustrated and matched with ethnographic studies realised as part of the Inner Ionian Archipelago survey, led by the University of Crete and the Ephorate of Antiquities of Aetoloakarnania and Lefkada. The various features presented in the study are matched with similar ones from the rest of the archipelago. In the absence of ground truthing, due to constraints related to the Covid 19 pandemic, data from the survey are used to attempt to date such features.

2.1 Geography

i. Geomorphology

Meganisi is roughly 'L' shaped, with an upper square body, measuring approximately 6 x 3 km, to which is appended a narrow peninsula angled to the east, roughly 6 km long with a width of c. 600 m. The island has an area of c. 20 km^2. Meganisi is separated from Lefkada by a channel whose width ranges from 1 to 2.5 km. Between the two islands is the islet of Thilia (c. 0.15 km^2). On the edge of the southern peninsula lies the islet of Kythros (c. 0.8 km^2). The main body of Meganisi can be divided in two parts: the western part is hilly, with heights rising to the peak of Raches (297 m asl), while the eastern is constituted by gentle slopes and plateaux, rarely surpassing 100 m asl. The main plain areas are in the north, but a thin plateau runs across the centre of the southern peninsula. The rocks that form the main structure of the island are chiefly micro-limestone brecciae with occasional appearances of marls and marly limestones.[177] The island was deemed by Evelpidou to have a medium risk of soil erosion.[178]

Table 18: Elevation and physiographical classes for Meganisi, including Thilia and Kythros.					
Elevation class		**Physiographical classes**			
Definition	**Value**	**Num.**	**Slope factor**	**Definition**	**Value**
Valley below 200 m asl (< 200)	92.51 %	**1**	< 5 %	Valley or basin	7.63 %
		2	≥ 5 % and < 10 %	Gentle slope	11.84 %
		3	≥ 10 % and < 20 %	Foothill, moderate slope	25.36 %
		4	≥ 20 % and < 35 %	Foothill, severe slope	25.60 %
		5	≥ 35 %	Foothill, very severe slope	21.37 %
Hill below 600 m asl (≥ 200 < 600)	7.49 %	**6**	< 5 %	Plateau	0.24 %
		7	≥ 5 % and < 10 %	Gentle slope	0.69 %
		8	≥ 10 % and < 20 %	Moderate slope	2.45 %

[177] Evelpidou et al. n.d., p. 2. Geological data for Meganisi taken from Geological Maps of Greece, 1:50 000 series, Athens Institute of Geology and Mineral Exploration: Lefkas Island sheet (1963).
[178] Evelpidou 2012, p. 307, figure 9.

		9	≥ 20 % and < 35 %	Severe slope	3.30 %
		10	≥ 35 %	Very severe slope	1.52 %
Mountain above 600 m asl (≥ 600)	-	**11**	< 5 %	Plateau	-
		12	≥ 5 % and < 10 %	Plateau, gentle slope	-
		13	≥ 10 % and < 20 %	Moderate slope	-
		14	≥ 20 % and < 35 %	Severe slope	-
		15	≥ 35 %	Very severe slope	-
Land with slope grade ≤ 23 %					55.56 %
Land with slope grade > 23 %					44.47 %

ii. Harbours and hydrology

Underground water is uniformly present across the north of Meganisi, according to data recorded by the Geographic Office of the Hellenic Army (topographic maps, series 1 : 50 000), though questions exist about its quality. The drainage system of the island is composed of 168 branches and has a total length of 45.86 km[179]. Only minor areas in the northern plains are affected by significant drainage channels. A number of good

[179] Evelpidou et al. n.d., p. 2.

anchorages can be found around the island. On the northern coast there are the bays of Spilia, Platiyiali, Ampelakia, and Atherinos; on the eastern coast, the bays of Elia, Limonari, Dichali, Makria, Kalopoulos, and Svourna.

2.2 The survey

The Inner Ionian Archipelago project was begun in 2009 as a cooperation between the University of Crete, the Ephorate of Antiquities of Aetoloakarnania and Lefkada, and the Ephorate of Antiquities of Kephallonia.[180] The intensive survey was designed following the methodology of the Kea Survey. Larger islands[181] were divided into tracts with a length of 600 m. Inside each tract, members of the team walked in a straight line for 100 m, with a distance of 12 m between them, recording structures and picking up finds. Smaller islands and islets were treated as single units for the purposes of recording finds. Finds and structures recorded in the database ranged from the Middle Palaeolithic to the 20th century.

Finds retrieved as parts of the intensive survey were logged into a GIS database,[182] along with a variety of records:

1. Toponyms

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180 Galanidou et al. 2018, p. 447.
181 The Inner Ionian Archipelago Survey classified the following as large islands: Meganisi, Arkoudi, Atokos, Kythros, Thileia.
182 The GIS database was originally developed in an ARCGIS 9 3 environment, subsequently imported (by the author of thesis) into QGIS (originally QGIS 3 16 9 LTR ‘Hannover’, then upgraded to QGIS 3 20 1 ‘Odense’). GPS data were treated in an ArcPAD 8 environment. Originally geospatial data were recorded using the Greek Geodetic System GGRS 87 (EGSA 87), subsequently reprojected to WGS 84 Mercator EPSG: 4326 for uniformity with the other datasets of this thesis. The reprojection was effected through the native *translate* tool of QGIS (version 3 10 LTR ‘A Coruña’).

2. Landform features
3. Wetlands
4. Geological features (caves, cliffs, etc.)
5. Modern agricultural structures (threshing floors, enclosures for livestock, windmills; etc.)
6. Structures for the collection of rainwater
7. Topographical maps (scale 1 : 5 000)
8. Historical cartography
9. Geological maps

The database was structured to allow quantitative, qualitative, statistical, and distributional analyses.

2.3 Aerial imagery

i. Objectives

Meganisi was singled out for a methodological case study in this thesis for the following reasons. Firstly, the availability of suitable coverage for the entirety of the island from the Geographic Service of the Hellenic Army and the Archive of the British School at Athens, with dates ranging from 1944 to 2004, potentially allowing the study of the change of land cover across this period, measuring phenomena of afforestation and development. Secondly, the absence of sites deemed to be of strategic relevance allowed the purchase of unrestricted and unredacted coverage from the Geographic Service of the Hellenic Army (contrary to what will be illustrated in chapters 3 and 4). Thirdly, the existence of data from intensive land survey by the Inner Ionian Archipelago project made Meganisi a particularly promising case study. In particular, the amount of ethnographic information accrued in the survey made possible the identification of a number of features, similar to other structures seen also in different islands across the archipelago and documented in Appendix B. The existence of these ethnographic data became particularly strategic after the Covid-19 pandemic made direct ground-truthing impossible during the summer of 2020. Another source of data considered for the interpretation has been the records of standing and ruined structures in the relevant sheets of the 1 : 50 000 series of topographical maps of Greece published by the Geographic Service of the Hellenic Army, and illustrated in red (continuous line for standing structures and dashed line for ruins).

Along with providing a possible identification of retrieved features, this case study explores a way of reconciling detailed ground data with medium scale remote sensing material not originally realised for archaeological purposes. In this sense, the chapter aims to provide a useful methodological case study to inform projects unable to generate their own coverage for economic or legal reasons (no fly zones near military and civilian airports being a typical example).

ii. Coverage

Detailed aerial coverage for the entirety of the island was sought from the Geographic Service of the Hellenic Army and the Archive of the British School at Athens (World War II Allied Forces collection). The following flights and frames were retrieved:

Table 19: List of Aerial photographs included in the Meganisi case study. BSA stands for British School at Athens, Collection of Allied Aerial Imagery. GYS stands for Geographic Service of the Hellenic Army, Aerial Photographs Fund. Entries are recorded as continuous strips.

ID	**Sortie**[183]	**Date**	**Altitude**	**Focal Length**	**Scale of positives**[184]	**Frame numbers**[185]

[183] Sortie, date, altitude, and focal length are read from the identifying frisket of each frame for BSA photographs.

[184] Calculated for BSA photographs from the relation between altitude and focal length, as in Piccarreta 1987, pp. 221–227. A ground elevation of less than 200 m asl is deemed irrelevant for the purposes of this study. For GYS photographs the scale reported is the one provided on each positive print.

[185] When a sequence of frames is expressed as '3007 –3010', this means that the sequence has a forward overlap of at least 70%, due to the geomorphology of the site: Piccarreta 1987, 55–56.

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The flight BSA L 40 due to its scale was not particularly suitable for detailed photographic interpretation, even if it was partially informative for land cover. The GYS 1970 photographs showed some problems of exposure, rendering features less visible. Issues with exposure and development were identifiable also in several frames pertaining to the GYS 1972 coverage. The original plan to draw vectorial polygons corresponding to classifications of land cover (pastures, fields, forests, urban development etc.), comparing them statistically in the GIS environment was made impossible by these limitations in the material, along with the sub-optimal scale (1 : 15 000 and above) of the entirety of the imagery, except for the GYS photographs of 1984 and 2004.

The features listed hereafter were retrieved from the stereoscopic analysis of strips belonging to the following flights:

1. BSA L 40;
2. GYS 1984;
3. GYS 2004.

iii. Features

Detailed stereoscopic analysis of the imagery resulted in the retrieval of 19 features ***(fig. 14)***:

Table 20: List of features retrieved from detailed stereoscopic analysis of the aerial imagery for the island of Meganisi.							
ID	**Frames**[186]	**Description**	**Elevation visible through stereoscopic analysis**	**Visibility on georeferenced satellite imagery (Google Maps)**	**Visibility on georeferenced orthophotographs of the Greek National Cadastral Agency**	**Latitude**[187]	**Longitude**

[186] When multiple frame numbers are mentioned, they are meant to signify the existence of forward overlapping between the mentioned frames (e.g. for MEG.PH.8 "BSA L 37 3005, 6"). When the numbers are not immediately sequential (e.g. for MEG.PH.16 "GYS 163167, 9"), they still signify the existence of forward overlapping. In several cases, strips obtained from the Geographic Service of the Hellenic Army - Aerial Photographs Fund, presented forward overlapping for over 70 % of the surface of each frame, with lateral overlapping of more than 30 %, making them suitable for stereoscopic interpretation on multiple sides.
[187] Coordinate reference system (CRS): WGS 84 Mercator. EPSG: 4326.

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Figure 14: Map of the features retrieved for the island of Meganisi. Superimposed over virtual model with identification of land suitable for flat face agriculture (green) and land with a slope factor > 23 % yellow). ASTERDEM is a product of METI and NASA.

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2.4 Elements of a possible interpretation: the traditional water collecting and storing structures of Meganisi

i. The availability of water

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ii. Structures for the collection of water: data from the Meganisi survey

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2.5 Other possible identifications

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Table 21: Possible interpretations of the features retrieved from detailed stereoscopic analysis of aerial imagery for the island of Meganisi.						
ID	**Frames**[188]	**Description**	**Elevation visible through stereoscopic analysis**	**Visibility on georeferenced satellite imagery (Google Maps)**	**Visibility on georeferenced orthophotographs of the Greek National Cadastral Agency**	**Possible interpretations**
MEG.PH.1	BSA L 37 3004, 5	Circular negative cropmark, with a diameter of	Not visible	No, but other ruins, maybe terraces are visible	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge

[188] When multiple frame numbers are mentioned, they are meant to signify the existence of forward overlapping between them (e.g. for MEG.PH.8 "BSA L 37 3005, 6"). When the numbers are not immediately sequential (e.g. for MEG.PH. 16 "GYS 163167, 9"), they still signify the existence of forward overlapping. In several cases, strips obtained from the Geographic Service of the Hellenic Army - Aerial Photographs Fund presented forward overlapping for over 70 % of the surface of each frame, with lateral overlapping of more than 30 %, making them suitable for stereoscopic interpretation on multiple sides.

		approximately 10 to 12 m				catchment area, or threshing floor
MEG.PH.2	BSA L 37 3004, 5	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH.3	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH.4	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge

		approximately 10 to 12 m				catchment area, or threshing floor
MEG.PH.5	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH.6	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH.7	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with rectangular structure to

		approximately 10 to 12 m, with smaller rectangular cropmark on one side				enlarge catchment area, or threshing floor
MEG.PH.8	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH.9	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Yes	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor

MEG.PH. 10	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Not visible	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH. 11	BSA L 37 3005, 6	Circular negative cropmark, with a diameter of approximately 10 to 12 m	Not visible	Not visible	Not visible	Traditional cistern (*sterna*) for water harvesting, with circular structure to enlarge catchment area, or threshing floor
MEG.PH. 12	BSA L 37 3006, 7	Two small circles of stones, diameter of approximately 10 m. One of them might be possibly	Not visible	Partially	Not visible	Traditional cisterns (*sternes*) for water harvesting, or threshing floors

		visible on gmaps, but they seem to be under current buildings.				
MEG.PH. 13	BSA L 37 3006, 7	Small circle of stones	Not visible	Not visible	Not visible	-
MEG.PH. 14	GYS 2 720 95	Circular positive cropmark diameter of approximately 10 to 12 m	Not visible	Not visible	Not visible	Possibly remains of a windmill, labelled as such on the topographical maps produced by the Geographic Service of the Greek Army. Otherwise traditional cistern (*sterna*) for water harvesting, or threshing floor

MEG.PH. 15	GYS 1 631 75	Linear negative cropmarks, parallel	Yes, slight	Traces, possibly rubble	Traces, possibly rubble	Possibly remains of terraces
MEG. PH.15 bis	GYS 1 631 98	Round negative cropmark, with a diameter of approximately 10 to 12 m, enclosed in a rectangular structure	Not visible	Not visible	Not visible	Traditional cistern (*sterna*) for water harvesting, with rectangular structure to enlarge catchment area, or threshing floor
MEG.PH. 16	GYS 1 631 67, 9	Positive cropmark, roughly rectangular with rounded angles	Not visible	Not visible	Not visible	-
MEG.PH. 17	GYS 1 632 32	Circular negative cropmark, with a	Yes	Yes	Yes	Possibly remains of a windmill, labelled as such

		diameter of approximately 5 to 7 m				on the topographical maps produced by the Geographic Service of the Greek Army. Otherwise well (*pigadi*), or threshing floor
MEG.PH. 18	GYS 1 632 32	Circular negative cropmark, with a diameter of approximately 5 to 7 m	Not visible	No, but other remains are present, maybe terraces	Not visible	Probably remains of windmill, labelled as such on the Topographical maps produced by the Geographic Service of the Greek Army. Otherwise well (*pigadi*), or threshing floor

2.6 Matching the features with survey data

The nineteen features retrieved from the stereoscopic analysis of the aerial photographs were at this point matched with the records of pottery found during the land survey activities of the Inner Ionian Archipelago project. As mentioned above, Meganisi was divided into tracts with a length of 600 m. Inside each tract, members of the team walked in a straight line for 100 m, 12 m apart, recording structures and picking up finds. No detailed GPS record of the location of finds was provided. Finds and structures recorded in the database ranged from the Middle Palaeolithic to the 20th century. The first challenge was how to visualise spatially the distribution of finds inside a given tract. The excel spreadsheet containing the record of the various categories of finds retrieved was converted from the XLSX to Comma Separated Values (CSV) format, to make it suitable for analysis in a GIS environment. The CSV file was input into the GIS database as a Delimited Text Layer.[189] Through interpolation the data of the GIS table derived from the CSV file were attached as additional fields to the polygons corresponding to the tracts of the survey grid. Different point based vectors were created, scattering automatically inside each tract an amount of points corresponding to the number of finds of each category retrieved in that tract.

The following datasets were created:

1. Late Bronze Age
2. Early Iron Age
3. 8th to 7th century BC

[189] The file had no coordinates at this point, and was imported into GIS as a table.

4. Archaic
5. Archaic to Classical
6. Archaic to Hellenistic
7. Classical
8. Classical to Hellenistic
9. Hellenistic, Hellenistic to Roman
10. Early to Middle Roman
11. Late Roman
12. Modern pottery

The datasets were therefore condensed through the generation of two more general datasets:

1. Ancient finds (comprising categories from 1 to 11).
2. Modern pottery.

The nineteen features were at this point analysed on their proximity to Ancient finds or Modern pottery. A distance of approximately 600 m (corresponding to a side of the tract of the survey grid) was chosen for convenience. Different simulations were made with a variety of distances, up to 1 km, without a significant alteration of the results of the analysis.

Ten features were found to be within a distance of 600 m from Ancient finds. All nineteen features were within the same distance from Modern pottery, in five cases the feature was located inside a tract where Modern pottery had been found. Furthermore, in Antiquity the main focus area on the island appears to have been in the centre of the southern peninsula, with a continuity of habitation from the Late Bronze Age to the Late Roman period. Nonetheless, only two features (MEG.PH.15, MEG.PH.16) were identified in this area when one might reasonably a considerably higher number were they to be ancient.

This data contributes to the interpretation of the features as modern structures. It therefore seems that cisterns were not built to service settlements, but rather for the purposes of cultivation and husbandry at some distance from a settlement. Nevertheless, the absence of Ancient finds from the vicinity of the village of Spartochori could also be explained by the substantially lower visibility of earlier strata due to modern and contemporary urbanisation. In the same area, Sylvia Benton saw a substantial amount of Late Bronze Age pottery.[190]

[190] Benton 1932, pp. 230–232.

Table 22: Possible interpretations of the features retrieved from detailed stereoscopic analysis of aerial imagery for the island of Meganisi.

