Syracusan Settlement Expansion in South-Eastern Sicily in the Archaic Period

Jerrad Lancaster
Royal Holloway, University of London
Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Declaration of Authorship

I, Jerrad Lancaster, hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed: ____________________________

Date: ______________________________

Abstract

During the Archaic period Syracuse grew from a newly established colony to become a colonial power itself and its hegemony spread across the south-east part of Sicily. The motivations behind the expansion process and the foundation of multiple new settlements is the central theme of this thesis. The most notable are Heloros (late eighth century BC), Akrai (664 BC), Kasmenai (644 BC) and Kamarina (599 BC). The traditional interpretation behind this expansion is based on ancient literary sources and it stresses military intentions of Syracuse. However, even though the foundations did have a strategic motivation behind them, more central was the desire for wealth accumulation through access to new agricultural land and creation of an inland trade route. The aim of the methodologies (architectural energetics, population estimates and degrees of primacy) used in the thesis is to build a clearer picture of the settlements at key stages of their development from foundation to the end of Archaic period. Architectural energetics is used to estimate the comparative labour costs of building each settlement. Assessment of the architectural development of each site also supports the non-military motivation behind their foundation.

Table of Contents

Figures

Tables

Charts

Chapter 1: Introduction

1.1 Introduction of the Case Study

In the Archaic period, south-east Sicily witnessed the hegemonic expansion of Syracuse through its foundation of new settlements. Starting at the end of the eighth century BC with the foundation of Heloros along the south-east coast, the Syracusan advance continued inland with Akrai and Kasmenai in the mid-seventh century, ending in 599 BC with the establishment of Kamarina on the southern coast.[1] Syracuse's territorial expansion was not without its problems, and even though mostly peaceful, it was at times hostile. The rebellion and destruction of Kamarina in mid-sixth century highlighted the issue of control Syracuse wished to maintain over its settlements and south-east Sicily.[2]

The purpose of this dissertation is to provide new avenues of research into the colonisation practices of Syracuse through the socio-political and economic motivations behind them. Due to the highly fragmentary nature of the textual evidence, the emphasis of this thesis is naturally on the material record of the settlements: even though the interpretation of the archaeological evidence related to the earlier phases of the discussed sites is often problematic, it nevertheless provides a possibility of systematic approach to the topic. Until recently, the expansion of Syracuse across the region has been largely discussed in terms of martial motivations.[3] The role of the elite of Syracuse, the *Gamoroi*, should be considered in the assessment of possible motives behind the foundation of the settlements. It has been argued that the Greek cities of Sicily 'were spearheaded by elites who organized themselves into clans that tightly controlled the distribution of land and protected their place at the top of the social hierarchy.'[4] The faction dominated the city-state, and used it for its own political, social and material gains.[5] The expansion of Syracuse benefited the population as a whole, providing security and ensuring its prosperity, but it also provided opportunities for the ruling elites to increase their wealth and property.

Linking the material remains of the new Syracusan settlements with the political, social and economic factors of the Archaic period is a difficult task and the limits of the available source material must be recognised, but this thesis attempts to make a step towards this direction. Written sources are generally quite scarce for Greek Sicily in this time, focusing on

---

[1] There are other, smaller settlements in south-east Sicily that have been connected with Syracuse and its policy of expansion. However, the focus of this thesis is on these five settlements.
[2] De Angelis 2000a, p.124.
[3] One of the latest overviews of the Greek colonisation of Sicily maintains this view: Domínguez 2006, p. 284.
[4] De Angelis 2016, p.4.
[5] See section 2.4.1 below.

major themes in the area such as the founding of the Greek colonies and the rule of the tyrants.[6] Recent innovative archaeological research has provided fresh insights into the region. For instance, De Angelis's landscape archaeological studies have been able to estimate the agricultural capacities of the Syracusan settlements, and Melfi and Copani have presented reinterpretations of Kasmenai and Heloros.[7] This thesis will demonstrate that by integrating architectural energetics and rank-size distributions, not generally applied to this region, more information can be derived from the archaeological material: these methods and their associated literature are discussed in more detail in the third chapter.

1.1.1 Geography and Topography of the Area

Sicily is the largest island in the Mediterranean bordered by the Tyrrhenian Sea in the north, Ionian Sea in the east and the Strait of Sicily along the southern coast. Mountains largely dominate the island, plains only account for seven per cent of the island, particularly in the northern regions to the northeast corner.[8] The Strait of Messina separates the island at this point from the Italian peninsula by only about three kilometres. Three mountain ranges in the north, the Madonie, Nebrodi and Peloritani rise around 2,000 m above sea level in the highest places and are essentially an extension of the mainland Apennines. Just south of these along the east coast, with only eighteen kilometres from the coast to the crater,[9] sits Mount Etna, one of the most active volcanoes in the world and the tallest in Europe. Rising to a height over 3,300 m, it dominates the landscape for kilometres in all directions. For obvious reasons, this makes the soil and geology around the volcano unique to the island.[10] The south-eastern tip is almost separated from the rest of the island by the Hyblaean Mountains. The highest point, Monte Lauro, is just under 1,000 m in height, and is the source of the rivers Anapo (ancient Anapos), Irminio (ancient Herminius) and Tellaro (ancient Heloros); the rivers have their mouths at Syracuse, Kamarina and Heloros respectively (Fig. 1.1). Between these mountains and Mount Etna sit the plains of Catania, a valley historically rich in agriculture. To the west there is found the inland range of the Erean Mountains, at their highest just shy of 1,200 m. The last of the mountain ranges of Sicily is the Sicanian Mountains, up to 1,600 m, which form the eastern boundary of the north-west corner of the island. The remaining area of the island is comprised of hills and valleys running to the coasts. These mountain ranges act as natural boundaries, separating regions of the island, and even facilitate different weather patterns, from a colder, wetter climate in the north to a hotter, dryer climate in the south-west.

---

[6] Diod. Sic. 11.22-26, 13.59.4, 13.62.4; Hdt. 7; Strab. 6.2-4; Thuc. 6.3-5. See also De Angelis 2000a, p.113.
[7] De Angelis 2000a; De Angelis 2000b; Melfi 2000; Copani 2005.
[8] Chester et al. 2011, p.237.
[9] Distance measured using Google Maps Distance Calculator, Daft Logic 2014a.
[10] Giordano 2013, pp.53-4.

The largest annual rainfall is in the north, around 1,000 millimetres, and the lowest in the central to south-west coastal region, near 500 millimetres.[11] This cannot be taken for the norm in our period, however, as the climate of the region was wetter in the Archaic period.[12] It was common for the rivers near Heloros and Kamarina to inundate the surrounding land, resulting in some areas of wetlands and fishing.[13] Near Syracuse, at least three lagoons, and their use as salt pans, have been identified, and the local geography of the south-western coast also facilitates such an exploitation of natural resources. Mineral resources are abundant on the island: copper, iron and tin in the north-east and sulphur in the south-west. Throughout the centre of the island are found conglomerates, sandstones and clays, crystalline rocks dominate the north-east corner of the island, while limestone (white or yellow) is the most common stone type in the south-east, but volcanic rock is also present alongside sandstones and clay.[14] The island was well forested prior to the arrival of the Greeks, but at this time was introduced grapes, olives and figs.[15]

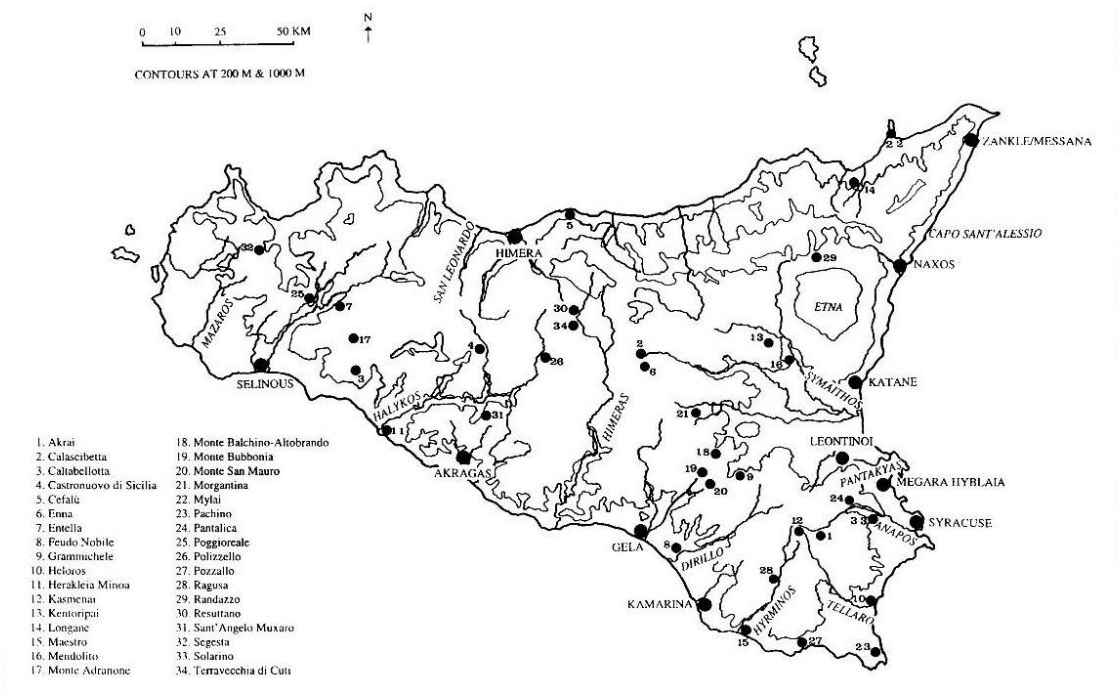

Fig. 1.1: Sicily with sites mentioned. De Angelis 2000a, p.114.

The territory of Syracuse and its settlements in south-eastern Sicily has the sea as its boundary on the eastern and southern sides; the northern border was probably the river Anapo and the northern reaches of the Hyblaean mountains and in the west it extended past the

[11] De Angelis 2000a, p.121; Chester et al. 2011, p.237.
[12] De Angelis 2016, pp.229-30.
[13] Cordano & Di Stefano 1997; Copani 2005, pp.246-7.
[14] Great Britain Naval Intelligence Division 1944, pp.392, fig.65; De Angelis 2003, pp.79, fig.29.
[15] Stika et al. 2008, p.147; Noti et al. 2009, p.384; De Angelis 2016, p.230.

mountains and the territory of Kamarina to the river Dirillo (ancient Achates).[16] Currently, the island is largely under extensive agriculture focused on the interior, highland areas.[17] Intensive agriculture makes up the majority of the remaining area, predominantly coastal. Archaic agriculture was largely cereal based (i.e. barley and millet), making up around sixty-five to seventy per cent of the regional diet.[18] Grain is strongly connected to Sicily,[19] but this would not have been the only foodstuff grown on the island. Fruit orchards and viticulture are common place today, along the coast of the modern Baia del Porto Grande outside the city of Syracuse, and it can be expected that the area was popular for the production of wine and olive oil.[20] The highest point in south-east Sicily (Monte Lauro) is less than 1,000 m above sea level which means much of the region is applicable for agriculture of any type, and so it can be considered that grain was the primary resource cultivated, but viticulture and fruit farming would have been commonplace as well. At Syracuse, Heloros and Kamarina, seafood would also have been a staple of the diet.

1.1.2 Chronological Context

The starting point of the Greek westward movement and colonisation of Magna Graecia[21] can be placed at the foundation of Pithekoussai in the second quarter of the eighth century BC,[22] located on the island of Ischia off the western coast of Italy. Within a few decades, Kyme was founded eighteen kilometres away on the western edge of the modern Bay of Naples.[23] Strabo (5.4.9) relates that Pithekoussai was a joint settlement by the Khalkidians and Eretrians and he places it after the foundation of Kyme. Livy (8.22.5–6), on the other hand, writes that Kyme was founded by the peoples who had left the island of Ischia. Either way, the settlement on Ischia was soon abandoned.[24] It is now generally accepted that Pithekoussai was the first Greek settlement in the western Mediterranean with Kyme given the honour of the first colonial Greek endeavour.[25]

---

16 De Angelis 2000a, p.122.
17 Henfrey 1977, pp.342-3; Chester et al. 2011, pp.236-7.
18 Gallant 1991, pp.62-8; De Angelis 2000a, p.118.
19 De Angelis 2000a; De Angelis 2000b.
20 Evans 2009, p. 30.
21 A list of Greek settlements abroad, their mother-city/cities, literary dates for the foundations and early archaeological evidence are discussed in Hansen & Neilsen 2004; Tsetkhladze 2006; Osborne 2009, pp.83-7, Table 5. For a further discussion of literary dates of the Sicilian colonies, see Miller 1970.
22 Coldstream 2003, pp.208-12. Foundation placed at 770-760 BC Cerchiai et al. 2004, p.13; before 750 Ridgway 1992, p.41.
23 The suggested dates for the foundation vary: 760-735, but after Pithekoussai: Coldstream 2003, pp.212-13; 750 BC though also 730-720: Cerchiai et al. 2004, p.13; 41 respectively; about 750: Buchner 1966, p.5; around 725: Whitley 2001, p.127.
24 Cf. Ridgway 1992, pp.31-3.
25 Ridgway 1992, p.32 considers Pithekoussai ‘pre-colonial’. See Domínguez 2011, pp.196-200 on this debate. For more on the use of the word ‘colony’ in Classical historiography, see section 1.3 below.

The traditional timeline of the Greek colonies on Sicily is summarised by Thucydides (6.3–5).[26] There was an indigenous population on the island, and the Greek and Phoenician settlements were founded simultaneously from the opposite ends of the island.[27] The traditional dates have been extensively discussed and compared with archaeological material from the settlements, and in the following are given the most widely accepted dates and relevant literature in the footnotes. The first Greek colony in Sicily was Naxos, founded in 734 BC by Khalkidians and Naxians.[28] In the following decade, the Khalkidians settled Zankle at the north-east corner of Sicily,[29] while Naxos founded its own settlements of Leontinoi and Katane.[30] A population from Megara, near Corinth, settled eighteen kilometres north of Syracuse in 728 BC,[31] and Gela was founded in 688 BC by settlers from Rhodes and Crete.[32] Other Greek Sicilian settlements[33] during this time include Mylai (Zankle; 716 BC),[34] Himera (Zankle; 648 BC),[35] Selinous (Megara Hyblaia; 628 BC)[36] and Akragas (Gela; ca. 576).[37]

In this period, the Greek settlements were in constant interaction with Phoenicians, indigenous peoples and other Greeks in South Italy and the mainland. These networks precipitated continuous contact in the social, political and economic dynamics of the island. Such close contact can expectedly cause problems. This view is at the heart of arguments towards defensive motivations in the foundations of the Syracusan colonies. However, the Archaic period of Sicily can be better characterized by developments in the Greek city-states and the associated territories: domestic and monumental architecture, agriculture, craft production, exchange, both inter- and intraregional, and socio-political relations within the communities and with neighbouring settlements.[38] Private houses developed from a single room to multiple rooms.[39] Monumental architecture was fast developed in the sanctuaries of the new wealthy settlements around or a little after 600 BC, the Temple of Apollo, analysed in

[26] Cf. Di Vita 1990, pp.345-6; Domínguez 2006, pp.253-6; De Angelis 2016, pp.66-73.
[27] Sjöqvist 1973, pp.15-6; Coldstream 2003, p. 223; Hodos 2006, p.91.
[28] Thuc. 6.3.1; *FGrH* 1 F 82; Domínguez 2006, pp.256-9; Lentini 2009, pp.15-7; Malkin 2011, pp.97-118; Pakkanen 2013a, pp.52-3.
[29] Paus. 4.23.7; Thuc. 6.4.5; Bacci 1978, pp.100-3; Coldstream 2003, p.219; Domínguez 2006, pp.263-6.
[30] Leontinoi and Katane: Thuc. 6.3.3; Rizza 1981, pp.313-7; Domínguez 2006, pp.261-3.
[31] Strab. 6.4.2; Thuc. 6.4.1; Sjöqvist 1973, p.17; Villard 1982, pp.181-5; Coldstream 2003, p.217; Domínguez 2006, pp.275-9.
[32] Hdt. 7.153.1; Thuc. 6.4.3; De Miro & Fiorentini 1978, pp.90-9; Domínguez 2006, pp.279-83.
[33] For a discussion over the term 'sub-colony', as compared to 'secondary' colony and 'sister' colony, see section 1.3 below.
[34] Miller 1970, p.13; Sabbione 1986, pp.221-36; Coldstream 2003, p.220; Domínguez 2006, pp.266-8.
[35] Diod. Sic. 13.59.4 13.62.4; Strab. 6.2.6; Thuc. 6.5.1; Bonacasa 1997, pp.56, 58; Vassallo 1997, pp.85-8; Domínguez 2006, pp.292-8.
[36] Or 650 BC. Cf. Diod. Sic. 13.59; Thuc. 6.4.2; Rallo 1982, pp.203-18; Domínguez 2006, p.302.
[37] Pind. *Ol.* 2.93–96; Thuc. 6.4.4; De Waele 1971, pp.88-97; Domínguez 2006, pp.306-11.
[38] De Angelis 2016, pp.65-101.
[39] See section 3.8 below.

more detail below, was the first Doric stone temple in Sicily.[40] The earliest large-scale defensive structures in south-east Sicily are at Kasmenai and Kamarina and are dated to early or mid-sixth century.[41] Hinterlands were exploited to a large extent to feed growing populations and provide trade goods.[42] Trade routes were established stretching across the Mediterranean, and sacred networks tied the new foundations with the Panhellenic sanctuaries of the Greek mainland.[43]

The elites of the Greek communities became wealthier and more powerful largely at the detriment of lower classes.[44] This latter phenomenon led to the first generation of political centralisation at the end of the sixth century.[45] The end of the Archaic period witnessed the rise of tyrannies at Gela, Akragas and Syracuse and rapid demographical changes.[46] The Greek victory in the Battle of Himera in 480 BC stops the Carthaginian expansion into eastern Sicily and it also marks the conventional end date of the Archaic period in Sicily.[47]

1.1.3 Historical Summary of South-East Sicily

In 733 BC (according to Thucydides a year after Naxos),[48] Syracuse is settled on the island of Ortygia. At the end of the eighth century, or the beginning of the seventh, people from Syracuse settled at Heloros, thirty kilometres south, on the eastern coast of Sicily (Fig. 1.2).[49] In 664, Akrai was founded in the Hyblaian Mountains thirty-five kilometres west of Syracuse, and twenty years later Kasmenai was settled twelve kilometres north-west of Akrai.[50] Syracuse's expansion programme in south-east Sicily concludes in 599 with the foundation of Kamarina. Thucydides (6.5.3) considers this as an independent settlement including their own *oikists*, but was most likely intended to be dependent to a degree on Syracuse.[51]