ID	Frames	Description	Proposed interpretations	Feature within 600m of Ancient finds	Feature within 600m of Modern

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2.7 Similar features on other islands

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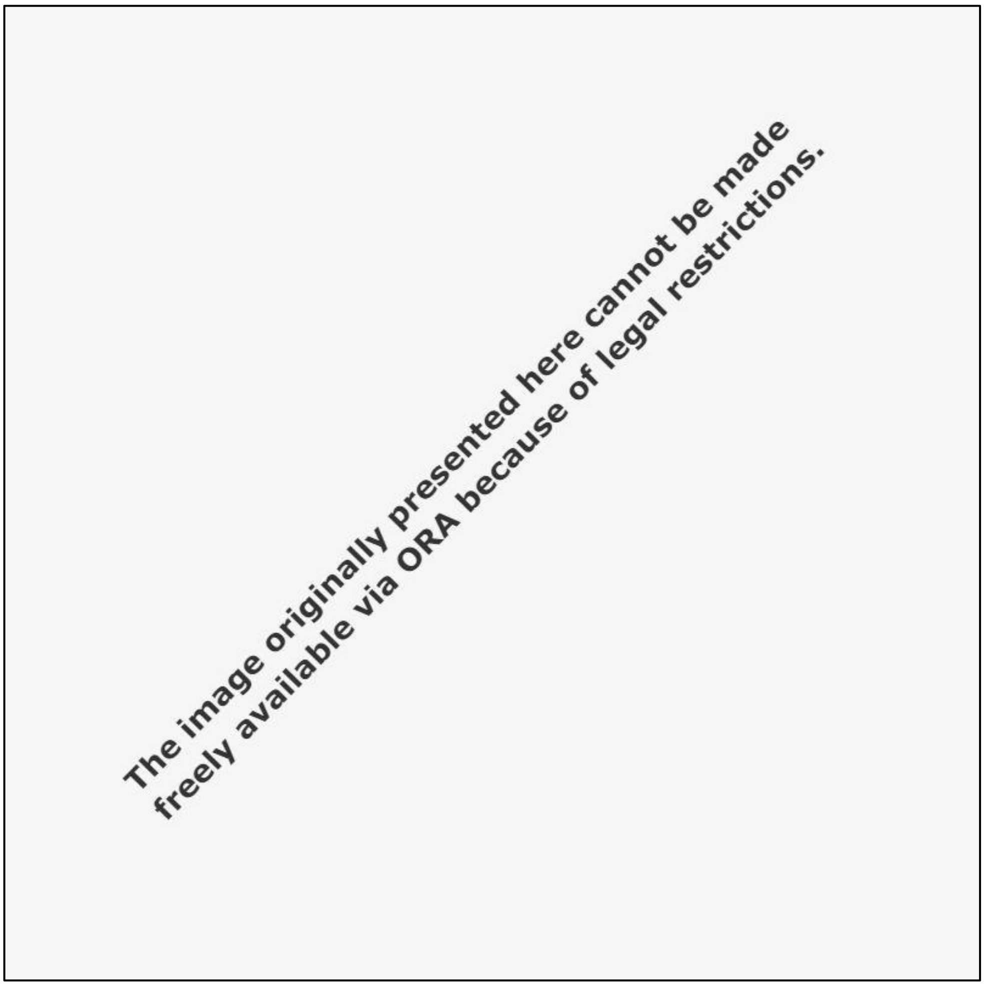

Figure 15: Map of the features retrieved for the islands of Kalamos and Kastos. Superimposed over virtual model with identification of land suitable for flat face agriculture (green) and land with a slope factor > 23 % yellow). ASTERDEM is a product of METI and NASA.

Figure 16: Map of the features retrieved for the island of Ithaki. Superimposed over virtual model with identification of land suitable for flat face agriculture (green) and land with a slope factor > 23 % yellow). ASTERDEM is a product of METI and NASA

Table 23: Possible interpretations of selected features retrieved from detailed stereoscopic analysis of aerial imagery for the islands of Arkoudi, Ithaki, Kalamos, and Kastos.

ID	**Frames**[191]	**Description**	**Elevation visible through stereoscopic analysis**	**Visibility on georeferenced satellite imagery (Google Maps)**	**Visibility on**	**Latitude**[192]	**Longitude**	**Possible interpretation**

[191] When multiple frame numbers are mentioned, they are meant to signify the existence of forward overlapping between them (e.g. for MEG.PH.8 "BSA L 37 3005, 6"). When the numbers are not immediately sequential (e.g. for MEG.PH. 16 "GYS 163167, 9"), they still signify the existence of forward overlapping. In several cases, strips obtained from the Geographic Service of the Hellenic Army - Aerial Photographs Fund presented forward overlapping for over 70 % of the surface of each frame, with lateral overlapping of more than 30 %, making them suitable for stereoscopic interpretation on multiple sides.

[192] Coordinate reference system (CRS): WGS 84 Mercator. EPSG: 4326.

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3. THE HELLENISTIC TOPOGRAPHY OF NEA KRANE, KEPHALLONIA

3.1 Krane and Nea Krane

The ancient city of Krane occupies a large plain located on the south-eastern edge of the bay of Argostoli ***(fig. 21, 1)***. The site is on the shores of the Koutavos lagoon ***(fig. 21, 2)***, the terminal part of the bay nowadays divided from the open sea by a bridge built in 1813.

Figure 17: Location of Krane (in the square) and modern Argostoli (3). Elaboration of frame BSA P3 5003 (13 October 1943, scale of the original print 1 : 56 000, reproduced with permission from the British School at Athens).

The bay is an excellent natural harbour, shielded from winds by hills and mountains on each side. Even today, the traveller navigating through the gulf ***(fig. 21, 4)*** from Lixouri to modern Argostoli ***(fig. 21, 3)*** may notice how, as the ferry enters the basin, the breeze becomes gentler and the sea calmer.

The site of Krane has been the subject of attention since the late nineteenth century, when it was recorded by Joseph Partsch.[193] Partsch mapped both the enceinte which enclosed the western acropolis on the hill of Kastelli ***(fig. 22, 1)*** and the eastern hill of Pezoules ***(fig. 22, 2)***, and the Early Hellenistic walls ***(fig. 22, 3)*** of a planned new city, with a so-called Dipylon Gate which has been interpreted as modelled on that in Athens ***(fig. 22, 4)***. Subsequent studies and excavations have shed light on the sequence of human activity in the area from the Early Bronze Age onward.[194] Two sections of rubble wall have been ascribed to the EBA,[195] and EBA pottery was identified by Sylvia Benton in a section of the foundations of the enceinte of the acropolis.[196] Sherds of the Late Helladic[197] and Geometric[198] periods have been recorded as well. A Doric temple was built in the sixth century BC,[199] followed in the Classical period by the foundation of another small temple.[200]

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[193] Partsch 1890, pp. 80–84, pl. 2.
[194] A list of finds can be found in Randsborg 2002, vol. 2, pp. 55–56.
[195] Randsborg 2002, vol. 2, p. 275 phase 1 and fig. IX, 79 sections U and V.
[196] Benton 1932, p. 224.
[197] Kavvadias 1911, pp. 7–8; Kyparisses 1919, p. 83.
[198] Blegen 1932, p. 61.
[199] Catling 1981, p. 28.
[200] Kalligas 1978.

Figure 18: The city of Krane and Nea Krane. 1: Eastern Acropolis. 2: Western Acropolis. 3: Northern Enceinte. 4. Dypilon Gate. The arrows show some of the visible marks of the orthogonal planning of Nea Krane. Elaboration of frame BSA P 6 4047 (22 June 1944, scale of the original print 1 : 12 500, reproduced with permission from the British School at Athens). Relief of the walls of Krane after Sotiriou 2013.

The establishment of a planned city in the valley north of the acropolis has been dated to the early Hellenistic period. The design of this settlement included an enceinte with regular square bastions[201] and the Dipylon Gate noted above,[202] which enclosed an area of c. 144 ha.[203] This enceinte was meant to enclose a large planned city conventionally named Nea Krane ***(fig. 23)***. The urban plan featured intersecting north–south and east–west roads,[204] creating *insulae* of c. 100 x 33 m, based on a Doric foot of 32.7 cm.[205]

3.2 Problems of visibility

The presence of this planned city at Krane, in the area partly enclosed by the Hellenistic enceinte, was first reported by Klavs Randsborg, who published a plan of it. Noting the almost total absence of surface finds, Randsborg concluded that the settlement was never completed.[206] Previously, mapping had been made difficult, if not impossible, by the presence of dense vegetation in the entire area.

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201 Randsborg 2002, vol. 2, p. 302, Fig. X. 8.
202 Randsborg 2002, vol. 2, p. 301, fig. X. 7, bottom.
203 Randsborg 2002, vol. 2, p. 56.
204 The city is aligned with magnetic north, and references to cardinal points are to be understood accordingly.
205 Randsborg 2002, vol. 2, p. 295, n. 32.
206 Randsborg 2002, vol. 2, pp. 297–307; the name Nea Krane was coined by Randsborg to distinguish the settlement from the older city.

Figure 19: The map of Nea Krane published by Klavs Randsborg.[207]

Significant emigration from the islands in the aftermath of the 1953 earthquakes resulted in the abandonment of fields and pastures. The sudden end to ploughing and grazing resulted in the rapid and uncontrolled afforestation of many areas, the shores of the Koutavos lagoon among them. In subsequent decades, the progressive shift from an economy based on husbandry and agriculture to one based on tourism and services further enhanced this phenomenon. In fact, the Danish team was able to study the site only after a fire had destroyed the vegetation in the area. This temporary, although partial, absence of coverage, made it possible to observe traces of the orthogonal road system from the

[207] Randsborg 2002, vol. 2, p. 302, fig. X. 8.

surrounding hills. Nevertheless, even in the immediate aftermath of the fire mapping with a total station was impossible due to quick regrowth of vegetation: the study was therefore undertaken using oblique aerial photographs, of which no details were published.[208] From 2009 onwards, surveying and mapping were undertaken by the Greek Archaeological Service, resulting in a new site plan which essentially confirmed the Danish findings.[209] Imagery pre-dating the 1953 earthquake and the ensuing afforestation therefore seems a particularly promising source to investigate for additional traces of the settlement. Aerial imagery has been widely used in the last 60 years to reconstruct schemes of urban and rural planning in the Greek world, especially in the Greek colonies in Italy and Sicily where a significant amount of photographic material is available.[210] Recently, the remarkable potential of modern remote sensing techniques has been demonstrated, yielding excellent results. Of particular relevance to southern Kephallonia, a study of multi-spectral satellite imagery aimed at the detection and mapping of near-surface remains of orthogonal roads has revealed extensive traces of the urban planning of Mantinea and Elis, potentially dating back to the fourth century in the former case and the fifth century in the latter.[211] Be it with aerial or satellite imagery, the study of urban and rural planning remains an ideal field for the application of remote sensing techniques due to the particular geometric relationship between different features (aligned, perpendicular or parallel). This peculiarity allows relevant features to be isolated easily, either manually or using specific digital algorithms.

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[208] Randsborg 2002, vol. 1, pl. B 98–9.
[209] Sotiriou 2013, pp. 24–27.
[210] Guaitoli 2003, pp. 357–359, with bibliography.
[211] Donati and Sarris 2016.

3.3 Gathering data

The coverage available from the Geographic Service of the Hellenic Army was made in preparation for the drawing of the 1 : 50.000 maps of Greece, with a scale of approximately 1 : 45.000. The material held by the Greek Cadastral agency was mainly connected to the planning of public works: it is therefore largely confined to urban areas and uses a scale unsuitable for archaeological photo-interpretation. The archive of the British School at Athens holds images from multiple flights covering the area of Krane made by Allied photo reconnaissance missions during World War Two.

Even though the Allied aerial imagery was not originally intended for archaeological interpretation, it has yielded excellent results in a number of cases, including the orthogonal plan of Metapontum.[212]

In that case, the fact that the ancient city was very close to an area of high strategic importance (the military airfields of Apulia) meant that a vast RAF photographic coverage was made, with a scale suitable for archaeological interpretation and mapping. A similar coincidence between an archaeological site and a strategic location is evident at Krane, where the ancient city lay close to Argostoli with its harbour, airfield, and German garrison. Twelve flights were retrieved, made between September 1943 and September 1944, and with scales between 1 : 10 000 and 1 : 52 000. These form the core of the analysis in this study. The imagery is supplemented with coverage realised by the Geographic Service of the Hellenic Army.

[212] Bradford 1957, p. 225; Adamesteanu 1965; De Siena 2003, p. 363, fig. 650.

3.4 Pre-processing

The British School at Athens does not hold the negatives of the Allied photographs in its collection. Analysis is therefore limited to study of the prints, entailing a potential loss of data and limiting the possibility of digital enlargement of the images. In dealing with this material, special care has been taken to avoid losing further quality both in the scanning and in the digital management of the files. The first step was the double scanning of the positive photographic prints at a resolution of 600 and 1200 dpi.[213] Each frame was scanned along with a ruler for the subsequent scaling of the images. A digital white balance of the images was then carried out, using as the colour reference for white the writing on the frisket.[214] Given that the orientation of a print is connected to the direction of the flight and the position of the camera, at this stage every image was rotated to place magnetic north at the top.[215] Since the greater the focal length, the greater the optic distortion on the edges of the image, the central c. 40 % of each image was cropped and exported to a separate file. Before cropping, the image of the ruler scanned along with the print was substituted for a vectorial one, and a bar matching the scale of the photo added.

Table 24: Catalogue of Allied photographic material from the library of the British School at Athens covering the area of Krane

[213] The positives were scanned into a tiff uncompressed file to avoid loss of details and data.
[214] The 'frisket' is the data strip at the bottom of each frame, obtained by placing an acetate strip on the enlarger. The data were written in black ink during development so appear as 'perfect white' on the positive prints.
[215] For reasons of convenience, magnetic north was chosen over geodetic (or true) north, since this is the alignment of the ancient city.

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Among these flights, P 3, P 10, P 11 and P 12 are unsuitable for archaeological photo-interpretation due to their scale; P 9 has just a marginal coverage of the shore of the Koutavos Lagoon; P 8 is not suitable for interpretation due to distortions; and P 1 is poorly exposed. The remaining flights and frames form the core of the analysis of this study.

Table 25: Catalogue of photographic material from the Archive of the Geographic Service of the Hellenic Army

Date	**Scale of positives**[216]	**Frame numbers**
The text originally presented here cannot be made freely available via ORA because of legal restrictions.		

Photographic material from the Geographic Office of the Hellenic Army is of interest in the framework of this study as it documents the progressive afforestation and diminishing visibility of features after the earthquake of 1953. None of the photographs listed in the table above contributed new features for the mapping of the settlement. Plates 4 and 5 contain details from these photographs, clearly illustrating the increase of land cover rendering features invisible. The appearance of the site of Nea Krane on the photographic material of the Geographic Office of the Hellenic Army is entirely compatible with the account of reduced visibility given by Klavs Randsborg.

[216] As given on the frames.

3.5 Preliminary reading

The reading of the frames was achieved via double stereoscopic analysis: two stereoscopes with a respective magnification power of 2x and 4x were used over each pair of images with a forward overlap of at least 70 %. The choice of foldable stereoscopes was deliberate, due to the peculiar accentuation of elevations that they provide, and thus their considerably higher potential to detect micro-relief.[217] The importance of their capacity to detect micro-elevations on the ground is confirmed by the information gathered about the surface remains. Klavs Randsborg's published description of the site suggested the presence of exposed remains: 'on the ground, this huge "ghost-city" appears as ribbons of flattened rock and a few rows of blocks etc. across earthen surfaces, both delineating the streets, 12+ parallel ones going north - south and at least four, also parallel, going east - west'.[218] For a significant number of features, it was possible to observe some kind of micro-elevation during the stereoscopic reading.

In the material identified, the area has a modest coverage of vegetation, mainly grass and bushes with only few trees. Terraces were immediately recognizable in the north west of the area of the ancient city, along with signs of land divisions in the entire area. A large number of anomalies in the land cover have been observed, belonging to three categories:

1. Micro-elevations (with or without shadow);[219]
2. Negative crop marks (anomalies of the vegetation resulting in clearer areas);
3. Positive crop marks (anomalies of the vegetation resulting in darker areas).

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[217] Piccarreta 1987, pp. 137–138.
[218] Randsborg 2002, vol. 2, p. 299.
[219] The friskets of the photographs state that all the sorties happened in the late morning.

The features noted during the stereoscopic analysis have been transcribed on the digital copy of each image.

3.6 Processing and comparative reading

Each frame (or stereoscopic pair of frames) displayed a certain number of features which required comparative study to achieve a global reading. The traces transcribed from each photograph and each flight were all subsequently scaled to 1 : 12 500, the scale of flight P 6.[220] Frame P 6 4047 was used as the basis for the subsequent drawing of features ***(fig. 24)***, since it had the best coverage of the area of interest for this study.

[220] The choice of flight P 6 as the basis for the scaling of all the other flights is due to the fact that it has the best scale and that it shows the highest number of features (in particular positive and negative crop marks).

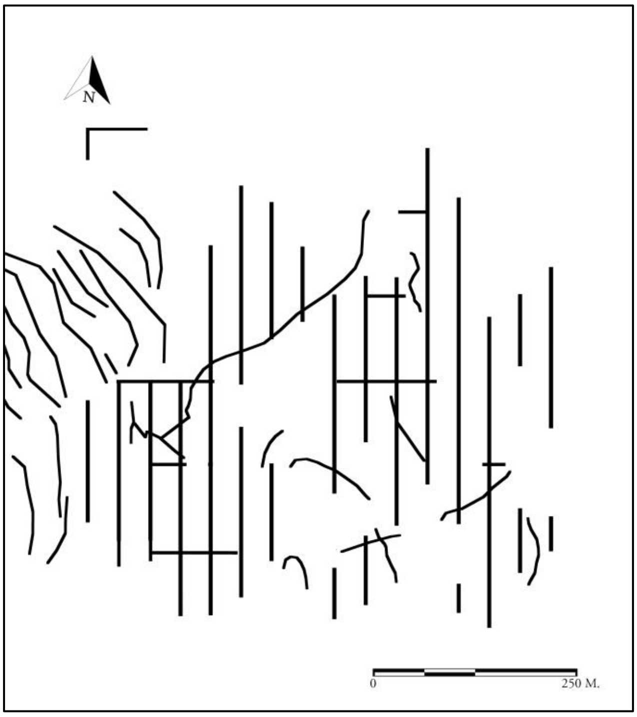

Figure 20: Cumulative drawing of the anomalies observed via stereoscopic interpretation of the positive prints.

Given that in this case the nature of the site was known and an orthogonal plan had already been described, the next step was to isolate features with a north-south and east-west orientation.[221] Figure 25 gives a global overview of all such features, which align over 16 axes north-south and six east-west.

[221] Given the relatively small number of photographs studied, this was done without the use of digital algorithms for processing.