With the foundation of the new settlements, the Syracusan hinterland grew to an estimated 1,000 square kilometres (Fig. 1.3).[52] Whether to include the *chora* of Kamarina (c. 650 km^2) in the territory of Syracuse is a matter of academic discussion.[53] However, since Kamarina's foundation was dependent on Syracuse, the total area under her control in the early

[40] See section 4.8 below.
[41] See Appendix 1: KM, section D; K, section D. Although Thuc. 6.3.2 suggests an early wall at Syracuse.
[42] De Angelis 2000a; De Angelis 2000b.
[43] Malkin 2011, pp.97-118. See section 8.2 below.
[44] See section 2.4.2 below.
[45] De Angelis 2016, pp.101-10.
[46] De Angelis 2016 provides a detailed study of the political changes in sixth-century Sicily.
[47] Antonaccio 2009, p.326.
[48] Thuc. 6.3.2; Pelagatti 1982a, pp.125-40; Domínguez 2006, pp.269-75.
[49] Herein, the date of 700 BC will be used for the foundation of Heloros.
[50] Thuc. 6.5.2.
[51] De Angelis 2000a, p.124.
[52] Gates 1997; Muggia 1997, p.59; De Angelis 2000a, pp.123-4; De Angelis 2000b, pp.112-3.
[53] Muggia 1997, p.97; De Angelis 2000a, p.124-6; De Angelis 2000b, pp.112-3 discuss Kamarina as separate from Syracuse. In his most recent work, De Angelis 2016, pp.96, Table 1 does include Kamarina in Syracuse's territory.

sixth century BC was c. 1,650 km².[54] Definitive boundaries for the territories of Heloros, Akrai and Kasmenai have not been suggested thus far. I will discuss the issue in relation to each site below. Since the interest of the historical sources is limited to foundation dates of the settlements and later sixth-century events, the developments of the intervening period can only be traced through the archaeological evidence. These are discussed below in section 1.2 and Appendix 1.

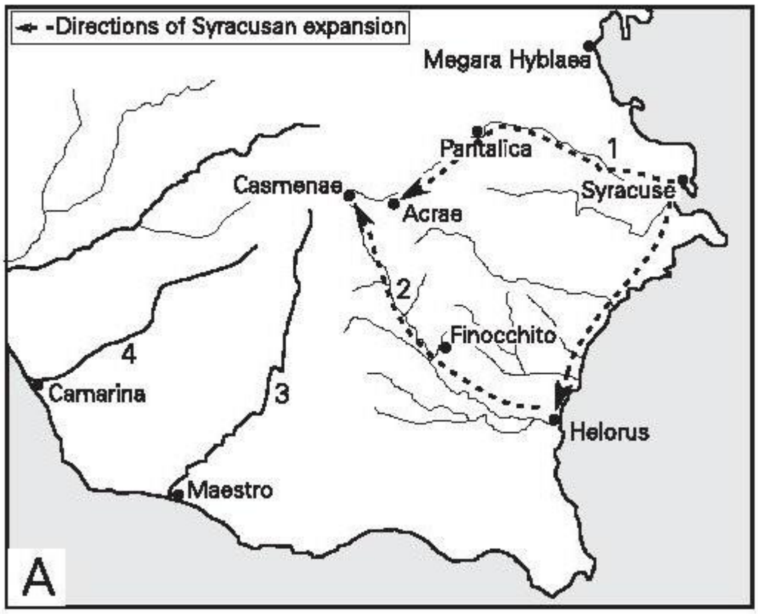

Fig. 1.2: Directions of the expansion of Syracuse. 1. River Anapos. 2. River Heloros. 3. River Herminius. 4. River Hypparis. Domínguez 2006, Fig. 10.

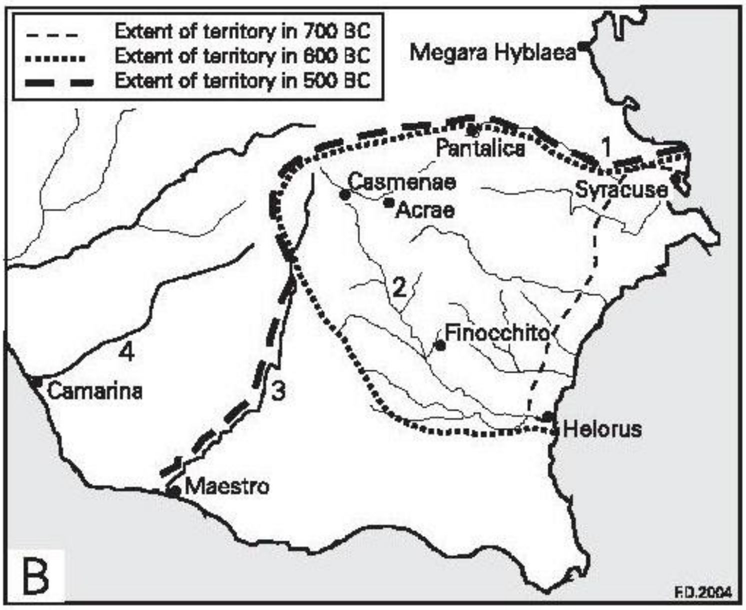

Fig. 1.3: Three phases of growth in expansion of Syracuse. 1. River Anapos. 2. River Heloros. 3. River Herminius. 4. River Hypparis. Domínguez 2006, Fig. 10.

---

[54] Muggia 1997, p.97; De Angelis 2000a, p.124-6; De Angelis 2000b, pp.112-3 estimate the territory of Kamarina as 670 km². However, a revision in the size of the hinterland brings it down to c. 650 km²; see section 4.10 below.

The developments in the sixth century gave rise to tyrants in several cities in south-east Sicily and changed the political and demographic landscape in the region. The rebellion of Kamarina against Syracuse in 552 BC resulted in the settlement's destruction by its metropolis.[55] This marks the beginning of a shift into powerful regional centres asserting their force upon their neighbours. At the beginning of the fifth century, Hippokrates of Gela began a conquest of eastern Greek Sicily by taking Zankle, Naxos, Leontinoi and other small settlements, leaving those places under the control of local tyrants, before marching on to Syracuse.[56] A battle at Heloros in 492 between the two sides ended in a draw, which ultimately resulted, after mediation by Corinth, in Syracuse giving away control of Kamarina.[57] In 485 BC, Gelon, now tyrant of Gela, aided the *Gamoroi*, who had been expelled years earlier in a democratic revolution, in retaking Syracuse, but instead took control of the polis himself.[58] Gelon also destroyed Megara Hyblaia and Kamarina, the latter of which had been refounded, and the populations were moved to Syracuse.[59]

The early fifth century is the chronological end of this study.[60] Ultimately, the capture of Syracuse by Gela in 485 BC marked the end of one phase of Syracusan settlement and dominance in south-east Sicily developing from the eighth through sixth centuries.[61]

1.2 Fieldwork

There are large gaps in knowledge of the archaeology of the new Syracusan settlements. The current state of research of the archaeological record of each site in the Archaic period is presented in the first appendix: the emphasis there is on fortifications, housing and monumental building, the three areas of focus this thesis. Much of the material is derived from published archaeological reports such as *Kokalos*, *Bolletino d'Arte* and *Monumenti Antichi*. *Archeologia nella Sicilia sud-orientale* (1973), edited by Pelagatti and Voza, summarised the then recent information on the Greek settlements in the area. *La Sicilia Antica*, edited by Gabba and Vallet, expanded in 1980 on the historiography of south-east Sicily within the context of the entire island. The latter publication remains the most up to date general archaeological study of the area, although emphases on how to interpret the material record have changed in recent years. This point will be further addressed throughout the study. There are a handful of scholars

---

[55] Thuc. 6.5.3. See also section 2.5.5.
[56] Hdt. 7.154; Thuc. 6.5.3; Sjöqvist 1973, pp.43-4; Martin et al. 1980a, p.662; Rijsberman 1995a, pp.271-3; Rijsberman 1995b, p.674.
[57] On the relationship between colonies and the role of mother-cities, see Malkin 2011, pp.17-63.
[58] Hdt. 7.155; Thuc. 6.5.3; Osborne 2009, p.326.
[59] Hdt. 7.156.
[60] Cf. De Angelis 2000a, pp. 112, n.7; Hodos 2006, p.4. De Angelis 2016, p.63 takes 500 BC as the end of his first chronological period in his diachronic study of Archaic and Classical Greek Sicily.
[61] De Angelis 2016, pp.101-10.

who have dedicated much of their work to the region, most notably Bernabò Brea, De Angelis, Di Vita, Orsi, Pelagatti and Voza. Orsi can be credited with identifying Heloros[62] and Kasmenai[63] as well as highly prolific work on Syracuse, Akrai and Kamarina. Bernabò Brea's largest contribution is to the settlement at Akrai, including his thorough overview of the site in 1956 and publication of the Temple of Aphrodite in 1986.[64] In the latter half of the twentieth century, much of the excavations on Kamarina have been led by Pelagatti, including numerous publications of the site and the surrounding lands. At the same time, Voza focused his work on the other three Syracusan settlements of Heloros, Akrai and Kasmenai.

1.2.1 Syracuse

The archaeological work carried on the island of Ortygia (Fig. 1.4) over the centuries is summarised in Appendix 1.[65] Cavallari and Holm are credited with the most methodical analysis of the history and archaeology of Syracuse in the nineteenth century.[66] The remains of the Temple of Apollo were of interest early on, but they were not fully excavated until Cultrera's work in the 1940s.[67] Through the second half of the twentieth century multiple excavations took place throughout the island, exposing various parts of the urban plan, but the focus of the fieldwork was mostly on the Classical and Later periods. However, during work under the modern Municipio building, housing from the period of settlement foundation was discovered beneath the Ionic temple.[68] This provides the only evidence of residences in the first stages of the Greek settlement.

Ortygia has been densely settled for close to three millennia, so the oldest layers of occupation are expectedly scarce. The Temple of Apollo and the houses beneath the Ionic temple represent the extent of Archaic period structures known on the island. Any early fortifications were replaced in the fifth century BC and subsequently over the following centuries. Therefore, the fortifications of Syracuse are not addressed below.

---

[62] Orsi 1899c.
[63] Orsi 1928, pp.75-8, Orsi 1930, p.144. Cf. Di Vita 1956a, p.189.
[64] Bernabò Brea 1956; Bernabò Brea 1986.
[65] See Appendix 1: S, section C.
[66] Cavallari & Holm 1883.
[67] Cavallari 1875; Cultrera 1951.
[68] Pelagatti 1982b.

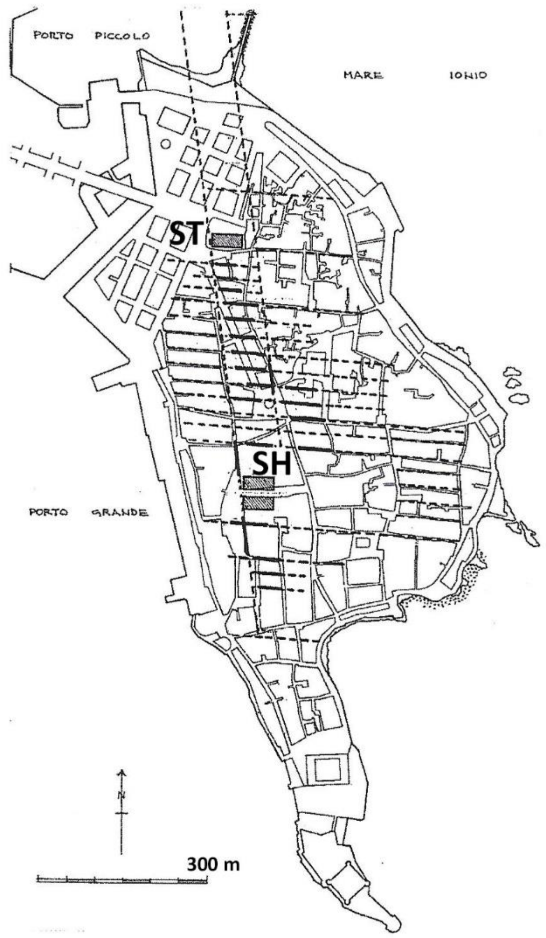

Fig. 1.4: Syracuse. Island of Ortygia with ancient urban plan overlay with location of the Temple of Apollo (ST) and foundation period houses (SH). Voza 1999, p.92.

1.2.2 Heloros

Orsi identified the plateau at the mouth of the river Tellaro as Heloros (Fig. 1.5) at the end of the nineteenth century.[69] Much of evidence uncovered at this time was Hellenistic, including the upper layers of the Koreion, although some material allowed him to suggest a date of foundation of the settlement in the sixth century. The site was revisited three decades later, but it was not until the mid-twentieth century that seventh century BC material was recovered by Militello.[70] At the same time, Archaic fortifications were discovered below the Hellenistic re-fortification. Work continued only occasionally for the next thirty years, focused largely on the Hellenistic agora in the south-west corner and the centre of the plateau below the second century Sanctuary of Demeter. It is in these areas that evidence was found dating the site firmly to the end of the eighth century BC with houses of the foundation period.[71]

[69] Orsi 1899c. See Appendix 1: H, section C.
[70] Militello 1966.
[71] Voza 1972-1973, p.189; Voza 1980-1981, pp.685-8.

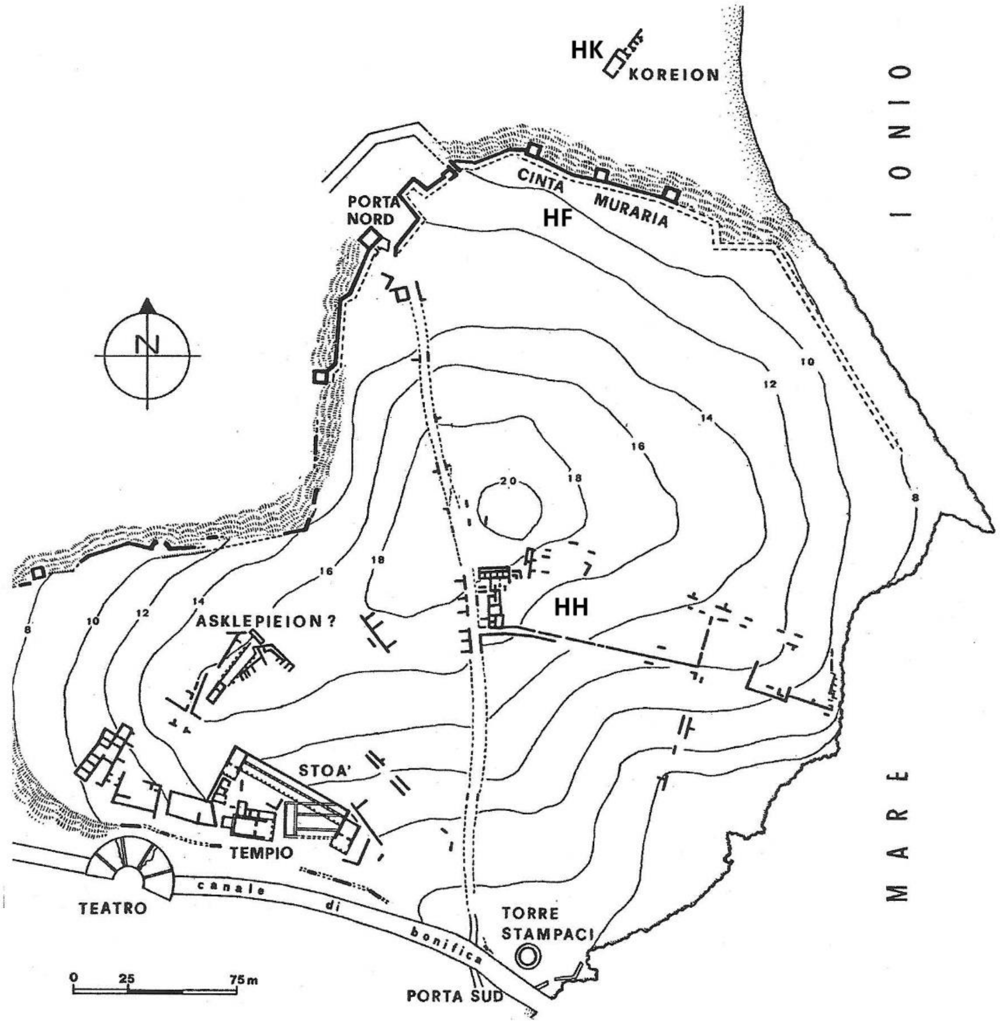

Fig. 1.5: Heloros. Urban plan including temples and agora of Hellenistic dating in south-west corner. Residential area (HH) in the centre, Archaic wall (HF), including northern gate, and Koreion (HK) north of urban centre. Voza 1999, p.115.

The occasional attention paid to the archaeological park at Heloros highlights the difficulties of assessments of the Archaic period based on archaeological data. The foundations of the Koreion and early residences, and a small stretch of the wall provide only a fragmentary picture of the material remains from this era; however, based on comparanda from other contemporary Greek Sicilian sites it is possible to discuss the settlement's foundation and subsequent development.

1.2.3 Akrai

Archaeological interest in Akrai was initiated in the sixteenth century by a Sicilian monk, Tommaso Fazello, who first identified the site as an ancient settlement (Fig. 1.6).[72] Excavations were started in the early nineteenth century by Baron Judica, and they continued for most of the century under different directors. Material recovered at this time was primarily Classical and Hellenistic, and the work is focused on the bouleuterion, theatre, catacombs and

[72] Chowaniec & Misiewicz 2010. See Appendix 1: A, section C.

necropolis. Archaeological work ceased in the middle of the twentieth century, and further material has only come from chance finds and agricultural work in the area surrounding the site.[73]

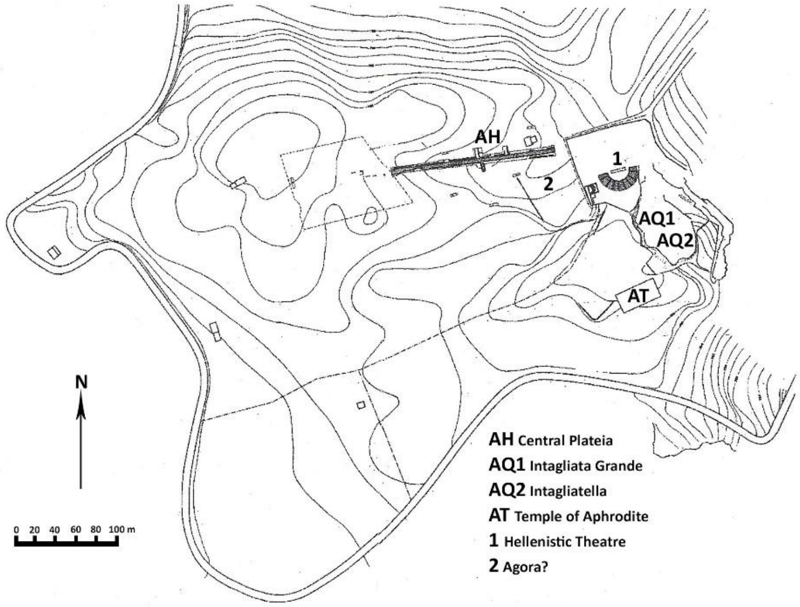

Fig. 1.6: Akrai. Urban plan of Archaic period showing the central plateia (AH), the quarries (AQ1, AQ2) and Temple of Aphrodite (AT). The modern ring road likely traces the path of the ancient fortifications (AF). Voza 1999, p.130.