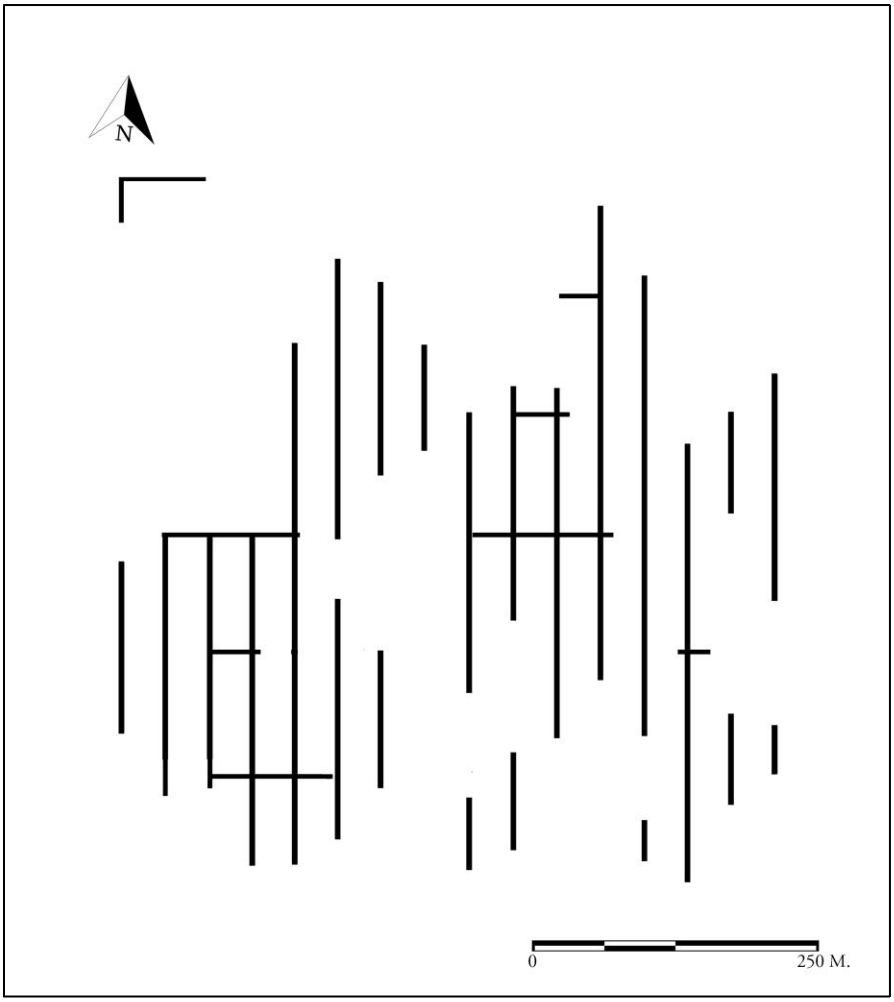

Figure 21: Synthesis of the marks connected to the orthogonal planning of Nea Krane observed in the stereoscopic analysis of the photographs.

3.7 Describing the anomalies

At this point, a few words must be said about the character of these features and what emerges from their comparative reading. It has already been noted that the features belong to three categories: micro elevations, negative crop marks, and positive crop marks. Clearly, an elevation, even if minimal and observable only through stereoscopic manipulation of three-dimensionality, is connected to the presence of something above ground level. Conversely, crop marks are generated by the interference of something present underground with the growth of the vegetation over it.[222] Unsurprisingly, comparative reading revealed that traces connected to micro elevations over ground were visible in all the photographs with just minor variations.[223] These features partially align with those observed and mapped by Klavs Randsborg.[224] However, the crop marks, whether positive or negative, were displayed differently in each flight. The presence and evidence of these features is directly connected to variable factors such as the moisture of the terrain, rainfall, heat, the kind of crop, and the season.[225]

Table 26: List of features retrieved for the area of ancient Krane.

ID	**Photos**	**Synthetic Description**	**Perceived elevation**	**Visible on Google Maps**	**Visible on the orthorectified image of the Greek Cadastrial Agency**

[222] Piccarreta 1987, pp. 115 and 126–134.
[223] Possibly connected to the action of the weather: a heavy rainfall or strong wind may result in exposure of additional over ground features.
[224] Randsborg 2002, vol. 2, p. 302, fig. X. 8.
[225] On the occasional visibility of crop anomalies connected to Greek urban orthogonal planning, see Donati & Sarris 2016, 363–4.

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The text originally presented here cannot be made freely available via ORA because of legal restrictions.

Figure 26 presents a comparative view of the orthogonal traces observed during the stereoscopic reading of each flight, along with the roads identified and published by Randsborg. Figure 27 presents a schematic synthesis of the urban plan and its reconstruction. The largest number of features appeared in flight P 6, taken in late June 1944.[226]

[226] The remarkable number of anomalies shown in these photographs can be ascribed to the season, excellent photographic exposure, and the scale of the prints.

Figure 22: Visibility of the north-south road 12. I: negative crop mark. II: positive crop mark. III: micro elevation. Elaboration of frame BSA P 6 4047 (22 June 1944, scale of the original print 1 : 12 500, reproduced with permission from the British School at Athens.

The crucial importance of a cumulative analysis of the features is exemplified by figure 26, which shows how the same north-south road can appear in different sections as a micro-elevation over terrain, as a negative cropmark, or as a positive one. To understand how this can be possible, a brief explanation of the possible dynamics of formation of such features is needed.

The occurrence of negative cropmarks seems to suggest the presence of the road buried at near ground level, thus creating an obstacle to the regular growth of vegetation. Positive cropmarks seem to be compatible with at least two scenarios, if we assume them to match the presence of an underground depression filled with humus which allows vegetation to grow stronger and greener.[227] The first is that they represent a different state of completion of an abandoned project, when the trenches to lay the foundations of the roads had been dug out. The second scenario is that sections of the roads had been removed to be reused, leaving exposed some kind of ditches. Clearly those possibilities are not mutually exclusive and could easily coexist in different parts of the planned city.

[227] Piccarreta 1987, pp. 126–131.

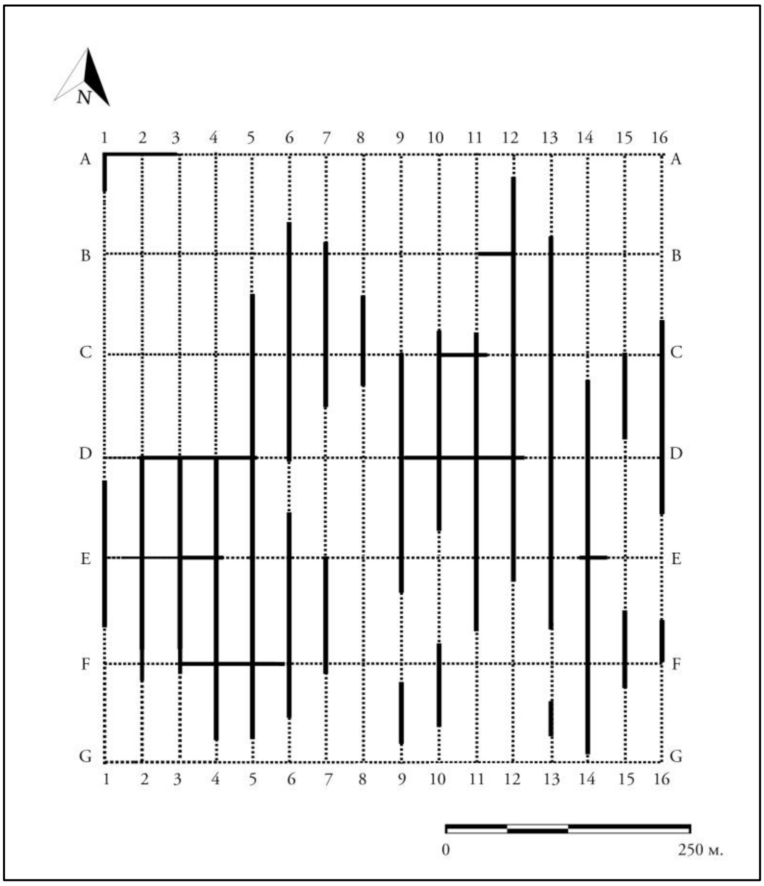

Figure 23: Reconstruction of the orthogonal planning of Nea Krane (dashed lines indicate hypothetical restorations).

3.8 A new map for Nea Krane

A general study of all the isolated features allows the map of the planned city of Nea Krane to be significantly updated ***(fig. 27)***. It gives a better understanding of the scale of this large-scale project of urban planning, which can now be seen to consist of 90 blocks. The map published in 2002 had 12 north-south roads[228] and four east-west:[229] now it is possible to map 16 and seven respectively.[230] The general plan appears to be different as well, as the map published by Randsborg assumed the existence of rows of blocks of different length, ranging from 133 to 200 m and with a fixed width of 33 m, with ratios ranging from 1 : 4 to 1 : 6. The historical aerial photographs display the presence of additional west-east roads, partitioning all the blocks with a regular size of 33 x 100 m, and a ratio of 1 : 3.[231]

The area of the planned city which can be reconstructed is almost doubled, rising from 19.8 ha[232] to 36.96 ha, and thus shedding new light on the scale of a majestic project which now counts 90 blocks. The newly mapped planned city occupies more than one third of the entire area enclosed by the walls ***(fig. 28)***.[233] It is not yet possible to speculate on whether the planned city was meant to be just the central part of the wider space

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[228] With a 13th assumed (Randsborg 2002, vol. 2, p. 280), those 12 streets match figure 7, nn. 3–14.
[229] Randsborg 2002, vol. 2, p. 299. They match figure 7, n. B, C, D, F.
[230] The seventh (figure 7, n. G) is assumed but not seen in aerial photographs.
[231] As summed up in figure 7.
[232] Taking into account one row of longer (33 x 200 m) blocks.
[233] Randsborg 2002, vol. 2, p. 56.

surrounded by the enceinte,[234] or whether this was simply the part completed at some stage of a wider project aimed at the organisation and division of the entire walled zone.[235]

Figure 24: The city of Krane and the reconstructed map of Nea Krane. Elaboration of frame BSA P 6 4047 (22 June 1944, scale of the original print 1 : 12 500, reproduced with permission from the British School at Athens). Relief of the walls of Krane after Sotiriou 2013.

[234] As suggested by Klavs Randsborg, Randsborg 2002, vol. 2, p. 305.
[235] There is a similar lack of clarity about the extent of the orthogonal grid inside the walled zone at Demetrias, see Donati *et al.* 2017, p. 455 and Marzloff 1994.

3.9 Krane and Nea Krane: settlement dynamics

To understand some of the implications of the new data for the planned city of Nea Krane, it is useful to look at the city in the wider framework of the settlement dynamics of the entire polis of Krane. Mapping undertaken by the Greek Archaeological Service from 2009 onwards has contributed to the identification of the main settlement on the south and western slopes of the acropolis.[236] This position puts the town of Krane in direct connection with at least three important foci of economic activity: the Koutavos lagoon, the harbour of the city, to the west; the forest of Mount Ainos to the east; and the large plain to the south. Archaeological evidence points to an economic model based on a plurality of activities undertaken in a wide range of satellite sites around the central town. A number of agriculture and herding communities (attested by their burials) lay across the entire plain around the central city: their tombs were located on rocky hills to preserve arable land for cultivation.[237] Two pottery kilns, of the sixth and the third centuries BC respectively, have been identified to the south west of the main settlement.[238] Salt extraction and quarrying happened in the area of modern Svoronata in the far south of the island.[239] The forest of fir trees on Mount Ainos, which provided superb raw material for ship building, was divided between the poleis of Krane, Same and Pronnoi,[240] constituting a further focus of economic activity for our city. At the centre of this wide network of economic activities, the town of Krane was in absolute terms modest in size: a narrow strip of 300 m inside the western and eastern enclosure of the walls. It does not appear to

[236] Sotiriou 2013, pp. 24–27.
[237] Marinatos 1932, pp. 1–5; Marinatos 1933, pp. 68–70; Sotiriou 1991; Sotiriou 1993; Sotiriou 1995.
[238] Sotiriou 2010, p. 109, fig. 5; Sotiriou 2013, pp. 27–29.
[239] Sotiriou 2013, p. 29.
[240] Sotiriou 2010, map 3.

have been a monumental settlement, although its comparatively large size by Kephallonian standards, and its position by a superb harbour and at the centre of this wider network of production, testify to its eminent role as a trading centre.

The project to build an large orthogonally planned city, this time on the north west of the acropolis therefore poses different questions about settlement patterns. It is reasonable to suppose that urban planning could have been a local concern given comparable developments elsewhere on Kephallonia. At least two other cities underwent planned redevelopment at various stages from the early fourth to the third century, the dates in both cases being more securely archaeologically corroborated. Same, on the eastern coast, has a Late Classical orthogonal development (*c.* 375 BC), based on the Ionian foot (37.5 cm), with blocks of 89 x 30 m (ratio 1 : 3) divided into square plots of 14.8 x 14.8 m.[241] South of Same, in the polis of Pronnoi, traces of orthogonal planning (too slight to propose a model) have been identified in the coastal town of Poros, for which a date *c.* 300 BC has been proposed.[242] Yet with a settlement area of almost 40 ha currently attested, in an entire walled area of almost 144 ha, Nea Krane had the potential to be one of the largest walled cities in Greece after Demetrias, depending on how much of the walled area was actually settled. For comparison, Early Hellenistic Leukas, which occupied the entire area within the walls, covered *c.* 100 ha.

Even if it is safe to infer that a city which was so much larger must have reflected what Andreas Sotiriou has called ‘an explosion of population’ around 300 BC,[243] it is not clear where such a significant number of people would have come from, and even more

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[241] Randsborg 2002, vol. 2, fig. X. 2; maps in vol. 1, pl. D LII–D LXI.
[242] Randsborg 2002, vol. 2, pp. 299–301.
[243] Sotiriou 2013, p. 26.

interestingly, where they went when the project was left unfinished. Were they the original inhabitants of Krane spontaneously planning to relocate to a wider area? Were people from the satellite settlements of the polis relocating to the projected Nea Krane? If what we are looking at is effectively just a fascinating example of a failed synoecism or plan to extend the residential area, what would have formed the economic base of the new city? What would a mass relocation to a centre have meant for an economy based on the exploitation of a variety of scattered resources? If they were locals, either from the town or the wider city territory, it is difficult to understand why in later periods no one ever went to inhabit what had become a monumental ‘ghost city’, especially after the great investment required by the construction of a new enclosure and the orthogonal roads. Nevertheless, that is what the archaeological evidence at the moment suggests, with no pottery found in the planned city, inside the fortification enclosure, or at the Dipylon Gate.[244] The aerial photographs too revealed no remains of structures in the area of Nea Krane apart from the roads.

The abandonment of the project of Nea Krane had no obvious impact on the city of Krane. Settlement continued into the Hellenistic and Roman periods both in the central town and in some of the satellite settlements, with a stoa built on the acropolis,[245] a pottery workshop producing amphorae in the Koutavos valley,[246] and a necropolis in the southern valley at Mazarakata.[247] It therefore seems that settlement dynamics continued in broadly the same way after the abandonment of the project of Nea Krane, with a number of smaller production sites around a central settlement connected to the sea. The question at this

[244] Sotiriou 2013, pp. 25–27, note 64 in particular.
[245] Kalligas 1969, pp. 270–271.
[246] Sotiriou 2013, pp. 27–29.
[247] Sotiriou 1993, p. 148.

point is whether these patterns had changed at all, if the local population had reverted to a dynamic of scattered settlements around a trading centre, or if this dynamic had never been abandoned. The substantial continuity of certain communities, such as that at Mazarakata, seems to point to the absence of any significant break, making it likely that that the economic model based on the exploitation of a variety of resources across the south of the island effectively continued not only unchanged but able to sustain those communities. Noting other instances of large-scale synoikism and urban relocation -Megalopolis being a striking example-,[248] it is rarely the case that there is an immediate abandonment or visible alteration in rural settlement, whatever contemporary rhetoric may suggest. One would not, therefore, automatically expect such a change in the case of Krane. However, the unusually large scale of Nea Krane would surely have made exceptional demands on population and resources: it is instructive to note that the entire area of the old city of Krane, as mapped by the Greek Archaeological Service, would fit into less than ten blocks of Nea Krane. So if the abandonment of the building project (whether by a single strategic decision or continuing failure to resume operations) is to be read in this wider framework, it seems logical to assume that the fact that the new city remained uninhabited indicates that it was unsuited to the settlement needs of the local communities alone. If this new colossal city did not fit the needs of the locals, the possibility that we are looking at a failed purely local plan for synoikism can be excluded, making external intervention more plausible.

Klavs Randsborg reached the same conclusion but on different grounds, arguing that because the project looks too big to have been undertaken by a single city, it must reflect

[248] Roy 2005.

external intervention. The fact that data from aerial photographs double the size of the planned settlement adds weight to this argument. What would be the attraction for an external investor? Proximity to the harbour at Koutavos must have been a major factor, since this is one of the finest natural locations to base a fleet in the Mediterranean,[249] especially given the availability of timber from the pine forests of Mt. Ainos. The harbour was easily defensible, with fine plain land behind it to support its population. The likelihood that the planning of Nea Krane should be linked to wider strategic, geopolitical concerns must therefore be considered.

As Randsborg indicates, the strategic location of Kephallonia in the context of the politics of the New Corinthian League (of which the central Ionian islands were part),[250] makes investment in the defensive and urban infrastructure of the island perfectly plausible. While he does not address the question of why Krane should have been chosen, we may suggest that the harbour was a key factor. The peculiar qualities of the gulf as a safe anchorage (potentially suitable for a large military fleet) -unique in all of north-western Greece- have already been mentioned in the introduction to this chapter. Recent studies on the sediments of the Koutavos Lagoon by Vött *et al.*[251] confirm the potential of the harbour and the large extent of the area suitable for anchorage, which was limited to the eastern part of the lagoon.[252] Randsborg, however, moved directly from questions of immediate strategic and political environment to propose that Demetrios I Poliorketes played a direct role in the planning of this new city, although it is never mentioned in

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[249] Randsborg 2002, vol. 2, p. 51.

[250] For a political narrative of the Successors' urban policies and their key synoikisms, see Boehm 2018, pp. 29–88.

[251] Vött 2007; Vött et al. 2014.

[252] It must be noted that a section of the enceinte of the acropolis appears to lead towards the eastern section of the Koutavos Bay.

historical sources.[253] On this argument, the project was abandoned because Demetrios moved on. This particular case is highly circumstantial and can be criticised on methodological grounds since it implies a desire to associate constructions with historical personalities and/or events. Randsborg may be correct, but there is no need to press the case to this extent.