Bernabò Brea was appointed director of the Soprintendenza Archeologica di Siracusa in 1941 and almost immediately began work in the area. In 1953, the detailed excavations on the site provided further information on the Greek settlement. More work was carried out on the theatre and bouleuterion, a few traces of the fortifications were identified, and the Temple of Aphrodite was identified.[74] The monograph of the temple published in 1986 provides a basis for the reconstruction discussed below.[75] As for the remains of the fortifications, evidence of the construction technique and the terraced wall following the natural topographical features was discovered at strategic locations. Bernabò Brea suggested a construction date around the fourth or third century BC based on historical reasoning, although an earlier dating is possible based on comparative material at other Greek sites.[76]

Work continued in the archaeological park and surrounding areas through the 1960s and 1970s under the direction of the Soprintendenza and further Classical to Roman material was discovered. One of the main plateiai and seven stenopoi have been located, providing an understanding of the urban plan. Yet, only late Hellenistic housing has been found. Foundation period residences must, therefore, be hypothesised based on the urban plan and contemporary housing elsewhere. In the last few decades the third century agora has been investigated; while

[73] Garozzo 1994, pp.194-5.
[74] Bernabò Brea 1956; Bernabò Brea 1986.
[75] See section 6.7 below.
[76] See section 6.1 below.

the most recent work has been largely non-destructive geophysical prospection and focused on the urban plan.[77]

1.2.4 Kasmenai

Compared to the other sites discussed here, Kasmenai has received the least amount of attention archaeologically.[78] Orsi first began work on the plateau of Monte Casale in the 1920s, identifying it with Kasmenai, although this was not widely accepted until a few decades later.[79] Orsi discovered numerous houses of the sixth to fifth century and the Temple of Ares but his work remained unpublished. Flooding in the mid-twentieth century revealed some blocks of the fortifications, although largely not in situ.[80] This is the extent of the archaeological understanding of any defensive structure at the site. Further work in the third quarter of the century focused on the urban layout with approximately forty stenopoi discovered, although no transverse plateia has been identified. An entire housing block was excavated, providing the plan for the reconstruction and labour cost calculations discussed in detail below.[81] Evidence for the temple and fortifications are not as secure, relying on foundations and a short stretch discovered in the 1950s; further analyses are, therefore, based largely on comparative material from other sites.

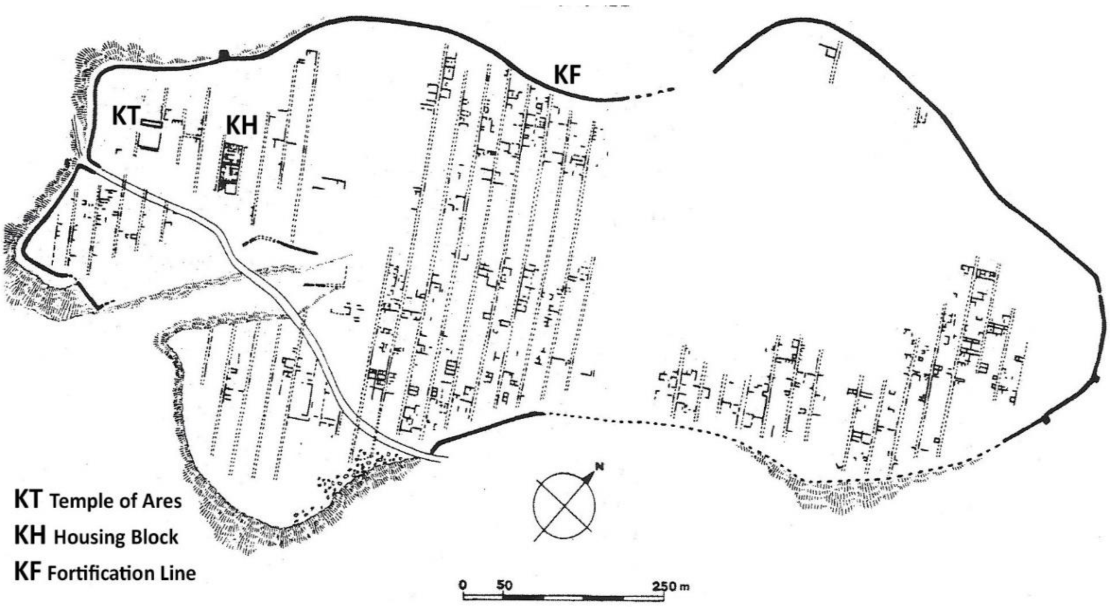

Fig. 1.7: Kasmenai. Urban plan of Archaic period. Black outline is known extent of Archaic wall (KF). The fully excavated housing block (KH) sits east of the Temple of Ares (KT). Voza 1999, p.138 with additions.

[77] Chowaniec 2015.
[78] See Appendix 1: K, section C.
[79] Pelagatti 2002.
[80] Rizza 1957.
[81] See section 7.6 below.

1.2.5 Kamarina

The first, brief, work on Kamarina (Fig. 1.8) was conducted in the last quarter of the nineteenth century by Cavallari.[82] Orsi began annual excavations in 1896, which ran until 1910, over the urban area, discovering the fifth century BC Temple of Athena, a stretch of fortification wall, and the necropoleis, with some work at the mouth of the river Ippari.[83] Between 1904 and 1907, his work provided quite limited results leading Orsi to believe that the site was destroyed too extensively in antiquity to warrant future work. Nonetheless, Pace continued the excavations after Orsi until 1925, but in the hinterland, connecting much of the area to the site. Excavations resumed in the 1950s and have continued almost annually to 1985, largely in the area surrounding the urban centre, but with some systematic excavations inside by Pelagatti. Di Stefano concentrated in the last decade of the twentieth century on the agora and shipwrecks discovered near the coast. Regarding the agora, Di Stefano has argued that it was part of the original town design.[84]

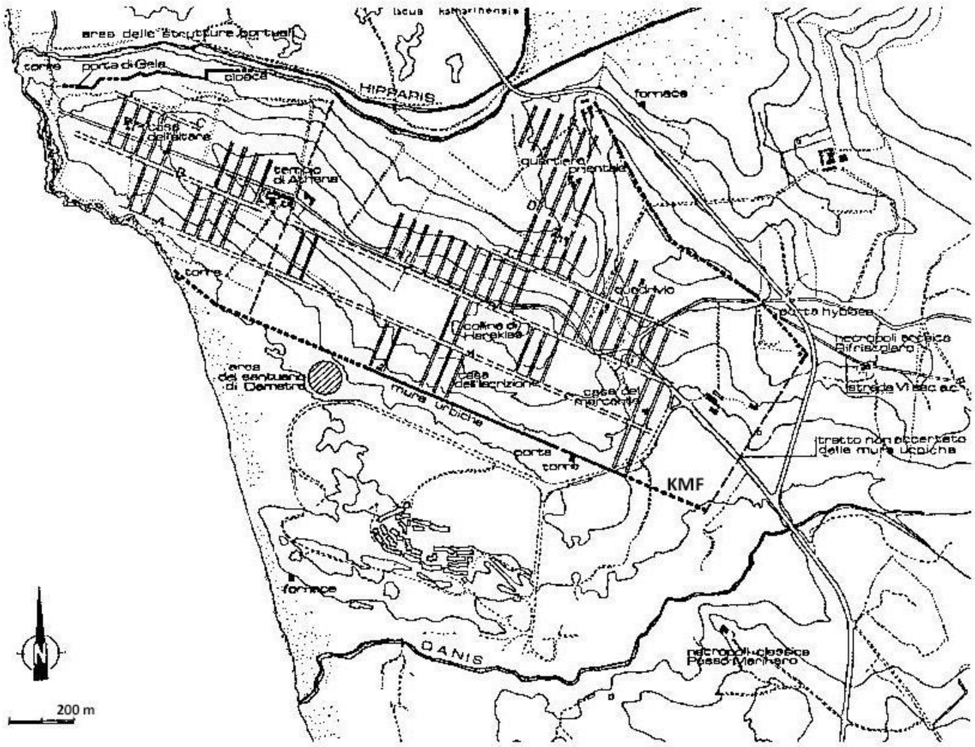

Fig. 1.8: Kamarina. Plan of urban centre to the Classical Period and fortifications (KMF) between the rivers Hypparis and Oanis. Domínguez 2006, p.291.

Orsi's observation of the severity of ancient destruction is largely correct. With regard to the Archaic period occupation, the site seems to have been destroyed thoroughly. The most important preserved features of the foundation period are the fortifications and the six-metre stretch of wall discovered by Orsi in 1896.

[82] See Appendix 1: KM, section C.
[83] Orsi 1966a.
[84] Di Stefano 2000b.

1.3 Terminology

Before proceeding, there are key terms for which the usage in modern scholarship has been inconsistent. In cases where it is possible to avoid using one of those terms and substitute it with a less problematic one I have done so: for example, 'settlement' is a more neutral term than 'sub-colony'. The latter brings with it the preconceived notions of the word 'colony', while the former does not. Debate over these terms is ongoing, and this is not the place to continue such a discourse. The discussion below introduces these terms and relevant ancient sources and modern studies.

The most logical place to start is with the term 'polis'.[85] The term has traditionally been used for independent Greek cities which were able to, for example, wage war, pass laws, strike coins and found colonies. These aspects can be inconsistent and confusing to use the term in a study on settlement patterns such as this. Hansen and Nielsen discuss Osborne's use of 'polis' in his *Classical Landscape with Figures* as an example.[86] Osborne uses 'polis' synonymously with city. This is acceptable to Hansen and Nielsen as 'the Greek terminology and the Greeks' understanding of their own environment are issues deliberately left out of consideration in this type of study.' However, there is no need to use the term 'polis' in this thesis. While there is little doubt about the affiliation of the term with Greek urban centres such as Syracuse or Gela,[87] the smaller settlements discussed here, such as Heloros, Akrai and Kasmenai, are less straight-forward, no matter how they may have perceived themselves in the Archaic period. Heloros is called a polis by Ps.-Skylax (13), but this is from its position at a later date.[88] Akrai is only referred to as a polis in reference to the treaty between Rome and Syracuse in 263 BC.[89] Herodotus (7.155.2) calls Kasmenai a polis when he discusses the return of the *Gamoroi* to Syracuse by Gelon, but there are no sources from the Archaic period.[90]

'City-state' is often used as a synonym of 'polis'. Trigger defines 'city-state' as a small polity consisting of an 'urban core surrounded by farmland containing smaller units of settlement.'[91] This definition is also relevant to the present study.[92] Heloros, Akrai and Kasmenai were all started as settlements of Syracuse and whether they can be classified as

---

[85] And the most logical start from there is to examine the bibliography of the Copenhagen Polis Centre. Hansen & Neilsen 2004 is the primary source for this discussion.
[86] Osborne 1987; Hansen & Neilsen 2004, p.26.
[87] See e.g. Fischer-Hansen et al. 2004, pp.192, 225.
[88] Fischer-Hansen et al. 2004, p.195 cannot be sure of its status in the Archaic and Classical periods and suggests it was dependent on Syracuse.
[89] Dio. Sic. 23.4.1. Heloros is included in the same treaty. Fischer-Hansen et al. 2004, p.189 is equally uncertain of Akrai.
[90] Fischer-Hansen et al. 2004, p.205 expresses the same uncertainty as at Heloros and Akrai.
[91] Trigger 2003, p. 92.
[92] What rural settlement units that may be attached to each territory is discussed below in the population assessments of each site.

'city-states' in the Archaic period is debatable: with the exception of Kamarina in 599 – 552 BC they were dependent on Syracuse and part of its territory, not independent 'city-states'. De Angelis prefers to use the term 'city-state' in studies of Greek Sicily, along with the associated 'territorial state', for the emphasis these terms provide to political, territorial and urban discussions.[93] This term 'territorial state' includes a definition of the administrative structure of the state: 'a ruler [governing] a larger region through a multileveled hierarchy of provincial and local administrators in a corresponding hierarchy of administrative centres.'[94] As we will see below, Syracuse wished to maintain control over its settlements, but it is not clear that there was a bureaucratic administrative organisation in place to do this. Therefore, Archaic Syracuse cannot be classified as a 'territorial state' following De Angelis' definition.[95]

The use of the terms 'colony' and 'sub-colony' are likewise in need of a definition.[96] The term 'colony' itself is derived from the Latin word *colonia* which is linked closely to the idea of cultivating and redistributing land. Thus, a 'colony' is linked with the land itself and the settlers working it.[97] By comparison, the Greek word *apoikia* translates best as 'home away from home' and is commonly used by modern scholars to describe the Greek settlements around the Mediterranean and the Black Sea.[98] An overseas settlement is seen, therefore, as an extension of the originating site ('mother city' or metropolis[99]) and culturally linked with it. The perceived neutrality of the term 'apoikia' compared to 'colony' has resulted in preference of the first in several studies in the previous decades, in academic scholarship focusing on the migration of the Greeks throughout the Mediterranean during the Late Geometric and Archaic periods and the problems in the use of the term 'colony' and its connotations have long been acknowledged.[100] To what extent the Greek expansion may be considered a colonial endeavour has been a topic of debate.[101]

Van Dommelen has addressed the issue of using the 'colonial' terms recently.[102] He addresses two fundamental questions with regard to the use of modern colonial concepts in current scholarship. The first revolves around the difficulty how modern concepts can be applied to the past and specifically Classical antiquity. The view of associating the migratory patterns of the Greeks with the colonial mind-set of a culturally superior group encountering an

[93] De Angelis 2016, p.63.
[94] Trigger 2003, p.92.
[95] De Angelis 2016, p.102.
[96] Cf. Descœudres 2008, pp.290-3.
[97] Gosden 2004, p.1. Cf. Finley 1976, p.173.
[98] For *emporion*, see n.114 below.
[99] See Malkin 2016 for the evolution of the term 'metropolis' in the Greek world.
[100] Goff 2005, pp.1-24.
[101] See Shepherd 2009, pp.15-7 and Malkin 2016 for recent overviews on how the use of and debate over colonial terminology has evolved and the place of the 'mother city'.
[102] van Dommelen 2012.

inferior indigenous society is the framework held in much of earlier scholarship on the topic. Also, 'outright refusal to compare ancient colonial situations to others elsewhere or of later times, however, ignores the long-standing anthropological and archaeological traditions of cross-cultural comparison.'[103] However, careless use of the 'colonial' terms can confuse or even distort the understanding of the past and distract from the factors leading to and the implications involved with the colonisation process.[104] Comparing past 'colonial situations' does not presuppose that they are inherently identical; instead merely a few specific aspects may be similar.

This leads to van Dommelen's second question on why such confusion currently exists on the topic of colonisation. During the world's most recent colonial era of the eighteenth and nineteenth centuries, the modern colonial experiences became imbued within the contemporary focus of European politics and education based on Classics.[105] Inevitably, scholars associating the present with the past came into positions of influence and guided the direction of academic research.[106] As Finley points out, 'once a settlement is labelled a colony, that word's cluster becomes attached', including the association of dependency to the place from which its population emigrated.[107] Extending the point further, Morley recognizes the possibility of an unintentional racist bias within ancient history and classical studies.[108] Referencing Bernal's critique of nineteenth-century classical scholarship,[109] Morley admits the likelihood of this Eurocentric influence, largely focused on the relations of the Greeks and Romans with the indigenous peoples.[110]

I will not go as far as suggesting that a degree of subconscious racism has shaped the archaeological historiography of the past century, yet one cannot dismiss that outside influences, such as current events, can affect scholarly research.[111] Also, traces of one-sided colonialist interpretations can be recognised in much of the early archaeological work on Syracuse and its settlements. Research completed during the first half of the twentieth century was done still, most likely unintentionally, with this frame of mind, culminating in Di Vita's 1956

---

[103] van Dommelen 2012, p. 397.
[104] Cf. Gosden 2004, p.6; Morley 2004, pp.103-4.
[105] Cf. Morris 1994, pp.9, 20; Descœudres 2008, pp.293-4; Attema et al. 2010, p.10; De Angelis 2016, pp.5-7.
[106] Van Dommelen specifically identifies Dunbabin's *The Western Greeks* as 'a classic example of a one-sided colonialist interpretation of an ancient colonial situation.' Cf. Hodos 2006, pp.10-1; De Angelis 2016, pp.16-8.
[107] Finley 1976, p.174.
[108] Morley 2004, pp.103-4.
[109] Bernal 1987.
[110] See also Hingley 1997, pp.83-4.
[111] Cf. Hodos 2006, pp.9-19; Hodos 2010b, pp.5-7. See also Malkin 2016, p.30; De Angelis 2016, pp.4-24 on the development of Sicilian archaeology from the sixteeth century to the present and the socio-political factors involved.

summary of Syracuse's 'penetrazione' in south-east Sicily.[112] The preconceived notions of a militaristic endeavour by Syracuse across south-east Sicily can be placed in this framework and they disregard many aspects of the motives behind the settling of Heloros, Akrai, Kasmenai and Kamarina and the relations with other neighbouring Greek and indigenous communities.

Academic mentality has shifted in the latter half of the twentieth century, allowing for broader contexts to be taken into consideration.[113] Returning to specific use of colonial terminology, the situation described above has resulted in some studies dismissing the use of the word 'colony' in favour of the terms used by the Greeks themselves, for instance *apoikia*.[114] Osborne even takes this one step further by proclaiming that 'Greek history will make a great advance when the word colonization is eradicated from the books of Greek history.'[115] On the other hand, Malkin rightly points out that there seems to be no acceptable substitution for 'colonisation' that can fully encompass the full range how the term is used in a large body of scholarship.[116]

Greek expansion into the Western Mediterranean, and more specifically the Syracusan spread across south-east Sicily, has been discussed as an act of militaristic establishment – Gosden debates this issue fully in *Archaeology and Colonialism.*[117] Also, lengthy discussions to define the term 'colony', such as Finley's are fruitful, but this will not be attempted here.[118] Several of the studies referred to in this thesis could be analysed for their inclusion of a colonial framework, because of an involuntary bias. However, this is not a focal point of this dissertation, but rather a topic which can be kept at the back of one's mind. Furthermore, even though the use of colonial terminology has fallen out of favour in recent scholarship,[119] the choice here is to continue using the variations of the word 'colony' at times since it is part of the standard vocabulary of the studies published over the past century.[120] However, the term 'settlement' will be used more predominately.