3.10 Parallels for a ghost city: Nea Krane and Greek urban planning

Randsborg's proposed early Hellenistic date for Nea Krane appeared to be supported by the elongated shape of the city blocks (where he identified a ratio ranging from 1 : 4 to 1 : 6). In this respect, Nea Krane conforms to the Early Hellenistic fortress city in the typology of Hoepfner and Boessneck, which they considered being probably modelled on military camps.[254] Randsborg's plan, however, shows residential blocks of different lengths in different rows, a feature which does not conform to the Early Hellenistic fortress model, nor indeed to the cases which he cites as parallels (see below). Randsborg's proposition can now be re-examined by comparing the extended and revised map of Nea Krane realised with aerial photographs with those of other Greek planned cities, including interesting new data from prospections and remote sensing in the central and western Peloponnese, noting especially Mantineia and Elis.[255]

The new information available for Nea Krane, and in particular the new east–west roads creating residential blocks of 100 x 33 m, calls into question the claim that the city conforms to this particular Early Hellenistic model simply because of the elongated shape

[253] Randsborg 2002, vol. 2, pp. 32 and 304–307.
[254] Hoepfner et al. 1994.
[255] Donati and Sarris 2016.

of the blocks. The claim can also be criticised on methodological grounds, since recent data from Peloponnese show how varied the shape of blocks can be, with the same ratio recurring in completely different periods.[256] In fact, if we follow Randsborg in using block shape, and in particular the ratio between width and length, as a criterion, then the 'fine general parallel' identified by the author[257] between Nea Krane (ratio 1 : 3) and Halos (ratio 1 : 6)[258] (from 302 BC) can no longer stand. The general similarities proposed with Goritsa (ratio 1 : 5)[259] and Demetrias (ratio 1 : 2)[260] do not fit the new data either. Interestingly, if we pursue Randsborg's methodology using the newly established ratio of 1 : 3 for Nea Krane, the closest parallel appears to be the Kephallonian polis of Same (also 1 : 3), the replanning of which is dated by Randsborg to the Late Classical period (with secure archaeological corroboration). Elsewhere, looking just at the Peloponnese, there is a parallel in Stymphalos in Arcadia, with its system of blocks of 100 x 30 m, dated to the mid fourth century.[261] Even Tegea (75 x 25 m), the planning of which is at present dated in the sixth century, looks like a suitable candidate.[262] All in all, the geometric relationship between the sides of residential blocks is insufficient evidence to assign a planned city to a certain type.

It is, however, interesting to compare the new map of Nea Krane with data recently obtained for Hellenistic Sikyon. Geophysical prospection, surface survey, and excavation by the University of Thessaly have revealed the orthogonal planning of a city founded by Demetrios I Poliorketes following his destruction in 303 of the previous settlement in a

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[256] Donati and Sarris 2016, p. 394.
[257] Randsborg 2002, vol. 2, p. 299.
[258] Blocks of 600 x 100 f., based on the Athenian foot of 31.5 cm: Reinders 1988.
[259] Blocks of 500 x 100 f., based on the Doric foot of 32.8 cm: Randsborg 2002, vol. 2, fig. X. 2.
[260] Blocks of c. 100 x 50 m: Hoepfner et al. 1994, p. 356.
[261] Donati and Sarris 2016, p. 393.
[262] Ødegård 2005.

lower valley. Investigations have brought to light a system based on square blocks with sides of approximately 60 m.[263] Notwithstanding this difference, we can recognize in Sikyon the fundamental traits of Nea Krane, notably a grid strictly following the cardinal points and not the geomorphology of the territory (an approach typical of the Hellenistic period), along with an extreme regularity and a tendency to create square blocks or plots. All of these elements, typical of Hellenistic urban planning,[264] can be found in Nea Krane. The rigid orientation along the cardinal points has already been explained, along with the regular creation of blocks of 33 x 100 m in the entire planned city as mapped from the aerial photographs. The square plots have been identified by Randsborg, with minor traces of the divisions separating each block into 12 plots measuring 16.5 m on each side.[265] The presence of all these elements together provides a much more reliable basis for a date in the early Hellenistic period that reliance upon the shape of city blocks, as it fits trends widely recognisable across Greece. An example of this trend can be seen for example at Demetrias,[266] with its roads with rigid north-south and east-west orientation and square plots with 25 m sides (eight plots per block).

3.11 Krane and the other planned cities in the Central Ionian Islands

Nea Krane was not the only planned city in the central Ionian islands. Further examples of orthogonal planning are found at the colonial city of Leukas and in other poleis on Kephallonia (at Same and at modern Poros, the port of Pronnoi). Leukas, a Kypselid

[263] Lolos, Gourley, and Stewart 2007; Lolos and Gourley 2011. The results of the Sikyon survey have recently been published in Lolos 2021.
[264] Greco and Torelli 1983, pp. 317–394, quoted in Donati & Sarris 2016, p. 393.
[265] Randsborg 2002, vol. 2, p. 299.
[266] Hoepfner et al. 1994, p. 394.

foundation of c. 630 BC, may be treated briefly as it belongs within an earlier tradition of Corinthian colonial planning. As many rescue excavations have confirmed,[267] the city plan featured *insulae* measuring 120 x 30 m, internally divided to form two rows of eight equally sized (15 x 15 m) plots. Preserved building phases date from the Archaic to the Hellenistic period.[268] The city plan is similar to that found in other contemporary Corinthian colonies including Ambracia and the second wave of foundations on Sicily.[269]

[267] Andreou 1998.
[268] Fiedler 2013.
[269] Andreou 1998, pp. 147–155.

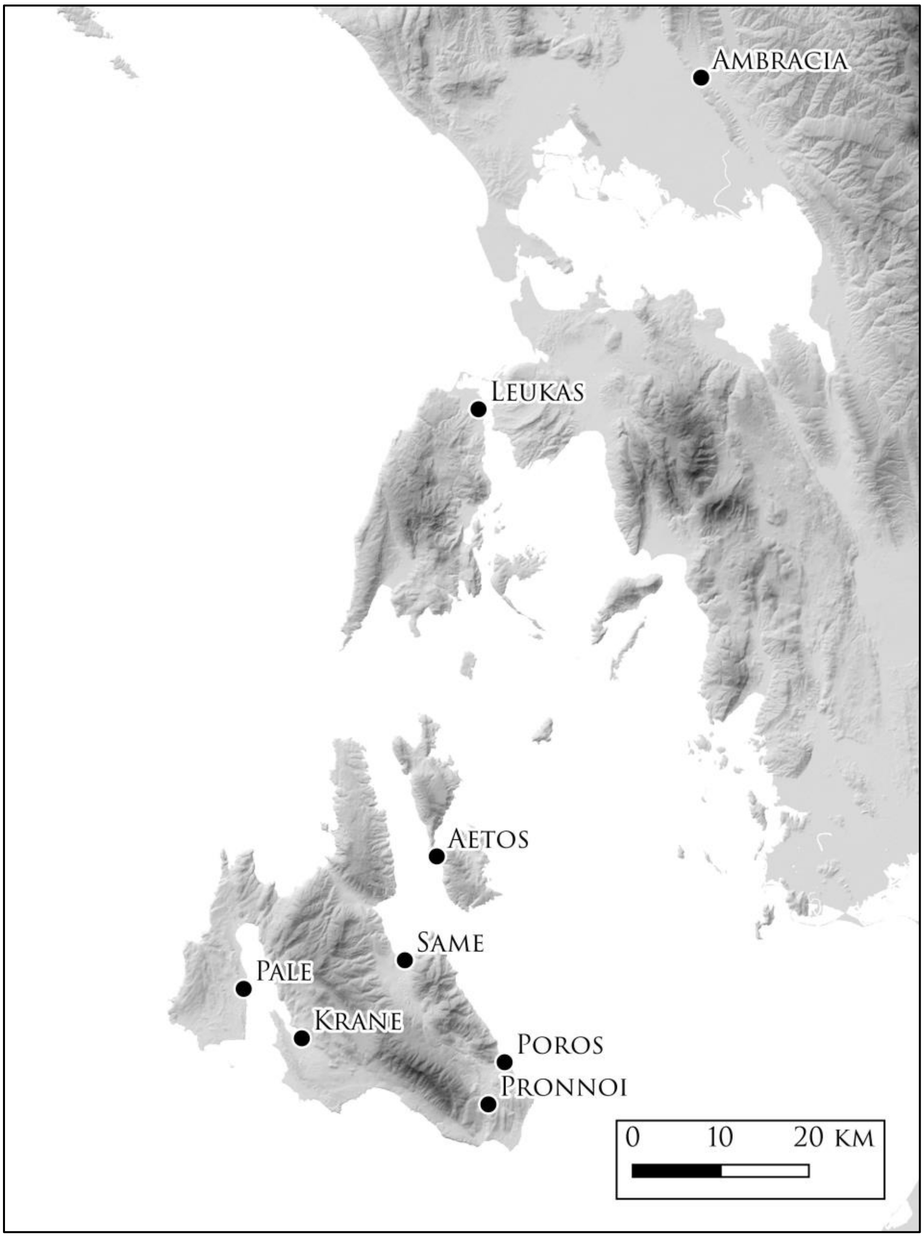

Figure 25: Central Ionian Island, with mentioned locations.

Moving to Kephallonia ***(fig. 29)***, the Late Classical plan of Same (*c*. 375 BC) was orthogonal, with blocks of 89 x 30 m (ratio 1: 3) divided into square plots of 14.8 x 14.8 m.[270] Traces of orthogonal planning have also been identified in the coastal town of Poros,

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[270] Randsborg 2002, vol. 2, fig. X. 2; maps in vol. 1, pl. D LII–D LXI.

with a proposed date of *c.* 300 BC, but they are too slight to propose a model.[271] While Klavs Randsborg does not exclude the possibility that further Early Hellenistic planned cities may have existed (or at least been projected) on the Palaikastro acropolis of Pronnoi and at Aetos on Ithaki, no traces of orthogonal planning have yet been identified on either site.[272] The fourth city of the Kephallonian tetrapolis, Pale, is extremely poorly preserved not least because its remains were used in the construction of modern Lixouri.[273]

The Kephallonian tetrapolis is an interesting example of four non colonial cities on a single island. Three of these four poleis preserve traces of orthogonal urban planning. The earliest, late Classical Same, is a large centralised walled settlement connected to a port and thus to the activities of a merchant fleet: while there are farmhouses in the *chora* outside the walls,[274] a substantial share of the population evidently lived in the city centre. The laying out of the planned city does not appear to have been a disruptive event, but was rather an extension of previous settlement growth which allowed for the continued exploitation of its harbour. The case of Poros is of particular interest given the closeness of its proposed date to that of Nea Krane. The town functioned as Pronnoi's main outlet to the sea,[275] and (like Nea Krane) is close to the slopes of Mt. Ainos and its fir forests which seem to have been the city's main economic resource.

[271] Randsborg 2002, vol. 2, pp. 299–301

[272] Detailed geomorphological analysis of the area in a 3D GIS environment through satellite generated elevation data (as detailed in the introduction) leads us to exclude the existence of an orthogonally planned settlement in Aetos. This is also matched by the absence of structures connected to such a development as evidenced in the cleaning of the area by the Greek Archaeological Service.

[273] Sotiriou 2010, p. 100.

[274] Sotiriou 2010, p. 99.

[275] A second may be Kato Katelios, although archaeological finds published to date are Roman: Randsborg 2002, vol. 2, p. 55.

In short, the Early Hellenistic period saw the development of two planned cities, both connected to the exploitation of the Kephallonian fir for shipbuilding. Investment in the defensive and urban infrastructure of the poleis of Krane and Pronnoi fits in the context of the politics of the New Corinthian League (of which the central Ionian islands were part).[276] Nea Krane and the planned city at Poros show how the islands, and Kephallonia in particular, engaged with early Hellenistic trends in urban development, as seen also at Halos, Goritsa and Demetrias.

[276] For a political narrative of the early Hellenistic period, see Boehm 2018, pp. 29–88, with bibliography.

4. NEW CENTURIAL GRIDS IN THE AREA OF NIKOPOLIS

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4.1 The grids

i. Grid 1

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ii. Grid 2

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iii. Grid 3

The text originally presented here cannot be made freely available via ORA because of legal restrictions.

4.2 Identification

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4.4 The centuriation(s) of Nikopolis

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4.5 *Limitationes* and their 'limits': centuriation in the scientific debate.

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4.6 Analysing the grids

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Table 27: Catalogue of Allied photographic material from the library of the British School at Athens covering the area of this case study						
ID	**Sortie**[277]	**Date**	**Altitude**	**Focal Length**	**Scale of positives**[278]	**Frame numbers**[279]

[277] Sortie, date, altitude and focal length are read from the identifying frisket of each frame.
[278] Calculated from the relation between altitude and focal length, as in Piccarreta 1987, pp. 221–227. A ground elevation of less than 200 masl is deemed irrelevant for the purposes of this study.
[279] When a sequence of frames is expressed as '3007 – 3010', this means that the sequence has a forward overlap of at least 70%, due to the geomorphology of the site: Piccarreta 1987, 55-56.

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Table 28: Catalogue of photographic material from the Archive of the Geographic Service of the Hellenic Army

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4.7 Pre-processing

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4.8 Results of the visual study and metrological analysis

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4.9 Elements for an identification

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4.10 Future steps

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4.11 The grids in their context: the foundation of Nikopolis

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5. SETTLEMENT PATTERNS AND CONCLUSION

The previous chapters presented the methodology behind this study, the rationale behind the selection of focus areas for the acquisition of aerial photographs, and three case studies which illustrate the contribution of aerial imagery to the understanding of the *longue durée* history of the islands. Chapter 2 focussed on the interpretation of small scale features, which constitute the vast majority of the data retrieved from the interpretation of aerial imagery, providing possible interpretations in the absence of ground truthing. Chapters 3 and 4 focussed instead on large scale interventions of a kind often invisible on the ground. Investigation of the extension of the Early Hellenistic polis of Krane on Kephallonia, and study of the extent of the centuriation associated with the Roman foundation of Nikopolis in Epirus both benefitted from the contribution of remote sensing, and in particular of archival material. Chapters 3 and 4 also explored the potential of aerial photography to redress the imbalance in the archaeological record of the region, which still reflects past attention to the search for Homeric *topoi*, resulting in a relative abundance of data of the Late Bronze and Early Iron Ages. They thus show the strategic importance of remote sensing for the study of Classical and post-Classical landscapes, given a tendency for the most superficial remains to be those most visible in aerial photographs. These large scale developments were analysed in the framework of regional settlement patterns.

This chapter delineates selected settlement patterns and developmental trends (or their absence) on island and regional scales for the time periods covered by the case studies of chapters 3 and 4, elucidating how our knowledge and understanding is advanced by the contributions of aerial photography. Data are obtained from the georeferenced database of archaeological finds populated from a literature review (APPENDIX A, the structure of which was presented in chapter 1), and from the case studies considered in this thesis. Finally, conclusions are drawn concerning the importance of aerial imagery for the study of the landscape archaeology of the region, with discussion of possible future directions of research.

5.1 Settlement patterns

i. Urbanism and orthogonal planning in the Ionian Islands

Nea Krane was not the only planned city in the central Ionian islands. Further examples of orthogonal planning are found at the colonial city of Leukas and in other poleis on Kephallonia (at Same and at modern Poros, the port of Pronnoi). Leukas, a Kypselid foundation dating *c.* 630 BC (Strabo 7.7.6, 10.2.8), may be treated briefly as it belongs within an earlier tradition of Corinthian colonial planning. As many rescue excavations have confirmed,[280] the city plan featured *insulae* measuring 120 x 30 m, internally divided to form two rows of eight equally sized (15 x 15 m) plots. Preserved building phases date from the Archaic to the Hellenistic period.[281] The city plan is similar to that found in other contemporary Corinthian colonies including Ambracia and the second wave of foundations on Sicily.[282]

[280] Andreou 1998.
[281] Fiedler 2013.
[282] Andreou 1998, pp. 147, 155.

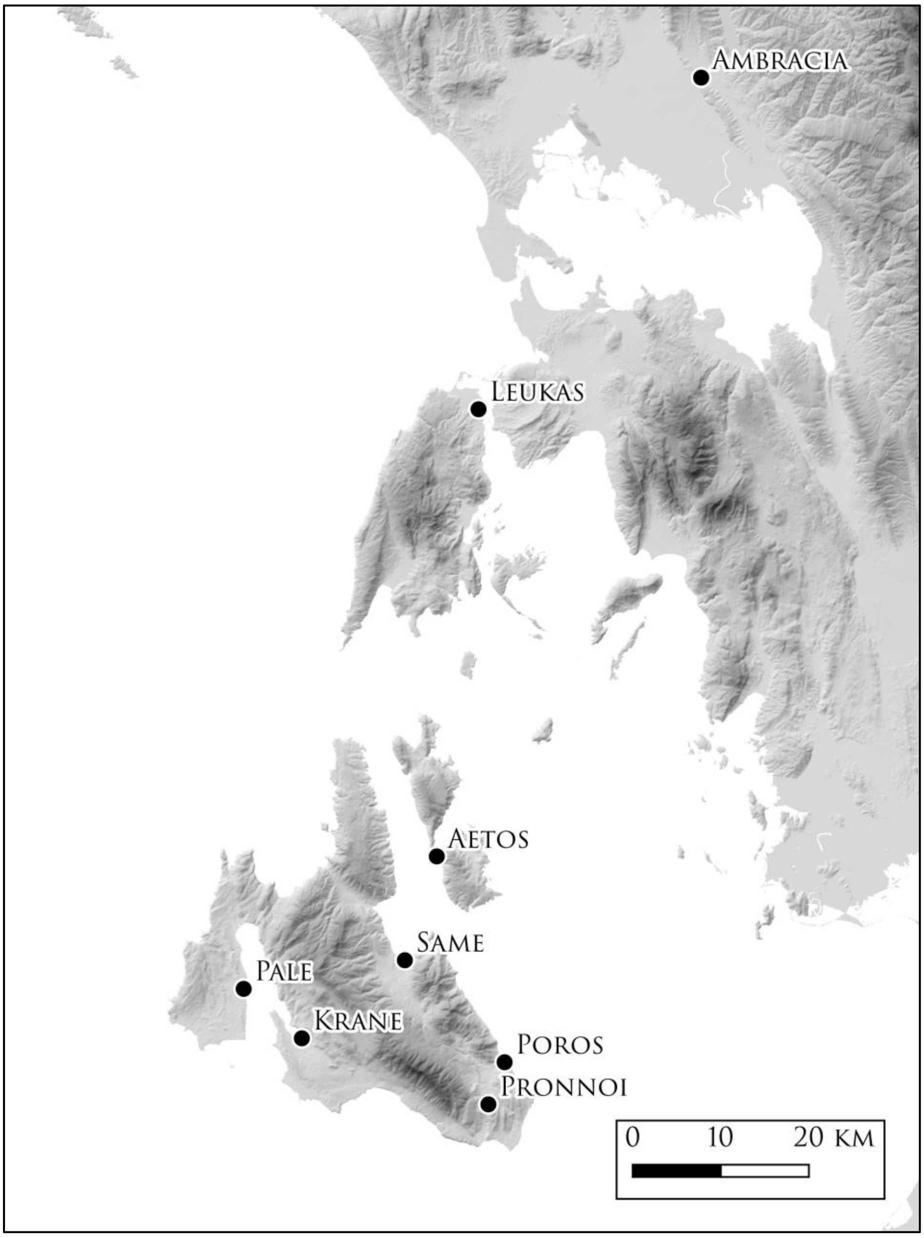

Figure 26: Central Ionian Island, with mentioned locations. ASTER DEM is a product of METI and NASA.