---

[112] Di Vita 1956a.
[113] Cf. Finley 1976 esp. p.173-4; Morris et al. 2003, pp.245-6; Shepherd 2009, pp.15-7; De Angelis 2010a, p.21; De Angelis 2016, pp.19-20. With specific reference to south-east Sicily: Copani 2005 overview of Heloros and Melfi 2000 reexamination of the weapons found at Kasmenai.
[114] See e.g. Bravo 1996, p.543; Greco 2000, p.14; De Angelis 2010a, pp.20-1. The term *apoikia* can be compared with *emporion*, two Greek words that refer to different types of settlements. See Ampolo 1994; Bravo 1996, pp.554-6; Wilson 1997; Hansen 2006a. Di Vita 1987, p.79 debates the proper term to apply to Akrai and Kasmenai.
[115] Osborne 1998, p.268. Cf. Morakis 2011 esp. 460-2 and the accompanying footnotes for an overview of the debate surrounding Osborne. See also Malkin 2016, pp.31-2 on the impact, or lack thereof, of Osborne's view.
[116] Malkin 2016, pp.28-33.
[117] Gosden 2004 esp. Chapter 1, including the different motives behind colonisation.
[118] Finley 1976.
[119] Although this has not impeded the continued use of the word. For a most recent discussion see De Angelis 2009.
[120] This is supported by Malkin's view that more work needs to be done before 'colonisation' can be eliminated, Malkin 2016, pp.32-3.

A further distinction in the context of settlement foundations in south-east Sicily concerns the designation of sites founded by a colony within generations of its own foundation. Lombardo focuses on a chronological factor to differentiate between the settlements founded by a settlement of colonial origin.[121] Chronologically, a 'sister' colony is a foundation by a colony within the first generation, or near to, of its existence. Those falling under this heading are considered too close to foundation to form its own colonial context. This term applies to Leontinoi and Katane from Naxos, for example, or more importantly for this study, Heloros. It will be stressed below that Heloros was likely placed to secure a fertile river valley while simultaneously preventing other Greek colonial endeavours from settling there. Next, a 'secondary' colony is one founded within three or four generations, such as Akrai and Kasmenai. These are products of 'dinamiche di crescita e articolazione della comunità politica e sociale', the dynamics of growth and articulation of political and social communities.[122] A 'sub-colony' has been characterized as one which was established more than four generations after the original colony. These colonies are so chronologically distant from the foundation of the principal colony that the latter has shed any colonial traits and has matured to an outright metropolis. Kamarina's settlement date can be placed within the sixth generation of Syracusans, and its foundation is markedly different than the previous three.

These designations have generally been confined to discussions within the grouping of colonies of colonies. This is the case here, and the variance between terms is relevant in the present discussion, although distinction is often not made in general academic work. For this reason, when discussing the sites together, all settlements founded by Syracuse are referred to simply as 'settlements' or, in order to avoid repetition, 'sub-colonies'.

The last terms to be discussed arise from similar concerns as the ones related to the term 'colony'. Hodos argues that neither 'native' nor 'indigenous' are acceptable terms in reference to the populations already present in Sicily when the Greeks arrived.[123] 'Native' carries with it connotations of racial inequality stemming from the prejudicial actions of Western civilisations in the nineteenth century. 'Indigenous', on the other hand, while not as offensive, implies a population that has been present in the territory for the entirety of its existence. This view is not supported by what is known about the migrationist patterns in the Mediterranean in the first centuries of the first millennium BC. She prefers the term 'local', but this itself is not without issue.[124] 'Local' is of more geographical designation and can over time come to mean the Greek populations that themselves have at that point been present in Sicily

[121] Lombardo 2009, pp.24-5.
[122] Lombardo 2009, pp.24-5.
[123] Hodos 2006, pp.14-5.
[124] Hodos 2010b, pp.14-5.

for generations.[125] Although both are still in use in academia today, 'indigenous' is preferred here over 'native'. I have avoided the use of 'local' since it may cause confusion when discussing those present at the end of the Archaic period and beyond.

Last, De Angelis stresses the use of 'elite' when discussing the highest social class of Greek society.[126] While privileged, wealthy and politically superior to the lower classes, they should not be called aristocracy or nobility as these terms have origins at the end of the Middle Ages and are instilled in the intricate ancient regime that followed.

As the historiography of Classical research has evolved, so too has the usage of the associated terms; development of the research of settlement patterns in antiquity has resulted in increased importance of defining the terminology used in the argumentation. The terms discussed above, including those preferred here, are prompted by a deeper grasp of the ancient Greek world and also an acknowledgment of the more recent past and its effects felt today. The terminology used below, therefore, attempts to achieve a balance between what is commonly used in archaeological and historical research of the area with what most aptly carries forward the argument of this thesis.

[125] For instance when Hermokrates, at the Congress of Gela, invokes 'Sikeliotai' as an identifier for Sicilian born Greeks in 424 BC (Thuc. 4.64.3), Lombardo 2012, p.79. Cf. Diod. Sic. 16.83.1.

[126] De Angelis 2016, p.146 following Duplouy 2006, pp.11-35.

Chapter 2: Historiography

This chapter presents both the ancient sources and modern studies of south-east Sicily. The textual sources provide a basis for comprehension of the area, but relying solely on them produces a very fragmentary and occasionally tendentious picture, so it is necessary to consider the archaeological evidence in relation to these texts. The changing focus of Italian scholarship of the region demonstrates how approaches and current events have influenced the examination of the archaeological record. The factors behind the Greek establishment of settlements in Sicily are addressed, followed by a discussion of recent theoretical approaches to the region. In earlier scholarship the prevalent point of view stressed that the motivation of Syracuse for founding settlements across the region was based on conquest and defence. The socio-political situation in Syracuse at the time offers a background to the expansion process, and the historiography of each site presents the earlier scholarship on Heloros, Akrai, Kasmenai and Kamarina. The recent studies on the interaction between the Greek settlers and their indigenous neighbours indicates that the relationship was more peaceful than that what was argued predominantly in earlier scholarship. Last, the approaches to available evidence analysed in this thesis are introduced.

2.1 Ancient Sources

Even though the ancient textual sources discussing Sicily are very fragmentary in their interests, they do provide a historical framework and some details on the socio-political events of the region. For dating the foundation of Syracuse and its colonisation of south-east Sicily, Thucydides (6.3.2; 5.2-3) remains the key resource. The exception to this is the foundation of Heloros, which is not mentioned by him. Thucydides also relates the foundation and destruction of Kamarina by Syracuse and again by Gela. However, the reliability of some parts of his narrative has been questioned in recent years, and must be read with modern accounts.[1] For instance, archaeological evidence questions his account (6.2.6) that the Phoenicians settled on the island prior to the Greek arrival, but this particular issue is not relevant to south-east Sicily.[2]

Another fifth century BC author, Herodotus, relates events of the Archaic period, although after that of Thucydides. Herodotus (7.154-156) describes the conflict between Gela and Syracuse at the beginning of the fifth century, including the latter's subjugation and the movement of populations from Kasmenai and Kamarina to the city-state. These events lie at the chronological end point of this study, but they are part of the socio-political connections

[1] Sjöqvist 1973, pp.15-6; Coldstream 2003, p.223; Hodos 2006, p.92; Morakis 2011, pp.463-7.
[2] De Angelis 2016, p.39.

between groups of people under Syracusan hegemony, such as the expulsion of the Gamoroi and their relocation at Kasmenai for refuge (7.155). Herodotus also becomes useful in his narration on the Bacchiad clan of Corinth and the possible political implications that the ruling class had on the founders of Syracuse (5.92.b). In the fourth century, Aristotle gives an account of the politics of the period.[3]

Writing in the first century BC, Diodorus Siculus (8.10) provides a potential glimpse into the economy and socio-politics of Archaic Greek Sicily. For example, Agathocles (8.11) used material earmarked for the Temple of Athena in the construction of his own house in the late seventh century BC. As punishment, he was struck by lightning and his house was lost to fire. While this plays as a warning to others from doing the same, it also relays insight into the social factors at work in the society against self-aggrandising actions to promote oneself above the community. In the first century AD, Plutarch (*Amatoriae* 2) and Strabo (6.2.4; 8.6.22) tell the foundation story around the *oikist* of Syracuse, Arkhias, and the events leading to his journey to Sicily. The distance of Strabo to these events is evident, however, as he claims that Syracuse and Kerkyra, both colonies of Corinth, were founded at the same time, which the archaeological evidence contradicts.[4]

The views of the role of Heloros in the expansion of Syracuse are grounded in Roman texts. The site is mentioned briefly by Pliny the Elder in *The Natural History* (32.7) as a 'fortified place in Sicily...not far from Syracuse' and Claudius Aelianus in *On the Nature of Animals* (12.30) as a *phrourion* (fort/citadel). Therefore, Heloros, prior to the archaeological discovery of the ancient site, was already regarded as a fortified settlement. These ancient sources are discussed in further detail below in this chapter.