Moving to Kephallonia, the Late Classical plan of Same (*c.* 375 BC) was orthogonal, with blocks of 89 x 30 m (ratio 1 : 3) divided into square plots of 14.8 x 14.8 m.[283] Traces of orthogonal planning have also been identified in the coastal town of Poros, with a

[283] Randsborg 2002, vol. 2, fig. X. 2; maps in v. 1, pl. D LII – D LXI.

proposed date of *c.* 300 BC, but they are too slight to propose a model.[284] Yet with a settlement area of almost 40 ha currently attested, in an entire walled area of almost 144 ha, Nea Krane had the potential to be one of the largest walled cities in Greece after Demetrias,[285] depending on how much of the walled area was actually settled. For comparison, Early Hellenistic Leukas, which occupied the entire area within the walls, covered *c.* 100 ha.

While Klavs Randsborg does not exclude the possibility that further Early Hellenistic planned cities may have existed (or at least been projected) on the Palaikastro acropolis of Pronnoi and at Aetos on Ithaki, no traces of orthogonal planning have yet been identified on either site. The fourth city of the Kephallonian tetrapolis, Pale, is extremely poorly preserved not least because its remains were used in the construction of modern Lixouri.[286]

The Kephallonian tetrapolis is an interesting example of four non colonial cities on a single island. Three of these four poleis preserve traces of orthogonal urban planning. The earliest, late Classical Same, is a large centralised walled settlement connected to a port and thus to the activities of a merchant fleet: while there are farmhouses in the *chora* outside the walls,[287] a substantial share of the population evidently lived in the city centre. The laying out of the planned city does not appear to have been a disruptive event, but was rather an extension of previous settlement growth which allowed for the continued

[284] Randsborg 2002, pp. 299–301.
[285] On the urbanistic development of Demetrias, see Marzolff 1994.
[286] Sotiriou 2010, p. 100.
[287] Sotiriou 2010, p. 99.

exploitation of its harbour. The case of Poros is of particular interest given the closeness of its proposed date to that of Nea Krane. The town functioned as Pronnoi's main outlet to the sea,[288] and (like Nea Krane) is close to the slopes of Mt. Ainos and its fir forests which seem to have been the city's main economic resource.

In short, the Early Hellenistic period saw the development of two planned cities, both connected to the exploitation of the Kephallonian fir for shipbuilding. Investment in the defensive and urban infrastructure of the poleis of Krane and Pronnoi fits in the context of the politics of the New Corinthian League (of which the central Ionian islands were part). Nea Krane and the planned city at Poros show how the islands, and Kephallonia in particular, engaged with early Hellenistic trends in urban development, as seen also at Halos, Goritsa, and Demetrias.

New data from the activities of the Greek Archaeological Service also confute the observation of Gallant that "from the Krane area, once again, there is a disquieting lack of habitation sites, due primarily to the fact that the type of research done in the area was amenable to locating only highly visibly obtrusive sites - tholoi, temples, etc., and not unobtrusive habitation sites",[289] with a settlement now identified on the slopes of the hills of Kastelli and Pezoules.[290]

ii. Roman centuriations and the development of the islands after the foundation of Nikopolis

[288] A second may be Kato Katelios, although archaeological finds published to date are Roman: Randsborg 2002, v.2, p. 55.
[289] Gallant 1986, p. 158.
[290] Sotiriou 2013.

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5.2 The contribution of aerial photography to the study of landscape archaeology in the Central Ionian Islands

i. The importance of aerial photography

This thesis aimed to answer the following research questions:

1. Can remote sensing make a contribution to the study of landscape archaeology in the Central Ionian Islands?
2. Can aerial photography contribute towards redressing the historical imbalance in the archaeological record, skewed towards the Late Bronze Age and Early Iron Age?
3. What sort of features of archaeological interest can be retrieved from the study of archival aerial imagery, and how is it possible to maximise the amount of data obtained from such study?
4. How may we provide possible interpretations for features retrieved exclusively from the analysis of aerial photographs and often no longer visible on the ground?
5. What are the peculiar potentials and limitations of the archaeological use of archival aerial imagery made for military purposes?

Can remote sensing make a contribution to the study of landscape archaeology in the Central Ionian Islands?

This thesis reveals a significant contribution brought by remote sensing to the study of landscape archaeology in the Central Ionian Islands. Three case studies were presented, showing the potential of aerial imagery to reveal features of different scale, chronology, and historical significance. Photographic material dating to the 1940s proved to be of unique importance in this region as it predates a major earthquake in 1953 (and several successive episodes) which caused important geomorphological alterations. The massive emigration, and abandonment of fields and pastures which followed gave rise in turn to a dramatic change in land cover, with progressive afforestation.[291] The aerial images used in this thesis record landforms both before and after the earthquake. Agricultural exploitation first, and touristic development thereafter, have resulted in a dramatic change in land cover and the obscuring and in some cases obliteration of archaeological traces. The case study on the centuriation of Nikopolis discusses the impact of systematic farming and the installation of military facilities on the survival of archaeological traces. The case study on the Hellenistic city of Nea Krane details the changes in land cover from the 1940s until the 1980s and their effect on the visibility of archaeological remains. The case of Fiskardo would have addressed the problem of diminishing preservation and access due to the rapid expansion of settlement attracted by the touristic potential of the port. Comparison of flights dating to different decades is of high interest for the study of the consequences of touristic development for the preservation of ancient remains.

Can aerial photography contribute to redress the historical imbalance in the archaeological record, skewed towards the Late Bronze Age and Early Iron Age?

The tendency of remote sensing to display more superficial layers allowed us to address imbalances in the available archaeological record in different ways. The case studies presented in chapters 3 and 4 examine large-scale landscape interventions (dating to the Hellenistic and Roman period) of kinds which are not easy to identify and/or read in full on the ground. Elsewhere, aerial imagery allows us to focus on later periods which have attracted relatively little attention in the archaeological literature. Aerial photographs

[291] Grandazzi 1954.

record a number of features of high interest for demographic and anthropological studies, portraying aspects of the landscapes which pre-date the 1953 earthquake and ensuing reconstruction and redevelopment. The case study of Meganisi details a number of such features, advancing possible interpretations based on data from land survey, ethnographic studies, and topographical sources. A modern date is proposed for the features (largely for water-capture) recorded in chapter 2. The case study on Nea Krane illustrates a number of linear features for which a possible identification as post-antique terraces was provided. The case study on Fiskardo would have moved from the study of traces visible in aerial imagery and finds from a small-scale survey to shed light on the life and development of a Roman settlement and its evolution through Late Antiquity resulting into the construction of an Early Byzantine Basilica, providing also information on the trends of imports in this settlement strategically located on the naval route to Nikopolis. While rescue excavation has revealed significant features of a port centre strategically located on the naval route to Nikopolis, the location of the town's wider population (and trends in imports in that settlement) have yet to be considered. In the same way, the implications of the construction of a large early Byzantine basilica, in terms of the existence (and scale) of local population can effectively be explored in the first instance by combining the study of historical aerial imagery with terrestrial prospection.

Numerous other features are visible in aerial imagery and occasionally in contemporary georeferenced orthophotographs and satellite imagery. The detailed study of such structures (or traces thereof) goes beyond the aims and possibilities of this thesis and would have required a substantially larger acquisition of aerial imagery from the Photographic Archive of the Geographic Service of the Hellenic Army. However, it holds great potential: for example, study of terracing in the Central Ionian Islands could be of interest to scholars of the Early Modern period, as certain such features could potentially be matched with those portrayed in Venetian cartography preserved in the National Archive of Venice.[292]

What sort of features of archaeological interest can be retrieved from the study of archival aerial imagery, and how is it possible to maximise the amount of data obtained from such study?

This thesis showed the potential of aerial imagery to display features on various scales, ranging from large-scale interventions invisible on the ground to small features often since covered by vegetation or modern development. This thesis also shows the importance of using a variety of techniques for the study of aerial imagery, to maximise the amount of data retrieved. Chapter 3 details the strategic use of the stereoscope (in conjunction with photographs selected to artificially inflate the impression of three-dimensionality) to gauge the existence or lack of elevation for features observed in aerial imagery. Possible interpretations for the varied appearance of features in the context of their supposed archaeological history are also provided. Chapter 4 explored the use of automated extraction of features through edge detection algorithms and the computer-based selection of features aligning to given angles.

[292] The cartography available under the following collections has been surveyed: Provveditori alle Fortezze, Provveditori da Terra e da Mar, Provveditori alla Sanità, Inquisitori di Stato, Fondo Schulemburg.

How may we provide possible interpretations for features retrieved exclusively from the analysis of aerial photographs and often not visible anymore on the ground?

This thesis stressed the importance of an approach based on the combined study of features retrievable from aerial imagery with ethnographic and archaeological data from a variety of sources. Chapter 2 used data from the land survey of the Inner Ionian Archipelago Project to provide a possible date for a number of small-scale features. Data from anthropological and ethnographic studies also provide a possible identification for several such features as structures for water capture. Chapter 4 used archaeological data from Roman farmsteads excavated by the Greek Archaeological Service in Lefkada to provide archaeological support for the identification of a Roman centurial grid otherwise entirely based on metrological criteria. The case study on Fiskardo would have hinged on a detailed study of finds from a small-scale survey aiming at providing dates and possible interpretations for the structures seen in aerial imagery. Together, these various forms of ground-truthing aimed to create interpretations or ranges of possible interpretations which are sufficiently robust to be applied as working hypotheses in cases where ground observation is not possible. Thus in chapter 2, features characterised on Meganisi were also identified on Ithaki, Kalamos, and Kastos.

What are the peculiar potentials and limitations of the archaeological use of archival aerial imagery made for military purposes?

Military aerial imagery revealed a unique potential for the study of the Central Ionian Islands. Firstly, it is the only type of photographic material available with a virtually uninterrupted continuity of coverage from the 1940s to date. The quality of the imagery varies, and often the scale is sub-optimal for the detailed interpretation of features of small scale. A great limitation is of course the existence of peculiar restrictions on access to coverage of areas deemed to be of strategic importance. Both chapters 3 and 4 showed such limitations, with areas removed from the coverage for the harbour of Argostoli and the airport of Preveza on the Aktion peninsula.

ii. The role of historical aerial photographs among remote sensing techniques

This thesis has thus demonstrated the key place that the study of historical aerial photographs may have among remote sensing techniques. Firstly, its potential to document patterns of landscape and land cover changes through several decades, detailing the dynamic interaction between anthropic transformations and the visibility of traces related to features of potential archaeological interest. Aerial photography is often the only source of detailed visual material for the study of landscape developments prior to the development of drone and satellite generated coverage. In the Mediterranean, historical aerial photographs display changes in settlement, land use, migration, and the impact of war. The timespan pre-dating the development of satellite generated coverage is therefore a crucial period on which to find data. Secondly, aerial photography provides a recurring (even if not uniform) coverage of large areas, with variations of scale among sorties but suitable for comparative study and for the investigation of patterns. There are nevertheless limitations due to the strategic nature of the coverage, with certain zones being privileged for sorties (airfields, railways, telegraph lines, etc.) above others, generating a non uniform representation of some sections of the landscape investigated. Satellite generated imagery until very recently did not have the necessary resolution for detailed investigation, while drone generate coverage tends to create imagery of considerably higher resolution for smaller areas. Thirdly, the relative availability of historical aerial photography (such as in the archives of the British School at Athens and of the Geographic Service of the Hellenic Army) makes it a promising potential source of material for projects with limited resources. Fourtly, technological developments allow researchers now to extract a substantially higher amount of data from these images. Even few decades ago, softwares able to stitch together images and reconstruct strips were not as available and accurate as today, while the development of skeletonisation algorithms and proedures to isolate features according to their orientation allows to extract and isolate features more effectively.

5. 3 Possible future research developments

i. A dangerous landscape

Discussion of the physical geography of the islands in the introduction noted that they are mainly constituted of secondary limestone formations,[293] the kind of permeable rocks directly connected to karstic phenomena. The significance of this geological environment -and its impact on the availability and the quality of water- was further explored in the methodological case study on the island of Meganisi (chapter 2). That study also stressed the importance of the high level of rainfall in the region (which is two to three times more than in continental Greece).[294] Furthermore, the Central Ionian Islands are located exactly along the Hellenic Trench, an area showing the greatest seismicity in the entire Mediterranean region,[295] with recurring events of high magnitude due to the subduction of the African plate towards the northeast and the continental collision of the Apulian platform with the Eurasian plate.[296] Recent studies on Lefkada and Kephallonia have

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[293] Thiry 1998, p. 5.

[294] The highest peak of rainfall is on the island of Kerkyra: Branigan and Jarret 1978, 336, quoted in Souyoudzoglou-Haywood 1999, 5. For more recent studies of precipitation in the Ionian Islands, see Nastos and Zerefos 2010 with bibliography.

[295] Papathanassiou, Pavlides, and Ganas 2005, p. 13.

[296] Vött 2007, pp. 895–897.

demonstrated how soil liquefaction during earthquakes enhances the destructive potential of seismic events.[297] Frequent tectonic movements also contribute to a constant modification of landforms,[298] generating slow but continuous changes (subsidence and uplift) in the environment.

ii. Old phenomena and new risks

The relevance of these phenomena for research into, and management of, archaeological heritage in the region has been already proved. As early as 1985, King and Bailey studied the effects of accumulated uplift connected to seismic activity over the reconstruction of palaeoenvironments in Epirus, the mainland region immediately north the archipelago.[299] More recently, the Zakynthos Archaeology Project of the University of Amsterdam investigated the impact of episodes of seismic activity on the visibility of archaeological finds during survey.[300] Currently, a new set of potential problems may arise as a consequence of climate change: rising sea level, increased extreme meteorological phenomena, and a higher risk of fires during the summer season due to increased temperatures. All of these pose new threats to the preservation of the archaeological heritage.

The impact of climate change is a topic of rising importance in the field of cultural heritage,[301] and it aligns with the strategic priorities of the Greek Ministry of Culture.[302] The threat is even more real because these new dynamics operate on a region already subject to intense geomorphological phenomena, as exemplified in the case of the

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[297] Papathanassiou, Pavlides, and Ganas 2005; Valkaniotis et al. 2014, with bibliographies.
[298] Ganas et al. 2012.
[299] King and Bailey 1985.
[300] Tendürüs, van Wijngaarden, and Kars 2010.
[301] Cassar 2016; Dawson et al. 2020.
[302] Sakis 2019.

archaeological site of Vasilikos-Kaloyeros on Zakynthos, situated on a cape heavily affected by erosion and as a result now fast disappearing.[303]

This thesis contains a geospatial database of archaeological sites across the archipelago which would be an excellent starting point to carry out an assessment of their level of risk and a simulation of the impact of each phenomenon. Advanced geospatial modelling could be used for this.

Concrete research steps would be:

1. Analysis of the database of sites over the 3D geospatial model built from open source satellite data.
2. Preliminary assessment of the level of risk of sites due to:
    a. Rising sea levels;
    b. Coastal erosion;
    c. Increased extreme phenomena;
    d. Fire hazard.

This assessment would take into account the resolution of the digital elevation model (30 m / pixel).

3. List of areas and sites with significant risk factors.
4. Sourcing better digital elevation data:

[303] Stein and van Wijngaarden 2012.

a. Commercial satellite data (the quality of data sold by Boeing is 30 or 60-fold better than the opensource ASTER DEM and EU DEM data available for Greece and used for this thesis);
b. Drone data, either generated from LiDAR or a digital elevation model realised through photogrammetry.

5. Having acquired high-quality data, a new high-definition 3D digital elevation model would be built in GIS, on which a simulation of impacts would be carried out.

Table 29: List of risk factors and impact simulation procedure in a high-definition 3D digital elevation model.

Risk factor	**Impact simulation procedure**
Sea Level Rise (SLR) above the Mean Sea Level (MSL).	Model of Potentially Inundated Areas.[304]
Coastal erosion	Coastline erosion and accretion predictive modelling.[305]
Increased extreme phenomena.	Water distribution modelling, through advanced computation and simulation of drainage basins and channels.
Fire hazard.	Extraction of forest areas through the automated comparison of satellite or drone-generated surface model and terrain model.

[304] Malik and Abdalla 2016.
[305] Hashmi and Ahmad 2018.

6. The analysis would result in a detailed assessment of the potential impact of every risk factor on each site close to an estimated hazard.

Research outcomes:

1. A valuable instrument for the protection of cultural heritage, to be shared with relevant stakeholders (Greek Archaeological Service, local authorities, archaeological missions working in the region);
2. Methodological case study on the regional impact of climate change, part of a field of research of rising importance.
3. Acquiring detailed geospatial data for this project (such as LiDAR coverage) would also support further research to locate and/or fully document archaeological remains currently not visible on the ground. For example, analysis of aerial photographs for the small peninsula immediately north of Fiskardo (Kephallonia) resulted in the detection of a number of features of high interest. This case study was interrupted due to the effects of the Covid-19 pandemic. The acquisition of detailed elevation data (drone-generated in this case) would permit digital removal of the vegetation cover present in various areas which have yet to be systematically investigated or are not readily susceptible to terrestrial exploration. This may have particular impact on our understanding of the exploitation of uplands, a phenomenon likely of importance from Late Antiquity onwards.

iii. Possible new developments for aerial archaeology

This thesis has demonstrated the important role aerial archaeology and remote sensing can play in investigating landscape developments in the region. While the intrinsic time and funding limitations of a doctoral project have imposed constraints on the amount of material that could be gathered, consulted, and analysed , there is scope for further work on the subject.

1. Other possible sources of historical imagery such as the National Archives and Records Administration (NARA, Washington, USA), The Aerial Reconnaissance Archives (TARA, Edinburgh, UK), or other Departments of the Greek Government could be explored. This could be particularly valuable for the "target areas" of this thesis, zones demonstrating potential for medium and large-scale developments, often matched by the presence of significant settlements and finds.
2. The entire subject of the centuriations of the Roman colonies of Nikopolis and Patrae needs a global reassessment. In particular, the area between the two cities could be of interest.[306] Apart from historical aerial photography, multispectral satellite imagery revealed itself as a valuable source of data to spot surviving traces associated to centurial grids.[307] A renewed global mapping of centuriations across western Greece and northern Peloponnese could provide a useful background for the study of farmsteads and settlements occasionally discovered and published by the Greek Archaeological Service.
3. This thesis has focussed (with the exception of the case study on Meganisi in chapter 2) on large scale developments. This is clearly a consequence of the nature and scale of the historical aerial imagery consulted. Technological advancements would now allow the various archaeological projects active in the region to obtain incredibly more detailed coverage, such as the one generated with LiDAR. This

[306] See Petroupolos 2007.
[307] Codini, Donati, and Sarris n.d.

could potentially result in the retrieval of features of smaller scale. Commercial satellite imagery could also be acquired, exploiting the added benefits of capturing data across specific wavelength ranges.

4. The difficulty of exploring uplands in particular has meant that the archaeological record we have it is skewed to lowlands, ports etc. This thesis revealed two Hellenistic and Roman developments, again on lowlands and ports. Byzantine and Medieval use of uplands could be investigated through a different approach, combining the targeted analysis of historical aerial imagery with the acquisition of LiDAR coverage.

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PLATES

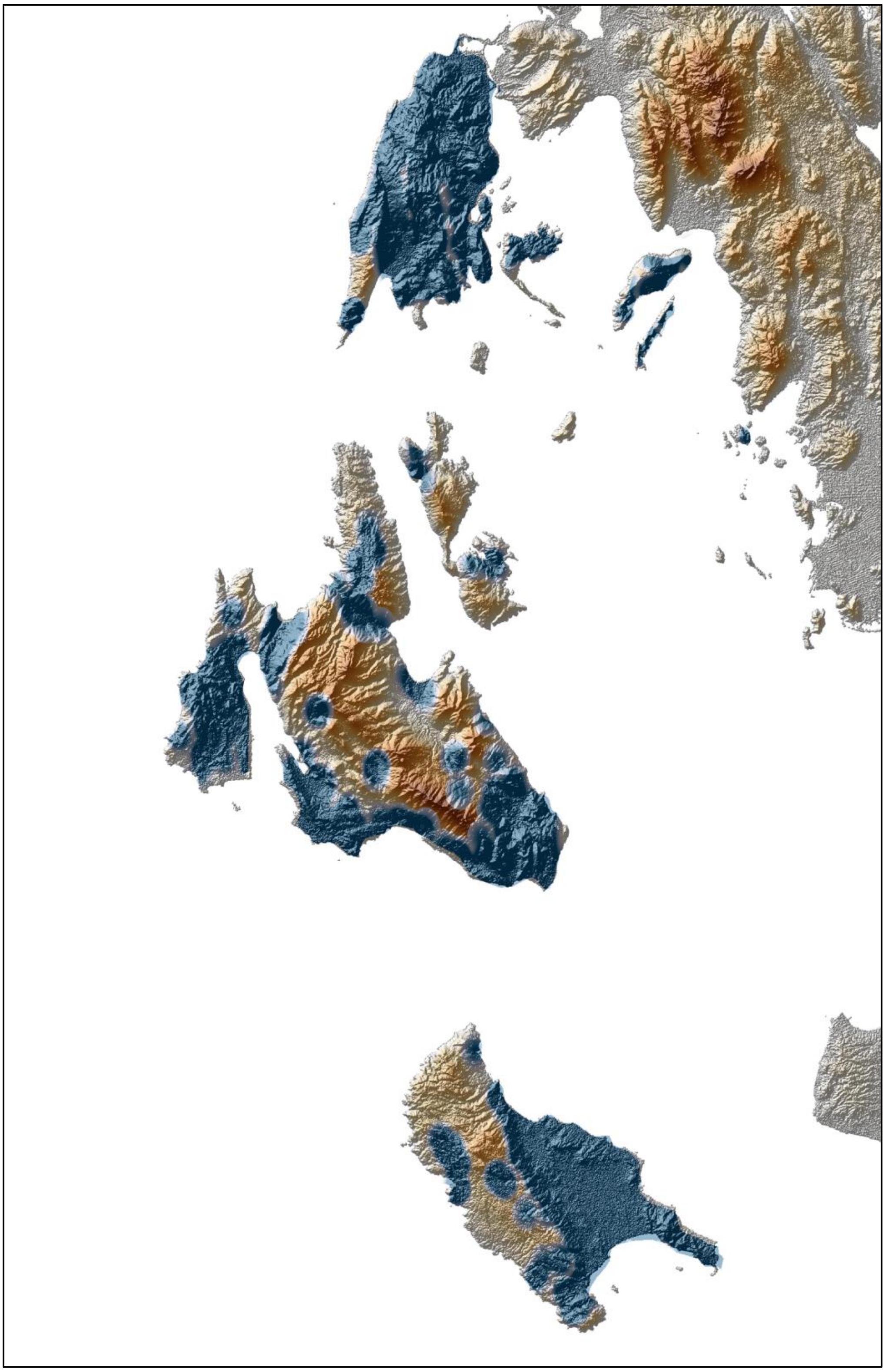

Plate 1: Model of availability of water across the islands, obtained from interpolation of water sources plotted by the Greek Army. ASTERGDEM is a product of METI and NASA.

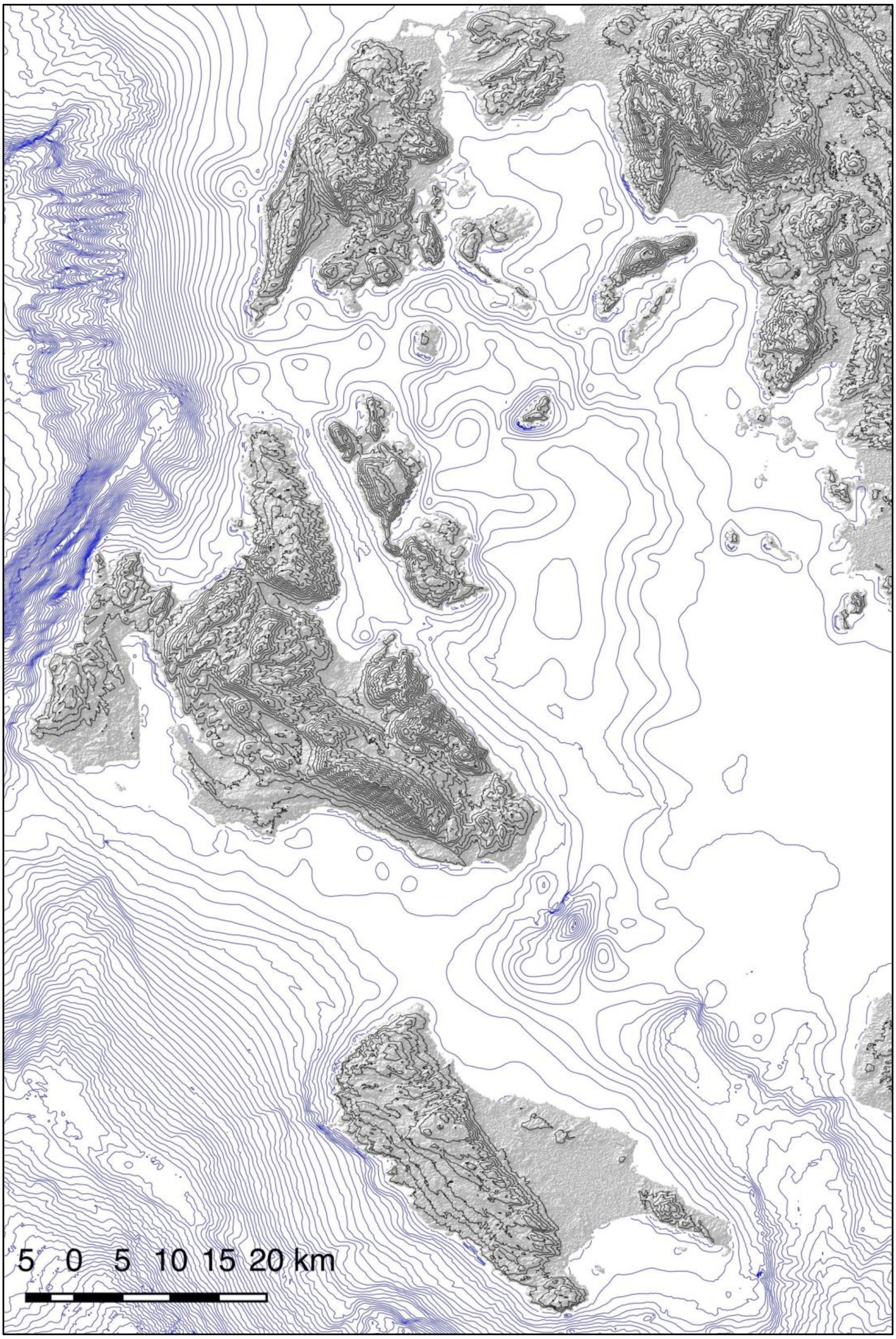

Plate 2: Terrain and bathymtetric contour lines. Land data are sampled with an interval of 100 mt, sea data are sampled at an interval of 50 mt. ASTERGDEM is a product of METI and NASA.

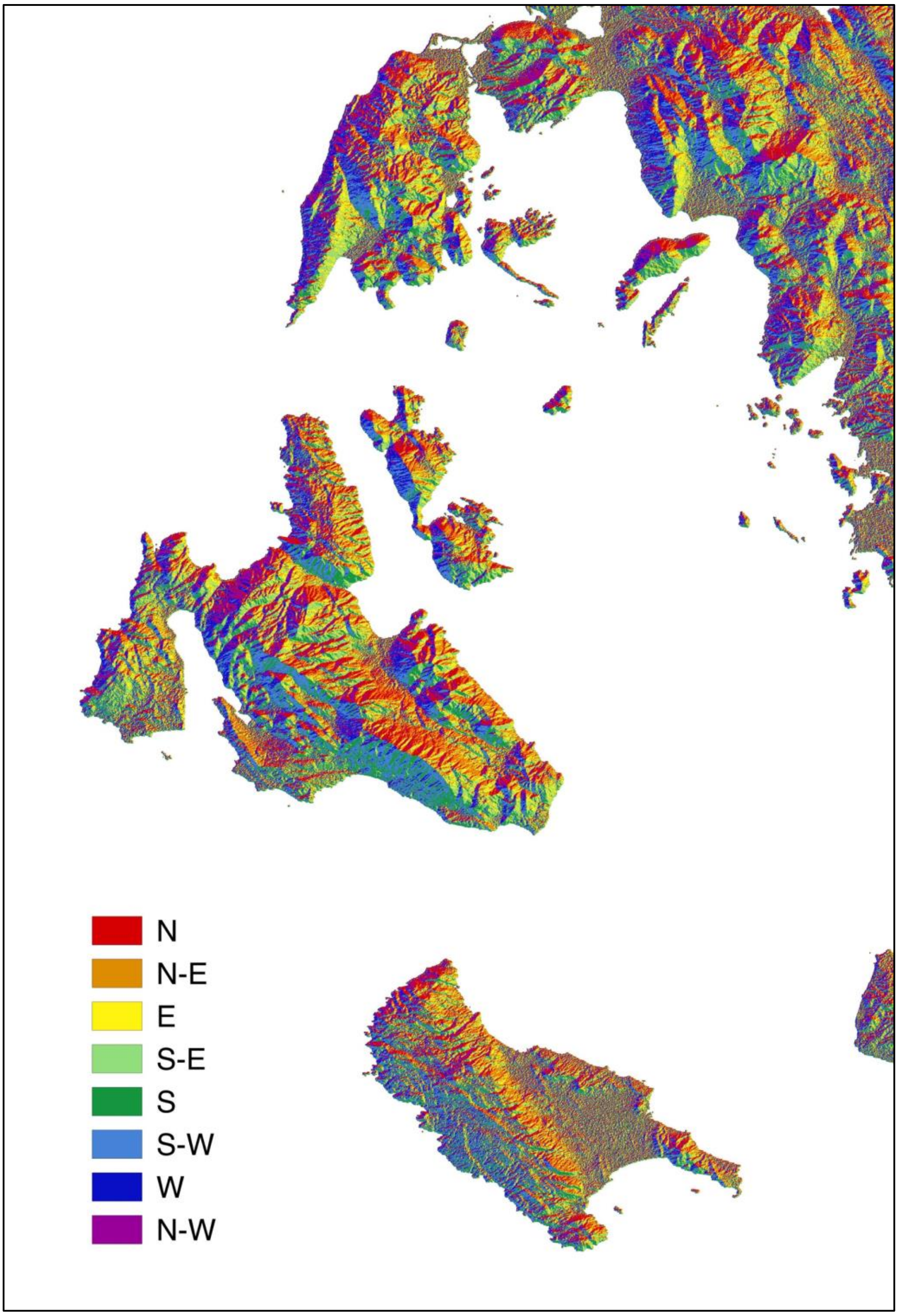

Plate 3: Modelling of aspect of slopes. Rendition after Chapman 2006. ASTERGDEM is a product of METI and NASA.

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Plate 4: Details of two GYS photographs for the area of Krane: top dates to 1972, scale of the original 1:15.000; bottom dates to 1978, scale of the original 1:15.000.

Plate 5: Details of two GYS photographs for the area of Krane: top dates to 23/06/1988, scale of the original 1:15.000; bottom dates to 02/07/1984, scale of the original 1:8.000.

Plate 6: The peninsula of Aktion, wih the positive cropmarks associated to grid 2. Detail of frame BSA L6 5011, 3rd January 1944. Reproduced with permission from the British School at Athens.

Plate 7: The peninsula of Aktion, wih the positive cropmarks associated to grid 2 enhanced in red. Detail of frame BSA L6 5011, 3rd January 1944. Reproduced with permission from the British School at Athens.

Plate 8: The peninsula of Aktion, with its military airbase and airfield removed from the photograph. Geographic Office of the Hellenic Army (GYS), frame 186-426, 13th June 1988.

Plate 9: The area of Ano Pounta wih the positive cropmarks associated to grid 3 in red. Another system of land division, with a different orientation is marked in green. Detail of frame BSA L6 5011, 3rd January 1944. Reproduced with permission from the British School at Athens.

Plate 10: Example of photomosaic of georeferenced images. Elaboration of frames (GYS) 8342, 8343, 8346, 8347. Year: 1964.

The image originally presented here cannot be made freely available via ORA because of legal restrictions.

Plate 11: Drawing of field boundaries as shapefiles in the area of the peninsula of Ano Pounta (grid 3). On the top image the boundaries are drawn on satellite imagery (Google Earth Pro, 31st December 2016). On the bottom image over frame BSA L6 5011, 3rd January 1944. Reproduced with permission from the British School at Athens.

Plate 12: Elaboration of the cropmarks of the peninsula of Aktion, with a module of 24 actus (black) and one of 12 actus (green). Frame BSA L6 5011, 3rd January 1944. Reproduced with permission from the British School at Athens.

Plate 13: Comparison of the visibility of the positive cropmarks of the centuriations of Nikopolis (top image, photomosaic of frames BSA L25 4059-60 24th September 1944) and the ones of grid 2 (frame BSA L6 5011, 3rd January 1944). Reproduced with permission from the British School at Athens.

Appendix A

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.01	Mt. Aenos	Cult	Sanctuary	Sanctuary of Zeus Aenesios, mentioned by Strabon X.2.15. Exact position unknown	-	-	Terminus ante quem, 24 AD	Literary source	Location unknown	-		Randsborg 2002, v.2, 54, L1; Partsch 1890, 88.
KEF.LR.02	Peratata	Cult	Monastery	Monastery of Agios Andreas Peratàton.	Venetian	17th century		Standing structure	Digital Orthophotographs			Randsborg 2002, L2; AD 26, 1971, 362.
KEF.LR.03	Peratata	Defence	Castle	Castle of Agios Georgios. Date foundation unknown, residence count Kephallonia, rebuilt by Venetians in 16th century.	Byzantine		Terminus ante quem 1085.	Standing structure	Satellite imagery		KEF.LR.3	Randsborg 2002, L3; Partsch 1890, 45-46 and 84,85; Soustal 1981, 154f.
KEF.LR.04	Homala	Cult	Monastery	Monastery of Agios Gerasimos.	Venetian		1570	Standing structure	Satellite		KEF.L.5	Randsborg 2002, L4;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Partsch. 1890, 88.
KEF.LR.05	Homala	Cult	Church	Church of Madonna of Jerusalem, under the Monastery of Agios Gerasimos (KEF.LR.4).	Frankish?		Terminus ante quem 1507	Accounts	Satellite imagery		KEF.LR.4	Randsborg 2002, L4.
KEF.LR.06	Skala	Concentration of finds	Spolia	Graves, mosaics and ancient structures in mortar walling	Roman?			Report	Scattered	Village		Randsborg 2002, Partsch 1890, 78
KEF.LR.07	Angon - Agia Kiriaki	Excavated structures	Mosaic	Roman mosaic pavement, reported by Kallipolitis. Reported by Andreas Sotiriou to Randsborg 2002,sborg	Roman			Excavation / reports	Village			Randsborg 2002, L6; AR 1961-1962, 13
KEF.LR.08	Svoronata, Agia Pelagia	Burial	Chamber Tomb	Two or three chamber tombs identified by Professor Iakovides, along with remains of Mycenean pottery near Hotel Irinna, no excavation was carried out.	Mycenean			Reports	Exact location unknown			Randsborg 2002, L7; S-H 39

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.09	Agios Ierousalim?	Excavated structures	Wall	Prehistoric wall at Agios Roussalim (sic!), possibly Agios Ieroussalim, north of Assos, natural harbour. Personal communication of Andreas Sotiriou to Randsborg 2002, team.	Prehistoric			Report	Exact location unkown			Randsborg 2002, L8
KEF.LR.10	Rachi	Defence	Fortress	Oval shaped fortress, peak of hill, built with rough block, measures about 70x35m. Prehistoric coarse ware found.	Prehistoric?			Survey	Georeferenced map < 1:100.000		KEF.LR.11	Randsborg 2002, L9; Randsborg 2002,sborg 2002, v.1, 34, site 211; Partsch 1890, 73.
KEF.LR.100	Kompomekrata	Burial	Graves	Three Hellenistic graves. Communication of Andreas Sotiriou to Klavs Randsborg 2002,sborg	Hellenistic				Village			Souyoudzoglou-Haywood 1999, 40

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.101	Kokkolata-Kouroupata	Concentration of finds	Pottery	Site found by Christina Souyoudzoglou-Haywood during fieldwork	EBA - LBA			Fieldwork	Village			Souyoudzoglou-Haywood 1999, 40
KEF.LR.102	Kokkolata-Kouroupata	Concentration of finds	Pottery	Phase of KEF.LR.101	EBA			Fieldwork	Village		KEF.LR.101	Souyoudzoglou-Haywood 1999, 40
KEF.LR.103	Kokkolata-Kouroupata	Concentration of finds	Pottery	Phase of KEF.LR.101	MBA			Fieldwork	Village		KEF.LR.101	Souyoudzoglou-Haywood 1999, 40
KEF.LR.104	Kokkolata-Kouroupata	Concentration of finds	Pottery	Phase of KEF.LR.101	LBA			Fieldwork	Village		KEF.LR.101	Souyoudzoglou-Haywood 1999, 40
KEF.LR.105	Kontogenada	Burial	Necropolis	LBA Necropolis excavated by Marinatos	LBA			Excavation	Village			Randsborg 2002, L36; Souyoudzoglou-Haywoo

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												d 1999, 43-44
KEF.LR.106	Kontogenada	Burial	Tholoi	Four tholoi in KEF.LR.105	LBA				Village		KEF.LR.105	Randsborg 2002, L36; Souyoudzoglou-Haywood 1999, 43-44
KEF.LR.107	Kontogenada	Burial	Pit graves	Pit graves in KEF.LR.106 (tholos A)	LBA				Village		KEF.LR.106	Randsborg 2002, L36; Souyoudzoglou-Haywood 1999, 43-44
KEF.LR.108	Kontogenada	Burial	Grave	Remains of a stone sarcophagus in KEF.LR.106	LBA				Village		KEF.LR.106	Randsborg 2002, L36; Souyoudzoglou-Haywood 1999, 43-44

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.109	Kontogenada	Concentration of finds	Pottery	Sherds and incomplete vases in KEF.LR.106 (tholos A)	LH III C				Village		KEF.LR.106	Randsborg 2002, L36; Souyoudzoglou-Haywood 1999, 43-44
KEF.LR.11	Rachi	Concentration of finds	Pottery sherds	Various PCW sherds, including handle.	Prehistoric			Survey	Georeferenced map < 1:100.000		KEF.LR.10	Randsborg 2002,sborg 2002, v.1, 34, site 211
KEF.LR.110	Kontogenada	Burial	Pit graves	Rock-cut pit graves excavated by Marinatos	LBA				Village			Souyoudzoglou-Haywood 1999, 44
KEF.LR.111	Korneli / Kornelos	Finds	Pottery	EH Ceramic	EH				Village	Village		Randsborg 2002, 55, L37
KEF.LR.112	Korneli / Kornelos	Finds	Pottery	MH Ceramic	MH				Village			Randsborg 2002, 55, L37

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.113	Korneli / Kornelos	Finds	Pottery	Roman Walling	Roman				Village			Randsborg 2002, 55, L37
KEF.LR.114	Korneli / Kornelos	Finds	Pottery	Church of Profitis Elias	Byzantine				Village			Randsborg 2002, 55, L37
KEF.LR.115	Krane	Finds	Pottery	LHIIIC seal-stone	LHIIIC				Village			Randsborg 2002, 55, 56 L37
KEF.LR.116	Krane	Finds	Pottery	Bronze Age hoard of fline blades and hand-made pottery	EH or MH, few LHIII fragments				Village			Randsborg 2002, 55, L37
KEF.LR.117	Krane	Finds	Pottery	Geometric pottery	Geometric				Village			Randsborg 2002, 55, L37
KEF.LR.118	Krane	Finds	Pottery	6th / 5th century graves	Archaic AND / OR Classical				Village			Randsborg 2002, 55, L37
KEF.LR.119	Krane	Temple		Doric Temple	Archaic				Village			Randsborg 2002, 55, L37
KEF.LR.12	Rachi	Defence	Fortress	Square fortress toward valley, 23 m down KEF.LR.10	Archaic			Survey	Georeferenced map < 1:100.000		KEF.LR.13	Randsborg 2002,sbo

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												rg 2002, v.1, 34, site 213
KEF.LR.120	Krane	Settlement			Classical				Village			Randsborg 2002, 55, L37
KEF.LR.121	Krane	Finds		Late Hellenistic dedications	Hellenistic				Village			Randsborg 2002, 55, L37
KEF.LR.122	Krane	Temple		Early Classical Temple on Eastern Acropolis	Classical				Village			Randsborg 2002, 55, L37
KEF.LR.123	Krane	Building	Stoa	Stoa in KEF.LR.122	Roman				Village			Randsborg 2002, 55, L37
KEF.LR.124	Krane	Graves		Hellenistic Graves	Hellenistic				Village			Randsborg 2002, 55, L37
KEF.LR.125	Krane	Fortification		13th century fortress on Western Acropolis	Byzantine	13th century			Village			Randsborg 2002, 55, L37
KEF.LR.126	Lakkethra	Burial	Grave	Two LHIIIB-C rock-cut graves	LHIII				Village			Randsborg 2002, 55, L37
KEF.LR.127	Lixouri	Finds	Sculptures	Roman sculptural remains in the area	Roman				Village			Randsborg 2002,, 55, L42

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.128	Mavrata	Burial	Tholos tomb	Mycenean tholos tomb	LH				Village			Randsborg 2002,, 55, L47
KEF.LR.129	Mazarakata	Burial	Tholos tomb	Tholos tomb	LHIII				Village			Randsborg 2002, 55, L37
KEF.LR.13	Rachi	Concentration of finds	Pottery sherds	Late Archaic pottery	Archaic			Survey	Georeferenced map < 1:100.000		KEF.LR.12	Randsborg 2002,sborg 2002, v.1, 34, site 213
KEF.LR.130	Mazarakata	Burial	Graves	16 rock-cut graves with 83 bodies	LHIII				Village			Randsborg 2002, 55, L37
KEF.LR.131	Mazarakata	Burial	Graves	Late Mycenean grave with two scheletons	Late Mycenean				Village			Randsborg 2002, 55, L37
KEF.LR.131	Mazarakata	Burial	Graves	Graves	Hellenistic OR Roman				Village			Randsborg 2002, 55, L37
KEF.LR.132	Melissani Cave	Cave Sanctuary		Pan and Nymphs	Hellenistic				Village	Satellite		Randsborg 2002, 55, L49
KEF.LR.133	Metaxata	Graves			LH				Village			Randsborg 2002, 56, L51

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.134	Metaxata	Finds	Pottery		Mycenean				Village			Randsborg 2002, 55, L37
KEF.LR.135	Metaxata	Finds	Pottery		Protogeometric				Village			Randsborg 2002, 55, L37
KEF.LR.136	Metaxata	Finds	Pottery		Geometric				Village			Randsborg 2002, 55, L37
KEF.LR.137	Metaxata	Finds	Pottery		Archaic				Village			Randsborg 2002, 55, L37
KEF.LR.138	Metaxata	Finds		Stelai	Classical				Village			Randsborg 2002, 55, L37
KEF.LR.139	Metaxata	Finds		Stelai	Hellenistic				Village			Randsborg 2002, 55, L37
KEF.LR.14	Agrinia	Burial	Tyle-covered tomb	Two tyle-covered burials (cappuccina) in the courtyard of the Monastery of Zodochou Pigis, near Agrinia.	Roman			Excavation	Satellite imagery			Randsborg 2002, L10; AD, 37, 1982, 152.
KEF.LR.140	Minias	Temple		Doric temple with architectural terracottas ascribed to	Archaic				Village			Randsborg 2002, 55, L37

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				a Corinthian workshop. Probably destroyed during construction of airport.								
KEF.LR.141	Oikopeda	Graves		Late Helladic Graves	Late Helladic	LH III			Village			Randsborg 2002, L56
KEF.LR.142	Pale	Polis		Polis of Pale	Late Archaic? to Classical	Minting from c. 480 BC		Site	Unknown	Unknown		Randsborg 2002, L56
KEF.LR.143	Parisata	Finds	Pottery	LHIIIA-B Mycenean tholos tomb	LHIII				Village			Randsborg 2002, L56
KEF.LR.144	Pastra	Burials	Stelai and graves	Referred by Sotiriou	Archaic and Classical				Village			Randsborg 2002, L56
KEF.LR.145	Pastra	Graves		Classical phase of KEF.LR.144	Classical				Village			Randsborg 2002, L56
KEF.LR.146	Spheterion near Sparties	Inscription		Inscription from the 4th century BC (BCH 47, 1923, 523).	Classical	4th century BC			Village			Randsborg 2002, L56

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.147	Fiskardo	Settlement			Paleolitic				Village			Randsborg 2002, 52-64
KEF.LR.148	Fiskardo	Settlemet			Classical				Village			Randsborg 2002, 52-64
KEF.LR.149	Fiskardo	Settlement			Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.15	Agrinia	Cult	Monastery	Monastery of Zodochou Pigis	Byzantine			Standing structure	Satellite imagery			Randsborg 2002, L10; AD, 37, 1982, 152.
KEF.LR.150	Fiskardo	Graves		Roman Graves	Roman				Village			Randsborg 2002, 52-64
KEF.LR.151	Fiskardo	Church		Basilica	Byzantine	Early Byzantine			Village			Randsborg 2002, 52-64
KEF.LR.151	Phokata	Grave	Grave		Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.152	Poros	Finds	Pottery	Pottery from 3rd to 1st millennium BC	Early Bronze Age			Publication	Village			Randsborg 2002, 52-64

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.153	Poros	Graves	Tholos tombs	Two Mycenean tombs	Mycenean				Village			Randsborg 2002, 52-64
KEF.LR.153	Poros	Finds	Pottery	Pottery from Classical to Roman periods	Classical				Village			Randsborg 2002, 52-64
KEF.LR.154	Poros	Finds		Hellenistic of KEF.LR.153	Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.155	Poros	Finds		Roman phase of KEF.LR.153	Roman				Village			Randsborg 2002, 52-64
KEF.LR.156	Poulata	Settlement	House	Mycenean house accounted by Sotiriou	Mycenean				Village			Randsborg 2002, 52-64
KEF.LR.157	Pronnoi	Settlement	Town	Settlement Pronnoi. Archaic to Hellenistic.	Archaic to Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.158	Pronnoi	Settlement	Town	Classical phase of KEF.LR.157	Classical				Village			Randsborg 2002, 52-64
KEF.LR.159	Pronnoi	Settlement	Town	Hellenistic phase of KEF.LR.157	Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.16	Assos	Defence	Castle	Venetian fortress of Assos	Venetian		1593	Standing structure	Satellite imagery			Randsborg 2002, L12;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Partsch 1980, 46, 65-66.
KEF.LR.160	Plagia	Fortification	Fortress	Hellenistic fortress	Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.161	Finds	Pottery and coins		Roman finds at KEF.LR.160	Roman				Village			Randsborg 2002, 52-64
KEF.LR.162	Roupaki near Sami	Finds	Architectural finds	MH or LH	MH OR LH				Village			Randsborg 2002, 52-64
KEF.LR.163	Sami	Settlement	Polis	Polis of Same	Archaic to Roman				Village			Randsborg 2002, 52-64
KEF.LR.164	Sami	Settlement		Archaic phase of KEF.LR.163	Archaic				Village			Randsborg 2002, 52-64
KEF.LR.165	Sami	Settlement		Classical phase of KEF.LR.163	Classical				Village			Randsborg 2002, 52-64
KEF.LR.166	Sami	Settlement		Hellenistic phase of KEF.LR.163: houses, graves and structures					Village			Randsborg 2002, 52-64
KEF.LR.167	Sami	Settlement		Roman phase of KEF.LR.163: baths, houses, mosaics	Roman				Village			Randsborg 2002, 52-64

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.169	Sarlata	Pottery oven			Roman?				Village			Randsborg 2002, 52-64
KEF.LR.17	Atros	Cult	Monastery	Monastery Iperagias Theotokou Atrou	Frankish	Terminus ante quem, 13th century		Standing structure	Satellite imagery			Randsborg 2002, L13; Partsch 1890, 75-76.
KEF.LR.170	Skala	Graves	Chamber tombs	Mycenean chamber tombs	Mycenean				Village			Randsborg 2002, 52-64
KEF.LR.171	Skala	Temple		Archaic tample at Agios Georgios	Archaic				Village			Randsborg 2002, 52-64
KEF.LR.172	Skala	Finds		Classical finds	Classical				Village			Randsborg 2002, 52-64
KEF.LR.173	Skala	Finds		Hellenistic finds	Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.174	Skala	Villa		Large Roman Villa with mosaics	Roman	2nd Century AD	Reign of Marcus Aurelius		Satellite imagery			Randsborg 2002, 52-64

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.175	Skinias	Settlement	Acropolis	Mycenean Acropolis referred by Andreas Sotiriou	Mycenean				Village			Randsborg 2002, 52-64
KEF.LR.177	Stani	Graves	Cist-graves	Two Hellenistic cist-graves	Hellenistic				Village			Randsborg 2002, 52-64
KEF.LR.178	Tzannata	Graves	Tholos tomb	Mycenean tholos tomb	Mycenean				Village			Randsborg 2002, 52-64
KEF.LR.18	Markopoulo	Settlement	Cave	Cave at Markopoulo with local incised pottery	Stone Age			Report	Village			Randsborg 2002, L14, AA 1937, 145.
KEF.LR.180	Vatsa	Remains	Architectural remains	Remains of walls and mosaics with dolphins and a three-fork, perhaps indicating a Late Roman Poseidon sanctuary.	Later Roman				Village			Randsborg 2002, 52-64
KEF.LR.181	Vlachata	Settlement	House	Mycenean House	Mycenean	LHIII			Village			Randsborg 2002, 52-64
KEF.LR.19	Peratata	Defence	Castle	Castle of Agios Georgios. Date foundation unknown,	Frankish			Standing structure	Satellite imagery			Randsborg 2002, L3;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				residence count Kephallonia, rebuilt by Venetians in 16th century.								Partsch 1890, 45-46 and 84,85; Soustal 1981, 154f.
KEF.LR.20	Peratata	Defence	Castle	Castle of Agios Georgios. Date foundation unknown, residence count Kephallonia, rebuilt by Venetians in 16th century.	Venetian	16th century	1504 (reconstruction) 1593 (heavy re-fortification)	Standing structure	Satellite imagery		KEF.LR.3	Randsborg 2002, L3; Partsch 1890, 45-46 and 84,85; Soustal 1981, 154f.
KEF.LR.21	Dionisi	Cult	Monastery		Byzantine ?			Standing structure	Satellite imagery			Randsborg 2002, L15, Partsch 1890, 78
KEF.LR.22	Diakata	Burial	Chamber tombs	Two chamber tombs, to the south remains of a LH houses	LHIIIC			Excavation	Georeferenced map < 1:100.000		KEF.LR.23	Randsborg 2002, L16 with

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				excavated by Kyparisses								bibliography; S-H, 38-39.
KEF.LR.23	Diakata	Settlement	House	Mycenean houses, excavated by Marinatos	LHIIIC			Excavation	Georeferenced map < 1:100.000		KEF.LR.22	Randsborg 2002, L16 with bibliography; S-H, 38-39.
KEF.LR.24	Digaleto	Settlement	Cave	Digaleto Cave	Prehistoric			Excavation	Exact location unknown			Randsborg 2002, L14
KEF.LR.25	Dilinata	Burial	Tomb	Two hellenistic graves	Hellenistic			Rescue excavation	Georeferenced map < 1:100.000			AR 1984-1985, 39-40.
KEF.LR.26	Dilinata	Cult	Monastery	Monastery of Panagia Lamia	Byzantine			Standing structure	Satellite Imagery			Randsborg 2002, L18; Partsch 1890, 89
KEF.LR.27	Kipouria	Concentration of finds	FIgurines	Fragments of ancient figurines	Ancient (generic)			Account	Exact location unknown			Randsborg 2002, L20;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Partsch 1890, 91
KEF.LR.28	Drapano	Cult	Monastery/Church	?	Byzantine ?			Account	Village			Randsborg 2002, L21
KEF.LR.29	Drapano	Excavated structures	Walls	Roman walls in the cemetery of Drapano, oral communication of Andrea Sotiriou in Randsborg 2002,	Roman			Communication	Satellite imagery			Randsborg 2002, L21
KEF.LR.30	Prokopata - Gefyra	Burial	Chamber Tomb	Small LH chamber tomb	LH IIIB			Excavation	Village			Randsborg 2002, L22; AD 5, 1919, fig 24, 25.
KEF.LR.31	Kouloura ta	Settlement	Cave	Cave explored by Sylvia Benton, sherds and Minyan handle.	EH/MH/LH			Survey	Village			Randsborg 2002, L24; Benton 193-1932, 225,6; S-H. 45.
KEF.LR.32	Kouloura ta	Concentration of finds	Pottery	EH pottery fragments in the cave	EH			Survey	Village		KEF.LR.31	Randsborg 2002, L24;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Benton 193-1932, 225,6; S-H. 45.
KEF.LR.33	Kolourata	Concentration of finds	Pottery	MH pottery fragments in the cave	MH			Survey	Village		KEF.LR.31	Randsborg 2002, L24; Benton 193-1932, 225,6; S-H. 45.
KEF.LR.34	Kolourata	Concentration of finds	Pottery	LHIII pottery fragments in the cave	LH III			Survey	Village		KEF.LR.31	Randsborg 2002, L24; Benton 193-1932, 225,6; S-H. 45.
KEF.LR.35	Kokkolata-Kangkalisais	Burial	Necropolis	Kangkalisais necropolis, excavated by Kavvadias. Slab cists, pit graves and tholoi	MH and LH			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												1931-1932, 222; S-H, 39-40.
KEF.LR.36	Kokkolata-Kangkalisais	Burial	Slab cist tomb	Six slab cist tombs	MH			Excavation	Village		KEF.LR.35	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.37	Kokkolata-Kangkalisais	Concentration of finds	Pottery	52 late MH vases found in KEF.LR.36	MH			Excavation	Village		KEF.LR.36	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.38	Kokkolata-Kangkalisais	Single find	Metal	Bronze knife found in KEF.LR.36	MH			Excavation	Village		KEF.LR.36	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.39	Kokkolata-Kangkalisais	Burial	Pit grave	Unprecised number of pit graves, excavated by Kavvadias; 38 vases and many small finds	LH III			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.40	Prokopata - Gefyra	Concentration of finds	Pottery	Vases found in KEF.LR.30	LH IIIA2			Excavation	Village		KEF.LR.30	Randsborg 2002, L22; AD 5, 1919,

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												fig 24, 25.
KEF.LR.41	Prokopata - Gefyra	Concentration of finds	Pottery	Vases found in KEF.LR.30	LH IIIB			Excavation	Village		KEF.LR.30	Randsborg 2002, L22; AD 5, 1919, fig 24, 25.
KEF.LR.42	Prokopata - Gefyra	Concentration of finds	Metal	Razor found in KEF.LR.30	LH III			Excavation	Village		KEF.LR.30	Randsborg 2002, L22; AD 5, 1919, fig 24, 25.
KEF.LR.43	Prokopata - Gefyra	Concentration of finds	Metal	Bronze ring found in KEF.LR.30	LH III			Excavation	Village		KEF.LR.30	Randsborg 2002, L22; AD 5, 1919, fig 24, 25.
KEF.LR.44	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Vases found in KEF.LR.39, composite vessel (A309), to piriform jars and four three-handled vases	LH IIIB			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												1932, 222; S-H, 39-40.
KEF.LR.45	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Vases found in KEF.LR.39, composite vessel (A309), to piriform jars and four three-handled vases	LH IIIC			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.46	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Vases found in KEF.LR.39, composite vessel (A309), to piriform jars and four three-handled vases	LH IIIA2			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.47	Kokkolata-Kangkalisais	Concentration of finds	Beads	Several beads of agate, sardonyx and steatite in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.48	Kokkolata-Kangkalisais	Single find	Metal	Gold bead in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.49	Kokkolata-Kangkalisais	Concentration of finds	Beads	Conuli of clay and steatite in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.50	Kokkolata-Kangkalisais	Concentration of finds	Metal	Three gold hair spirals in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.51	Kokkolata-Kangkalisais	Single find	Metal	Bronze knife in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												H, 39-40.
KEF.LR.52	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Two alabastra identified by Wardle in KEF.LR.54	LH IIIB			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.53	Kokkolata-Kangkalisais	Single find	Metal	Needle in KEF.LR.39				Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.54	Kokkolata-	Burial	Tholos	Tholos A, diameter 2.70m.	LH			Excavation	Village			Randsborg 2002, L25;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
	Kangkalisais											PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.55	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Three handled alabastra, piriform jars, squat jars in KEF.LR.54	LH IIA2			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.56	Kokkolata-Kangkalisais	Single find	Metal	Needle in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932,

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												222; S-H, 39-40.
KEF.LR.57	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Amphoriskoi and small jugs	LH IIIC			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.58	Kokkolata-Kangkalisais	Concentration of finds	Seals	Three sealstones of steatite	LH			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.59	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Three handled alabastra, piriform jars, squat jars in KEF.LR.54	LH IIB			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.60	Kokkolata-Kangkalisais	Concentration of finds	Seals	Eleven lentoid seals in KEF.LR.39	LH III			Excavation	Village		KEF.LR.39	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.61	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Three handled alabastron in KEF.LR.62	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.62	Kokkolata-Kangkalisais	Burial	Tholos	Tholos B, diameter 2.90-3.10m	LH III			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.63	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Piriform jars in KEF.LR.62	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												H, 39-40.
KEF.LR.64	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Squat jar in KEF.LR.62	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.65	Kokkolata-Kangkalisais	Concentration of finds	Pottery	Handmade vases in KEF.LR.62	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.66	Kokkolata-	Concentration of finds	Seals	Four sealstones of steatite	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
	Kangkalisais											PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.67	Kokkolata-Kangkalisais	Concentration of finds	Beads	Steatite and clay conuli	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.68	Kokkolata-Kangkalisais	Concentration of finds	Beads	Beads of glass and argydaramas	LH III			Excavation	Village		KEF.LR.62	Randsborg 2002, L25; PAE 1912; Benton 1931-1932,

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												222; S-H, 39-40.
KEF.LR.69	Kokkolata-Kangkalisais	Concentration of finds	Beads	25 glass paste relief beads, probably belonging to necklace or diadem				Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.
KEF.LR.70	Kokkolata-Kangkalisais	Burial	Cairn	Three cairn-like structures described as tombs or possible tombs, no mention of remains or grave goods	LHIII?			Excavation	Village			Randsborg 2002, L25; PAE 1912; Benton 1931-1932, 222; S-H, 39-40.

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.71	Kardakata	Concentration of finds	Figurines	Archaic and classical figurines	Archaic			Report	Village			Randsborg 2002, L26; BCH 45, 1921, 526; AJA 1932, 61
KEF.LR.72	Kardakata	Concentration of finds	Figurines	Archaic and classical figurines	Classical			Report	Village			Randsborg 2002, L26; BCH 45, 1921, 526; AJA 1932, 61
KEF.LR.73	Kardakata	Excavated structures	Wall	Peribolos wall	Archaic/Classical?			Report	Village			Randsborg 2002, L26; BCH 45, 1921, 526; AJA 1932, 61
KEF.LR.74	Kardakata	Concentration of finds	Architectural fragments	Architectural fragments	Archaic/Classical?			Report	Village			Randsborg 2002, L26;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												BCH 45, 1921, 526; AJA 1932, 61
KEF.LR.75	Karyà	Single find	Architectural fragment	Byzantine wall-painting from the Ag. Andreas church, now in Argostoli, late 12th or 13th century	Frankish	Late 12th or 13th century		Report	Village			Randsborg 2002, L28; AR 1989–90, 29; ADelt 36, 1981, 177, pin 112.
KEF.LR.76	Agios Nikolaos	Cult	Church	Church of Agios Nikolaos	Byzantine			Report	Satellite imagery			Randsborg 2002, L29
KEF.LR.77	Kastro tu Sordatu	Defence	Fortification	Irregularly square fortess, polygonal walling	Hellenistic/Roman?			Report	Satellite imagery			Randsborg 2002, L29
KEF.LR.78	Kato Kateleios	Burial	Graves	Roman graves. Communication of Andreas Sotiriou to Klavs Randsborg 2002,sborg. Locality Karavostasi or Lichidi	Roman			Report	Village			Randsborg 2002, L31

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.79	Kato Kateleios	Concentration of finds	Pottery	Roman sherds. Communication of Andreas Sotiriou to Klavs Randsborg 2002,sborg.	Roman			Report	Village			Randsborg 2002, L31
KEF.LR.80	Kato Kateleios	Concentration of finds	Architectural fragments	Columns and foundation of marble in the ground (sic!). Communication of Andreas Sotiriou to Klavs Randsborg 2002,sborg.	Roman			Report	Village			Randsborg 2002, L31
KEF.LR.81	Ano Keramies	Burial	Necropolis	20 rectangular rock-cut graves	Classical	4th-3rd century		Report	Village			Randsborg 2002, L32
KEF.LR.82	Ano Keramies	Burial	Graves	Hellenistic graves. Communication of Andreas Sotiriou to Klavs Randsborg 2002,sborg.	Hellenistic			Report	Village			Randsborg 2002, L32
KEF.LR.83	Kipuria	Cult	Monastery	Iperagia Thetokou Kipurion	Byzantine				Satellite imagery			Randsborg 2002, L33
KEF.LR.84	Kokkolata	Burial	Necropolis	Site of Kokkolata	MH - LH			Excavation	Village			Randsborg 2002, L34;

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Souyoudzoglou-Haywood 1999, 39-40
KEF.LR.85	Kokkolata	Burial	Tumulus	Tumulus (18m), excavated by Kavvadias	MH				Village			Randsborg 2002, L34; Souyoudzoglou-Haywood 1999, 39-40
KEF.LR.86	Kokkolata	Burial	Cist graves	Six cist graves inside KEF.LR.85	MH				Village		KEF.LR.85	Randsborg 2002, L34; Souyoudzoglou-Haywood 1999, 39-40
KEF.LR.87	Kokkolata	Concentration of finds	Pottery		Fifty-two late MH vases recovered in cist graves (KEF.LR.86)				Village		KEF.LR.86	Randsborg 2002, L34; Souyoudzoglou-Haywood

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												d 1999, 39-40
KEF.LR.88	Kokkolata	Burial	Pit graves	Unspecified number of pit graves 4-5m NW of KEF.LR.86, used for successive burials or ossuaries	LHIII				Village			Souyoudzoglou-Haywood 1999, 39
KEF.LR.89	Kokkolata	Concentration of finds	Pottery	Thirty-eight vases found in KEF.LR.88	LHIII				Village		KEF.LR.88	Souyoudzoglou-Haywood 1999, 39
KEF.LR.90	Kokkolata	Burial	Tholos	Tholos A (diam. 2.70m)	LHIIIB				Village			Souyoudzoglou-Haywood 1999, 40
KEF.LR.91	Kokkolata	Burial	Pit graves	Two burial pits in KEF.LR.90	LHIIIB				Village		KEF.LR.90	Souyoudzoglou-Haywood 1999, 40
KEF.LR.92	Kokkolata	Concentration of finds	Pottery	Thirty-four vases from KEF.LR.90	LHIIIB				Village		KEF.LR.90	Souyoudzoglou-Haywood 1999, 40

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.93	Kokkolata	Burial	Tholos	Tholos B (diam. 2.90-3.10m)	LHIIIB				Village			Souyoudzoglou-Haywood 1999, 40
KEF.LR.94	Kokkolata	Burial	Pit graves	Three burial pits in KEF.LR.93	LHIIIB				Village		KEF.LR.93	Souyoudzoglou-Haywood 1999, 40
KEF.LR.95	Kokkolata	Concentration of finds	Pottery	Eighteen vases in KEF.LR.93	LHIIIB				Village		KEF.LR.93	Souyoudzoglou-Haywood 1999, 40
KEF.LR.96	Kokkolata	Excavated structures	Walls	Absidal structure (Theta) excavated by Kavvadias, possibly burial	MH				Village			Randsborg 2002, L34
KEF.LR.97	Kokkolata	Single find	Inscription	Grave stele with inscription	Archaic/Classical			Report	Village			Randsborg 2002, L34
KEF.LR.98	Kompomekrata	Burial	Cist grave	Cist grave	Hellenistic			Report	Village			Randsborg 2002, L35

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
KEF.LR.99	Kompomekrata	Concentration of finds	Pottery	Kantaros and four amphorae in KEF.LR.98	Hellenistic	3rd century BC			Village		KEF.LR.98	Souyoudzoglou-Haywood 1999, 40
LEF.LR.01	Steno	Site			EBA - LBA			Excavation	Georeferenced map < 1:100.000	GYS 1:50.000		Souyoudzoglou-Haywood 1999, 18-19
LEF.LR.02	Steno	Settlement?		Interpreted as settlement, the palace of the 'kings' buried in the R-Grave cemetery. Other ipoheses ranging from defensive wall of cemetery to defensive wall are not judged as completely satisfactory (Souyoudzoglou-Haywood 1999, 19)	EBA-LBA			Excavation	Village			Souyoudzoglou-Haywood 1999, 19
LEF.LR.03	Steno	Excavated structures	Wall	Structure P, 40m long wall. Foundation made up of two courses of round	EBA			Excavation	Village			Souyoudzoglou-Haywoo

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				stones, with wall constructed with large flat stones on exterior and infil of pebbles and small stones.								d 1999, 19
LEF.LR.04	Steno	Concentration of finds	Pottery	Glazed pottery around LEF.LR.2				Excavation	Village		LEF.LR.2	Souyoudzoglou-Haywood 1999, 19
LEF.LR.05	Steno	Concentration of finds	Pottery	Glazed pottery near LEF.LR.2	EBA			Excavation	Village		LEF.LR.2	Souyoudzoglou-Haywood 1999, 19
LEF.LR.06	Amali	Site			EBA-LBA			Excavation	Village			Souyoudzoglou-Haywood 1999, 18-19
LEF.LR.07	Amali	Settlement		Twelve structures on the NE slope of Mount Amali (Omali), poorly preserved	EH III			Excavation	Village			Souyoudzoglou-Haywood 1999, 19

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
LEF.LR.08	Amali	Concentration of finds	Pottery	EBA pottery: coarsware-type	EBA			Excavation	Village		LEF.LR.7	Souyoudzoglou-Haywood 1999, 19
LEF.LR.09	Amali	Concentration of finds	Pottery	Two Grey Mynian sherds	EH III			Excavation	Village		LEF.LR.7	Souyoudzoglou-Haywood 1999, 19
LEF.LR.10	Syvros	Burial	Necropolis	EBA necropolis of Syvros	EBA			Excavation	Village			Souyoudzoglou-Haywood 1999, 20
LEF.LR.11	Syvros	Burial	Slab cist tomb	Grave A, containing at least five skeletons	EBA				Village		LEF.LR.10	Souyoudzoglou-Haywood 1999, 20
LEF.LR.12	Syvros	Concentration of finds	Metal	One earring and two beads, of bronze	EBA				Village		LEF.LR.11	Souyoudzoglou-Haywood 1999, 20
LEF.LR.13	Syvros	Burial	Slab cist tomb	Grave B, containing at least six scheletons	EBA				Village		LEF.LR.10	Souyoudzoglou-

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
												Haywood 1999, 20
LEF.LR.14	Steno	Burial	Necropolis	Tholos cemetery of Steno, Dörpfeld believed it was constituted by forty of fifty tumuli, of which he revealed thirty-three.	EBA-MBA			Excavation	Village			Souyoudzoglou-Haywood 1999, 18-20
LEF.LR.15	Steno	Concentration of finds	Pottery	Coarse and semi-coarse ware found by Dörpfeld in tombs R1, R5c, R12, R13G	EHII - EHIII			Excavation	Village		LEF.LR.14	Souyoudzoglou-Haywood 1999, 27
LEF.LR.16	Steno	Concentration of finds	Metal	Four spearheads and two long daggers, probably daggers are import from Cyclades	EHII - MHI			Excavation	Village		LEF.LR.14	Souyoudzoglou-Haywood 1999, 28
LEF.LR.17	Lygia Katounas	Excavated structure	Public building	Public building, probably of commercial function, destroyed in early 2nd BC. Destruction associated with siege	Hellenistic			Rescue excavation	Village			AD 48B (1993), 290-293

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				of Leukas by Flamininus (197 BC)								
LEF.LR.18	Lygia	Concentration of finds	Inscriptions	Two identical building inscriptions found in front of LEF.LR.17: ΑΠΟΛΛΩΝΙΑΤΑΙ ΟΙΚΟΔΟΜΗΣΑΝ	Roman	2nd \ 1st BC		Excavation	Village			IG 10.1 535,536. Quoted in Pliakou 2001, 151
LEF.LR.19	Karyotes	Excavated remains	Walls	Houses parallel to ancient road	Classical - Roman			Rescue excavation	Village			AD 48B (1993), 293-296
LEF.LR.20	Karyotes	Excavated remains	Walls	Classical phane LEF.LR.19	Classical	5th BC			Village			AD 48B (1993), 295, fig 15
LEF.LR.21	Karyotes	Excavated remains	Walls	Hellenistic phase of LEF.LR.19	Hellenistic				Village			AD 48B (1993), 295, fig 15
LEF.LR.22	Karyotes	Concentration of finds	Pottery	Roman pottery found inside two houses, interpreted by A. Douzougli as representing the last finds before the	Roman	1st BC, early BC			Village			AD 48B (1993), 296

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
				abandonment of the LEF.LR.19 houses								
LEF.LR.23	Leukas	Defence	Urban walls	Roman phase of the urban walls of Leukas, reported by Dodwell	Roman			Accounts	Village			Dodwell 1819, 50
LEF.LR.24	Kalligonion	Burial	Necropolis	North necropolis of Leukas	Classical - Roman			Rescue excavation	Village			Pliakou 2001, 151-152
LEF.LR.25	Fragoklissia	Burial	Necropolis	Northern	Archaic - Classical			Rescue excavation	Village			Pliakou 2001, 151-152
LEF.LR.26	Leukas	Burial	Funerary monument	Roman funerary monument built inside the walls of Leukas among deserted houses	Roman			Rescue excavation	Village			AD 48B (1993), 287
LEF.LR.27	Megali Vrissi	Excavated structures	Farmhouse	Megali Vrissi agriki	Roman	1st BC - 2nd AD		Rescue excavations	Village			Pliakou 2001, 153-155
LEF.LR.28	Megali Vrissi	Concentration of finds	Pottery	Aretine Terra Sigillata	Roman	1st BC - 1st AD			Village			Pliakou 2001, 153-155

ID	Toponym	Typology	Sub-Typo	Description	Chronology	Add. Chro.	Date	Record Nature	Prec. Loc.	Spatial Extention	Relation	Bibliography
LEF.LR.29	Megali Vrissi	Concentration of finds	Pottery	Relief lamps	Roman	1st AD - 2nd AD			Village			Pliakou 2001, 153-155
LEF.LR.30	Megali Vrissi	Single find	Coin		Nicopoletan coin minted under Hadrian, not better identified in report of the excavation	2nd AD		Rescue excavation	Village			Pliakou 2001, 153-155

Appendix B

ID	Frames[308]	Description	Elevation visible through	Visibility on georeferenced satellite imagery (Google Maps)	Visibility on georeferenced orthophotographs of the Greek National Cadastral Agency	Latitude[309]	Longitude	Possible interpretation

[308] When multiple frame numbers are mentioned, they are meant to signify the existence of forward overlapping between them (e.g. for MEG.PH.8 "BSA L 37 3005, 6"). When the numbers are not immediately sequential (e.g. for MEG.PH. 16 "GYS 163167, 9"), they still signify the existence of forward overlapping. In several cases, strips obtained from the Geographic Service of the Hellenic Army - Aerial Photographs Fund presented forward overlapping for over 70 % of the surface of each frame, with lateral overlapping of more than 30 %, making them suitable for stereoscopic interpretation on multiple sides.

[309] Coordinate reference system (CRS): WGS 84 Mercator. EPSG: 4326.

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