2.2 Italian and International Scholarship

Over the last 150 years, scholarship by Italian and international historians and archaeologists has developed through various methodologies and theoretical approaches. Already in the nineteenth century, Hellenism was well established and rooted deeply in a discourse separating the Greeks and the non-Greeks, thanks in large part to the works of George Grote and Adolf Holm.[5] Edward Freeman's work at the end of the century compared Greek colonisation with the modern American colonisation, and he addressed the reciprocity of the interaction between the Greeks and their indigenous neighbours, although, as archaeology was still in its infancy, he relied largely on literary sources.[6] At the same time, Paolo Orsi and Luigi Bernabò Brea,

[3] *Pol.* 5.1303b.20-22; 2.1265b.12–16; 127a; 1296a.18-22; 1303b.20.
[4] Domínguez 2006, pp.271-2.
[5] Grote 1946-56; Holm 1870-1898. Cf. Osborne 1998.
[6] Freeman 1891-94.

archaeologists, integrated prehistoric material culture into classical literature and culture, allowing for the archaeology to be seen in a wider context and placing more predominantly the connections between the cultures, yet still from a pro-Hellenic viewpoint where the two cultures were defined by their material culture. The work of these two still plays important roles in the understanding of south-east Sicily today, and in fact their archaeological endeavours are at times the main resource for the studies in the following chapters.

As archaeology evolved and more material was uncovered, research and understanding of Ancient Sicily broadened, largely in thanks to Biagio Pace who incorporated the indigenous culture, Carthaginians and Romans with the Greek studies.[7] He also dedicated large sections to the functions of demography, production, exchange, architecture, law and philosophy, amongst others, within the overall analysis. However, the region was still seen through two opposing cultures, largely following the work by Thomas Dunbabin.[8]

From the 1960s, this view mostly changed. Decolonisation practices implemented by newly-formed countries fostered an enthusiasm towards postcolonial approaches of regional history.[9] An important part of the new methods of scholarship is the development of culture contact, or middle-ground. In Sicily, this model has been strengthened by increasing research in prehistoric and indigenous cultures over the past few decades.[10] In general, new methodologies and theories of archaeology and history are widely accepted, paying attention to the relationship between the indigenous communities and their new Greek neighbours, as will be discussed further in the next section. However, even though the changing approaches to the archaeology and historiography of south-east Sicily, there is a tendency to emphasise the military aspect of the expansion of Syracuse across the region.

2.3 Current Approaches to Colonisation and Sub-Colonisation

For almost a century, commercial success through exploitation of already established trade routes has been considered a motivation for sending out colonists,[11] supported by literary evidence.[12] The first pre-colonial trading settlement, Pithekoussai, had connections with a large number of cities across the Greek world.[13] In fact, the location of Syracuse hints that the

[7] Pace 1935-49 and the second edition of the first volume in 1958. Cf. De Angelis 2016, p.18, n.73.
[8] Dunbabin 1948. Cf. Manni 1977, pp.19, 27-9 and Dyson 2006, p.195 for criticism of his approach.
[9] Cf. Malkin 2004.
[10] Hodos 2006, pp.99-157.
[11] First hypothesised by Blakeway 1932/1933, pp.205-7. Although there are flaws in his argument, the hypothesis has remained. Cf. Young 1939, pp.3, n.2; Dohan 1942, p.29; Cook 1946, pp.80-1, n.119; Asheri 1980; Graham 1990; Giangiulio 1996, pp.505-6; Osborne 1996, pp.41-2; Coldstream 2003, pp.203, 225; Hodos 2006, pp.89, 94-9; De Angelis 2016, pp.34-9.
[12] Dion. Hal. *Ant. Rom*. 3.46.3–5; Herod. 4.151-2; Thuc. 1.13.2.
[13] Ridgway 1992, p.108; Domínguez 2011, pp.196-7. Cf. Ampolo 1994; D'Agostino 1994; Greco 1994; Hall 2007, pp.98-9. For a recent overview of the study surrounding Pithekoussai, see Guzzo 2011, pp.71-91.

colonial party already knew the area, presumably, at least in part, through trading ventures that had previously scouted the site.[14] Alternatively, overpopulation and climatic changes place an importance on landownership and agricultural capacity: when there is an inadequate amount of resources, emigration provides a possible solution.[15] While this is difficult to prove archaeologically,[16] land and agriculture nonetheless were important to the Greeks and the colonial process, as can be seen in the specific mention of the agricultural delegation from Tenea sent with the colonists to settle Syracuse.[17]

Giangiulio places all of these under an overall 'Greek revival' in which the enterprise to occupy resource-rich, undisturbed land was instigated by and predicated upon the flourishing trade networks throughout the Mediterranean.[18] During this *fase di profonda ridefinizione*, phase of profound redefinition, hierarchies were altered through fluctuating social power and personal influences. From the beginning of the expansion into Magna Graecia, the movements of the poleis were dictated by the decisions of the ruling party members, and, no matter the form of government, these would have been in the hands of the rich and powerful.[19] The placement of the ruling elite at the centre of a colony can be seen through the myth attached to the foundation of Syracuse.[20] In this, Arkhias is responsible for the death of a young boy, Aktaion. Arkhias voluntarily exiles himself, lifting a curse, thereafter sailing to Sicily and settling Syracuse. Although Salmon views this myth of Arkhias as a 'patently romantic invention',[21] and indeed this may be said about any foundation myths surrounding social disorder, there may be some truths to be found within it.[22] Perhaps there was a social backlash for this incident, or something similar, towards Arkhias and the elite social class, the Bacchiads.[23] On the other hand, Arkhias can simply be an elite invention to bring honour to themselves through his admission of wrongdoing and voluntary exile.

---

[14] Salmon 1984, pp.66, 92-3; Snodgrass 1993, pp.31-2; Domínguez 2011, p.200; La Torre 2011, p.160. Cf. Hodos 1999, p.73; Crouch 2004, p.89; Guzzo 2011, p.192.
[15] Herod. 4.151.1; Paus. 2.29.7, 9.40.1; Plato *Laws* 708b, 740e; Camp 1979; Graham 1982, p.157; Salmon 1984, pp.63, 95; Hoepfner & Schwandner 1994, p.1; Muggia 1997, pp.25, n.55; Coldstream 2003, p.203; Scheidel 2003, p.121.
[16] Hansen 2006b, pp.12-4, 77-91; Descœudres 2008, pp.361-3; Osborne 2009, pp.29-31.
[17] Strab. 8.6.22. Cf. De Angelis 2016, p.160.
[18] Giangiulio 1996, pp.505-6. Cf. Muggia 1997, p.25; Domínguez 2011, pp.203-4; De Angelis 2016, p.49.
[19] Coldstream 2003, p.204; Domínguez 2011, p.199. For instance, the Myletidai were obliged to be a part of the foundation of Himera after their political faction was expelled from Syracuse (Thuc. 6.5.1). Cf. D'Agostino 2006, p.219; Morakis 2011, pp.491, n.177.
[20] Plut. *Amatoriae* 2. Cf. Diod. Sic. 8.10; Plut. *Moralia* 773b; Strab. 6.2.4.
[21] Salmon 1984, p.65). Cf. Dougherty 1993a, pp.178-98; Dougherty 1993b, pp.31-44 157-63; Domínguez 2006, p.271. The credibility of colonial foundation stories has not gone untested. See Hall 2007, pp.100-6.
[22] Malkin 2016 provides argument to the authenticity of *oikist*s.
[23] Guzzo 2011, p.195.

Dominguez sees the foundation of Syracuse as a planned enterprise.[24] Although material remains cannot be used to support Strabo's claim (6.2.4) that Kerkyra and Syracuse were founded simultaneously, he views the Bacchiad connection between Arkhias and Kerkyra *oikist* Khersikrates as evidence of Corinth planning westward trade routes. Colonial endeavours, whether led by a group of enterprising individuals or an entire polis, benefited the elite. First off, overpopulation or land scarcity could be a result of the elites not willing to share the inherited land or political advantages with rival factions and their supporters. Expelling a large number of those individuals secured the position of people remaining at home. Second, the elite factions were most likely the ones that had the resources to mobilise a community to found a colony, and in turn provide connections to resources abroad that furthered their own need for wealth. The westward expansion of the Greek peoples then becomes not a matter of solutions to specific problems, but instead multifaceted state-sponsored socio-economic endeavours led by elitist groups.[25] Further, Morakis sees this planned enterprise as an underlying cause of the second-generation colonies in Sicily.[26] Wealth, property, resources and trade all provide motives for the Syracusan expansion of south-east Sicily.

These outlined motivations and the scholarship behind them can be classified as a 'colonisation-as-foundation' approach, which focuses on people who founded the new settlements, or the 'colonizers', rather than considering wider processes and contexts of colonialism.[27] More attention needs to be placed on the interactions and relationships between the Greeks and their new neighbours. In a way this shift began in 1990 with Descœudres' publication of *Greek Colonists and Native Populations*.[28] Over the past few decades, this emphasis has evolved in overlapping terms as a part of postmodernism, postcolonialism and globalization, although these three theoretical methodologies are distinct in their own rights.[29] Whatever the theoretical umbrella, looking at the history of colonisation in this manner demonstrates how the interaction between indigenous and Greek cultures resulted in numerous new practices, identities and objects that represented a new and evolving culture in itself.[30] This new culture would come to be known as 'Sicilian', which incorporated not just the generations of Greeks born on the island but also their non-Greek neighbours.[31] This becomes

[24] Domínguez 2006, pp.271-2; Domínguez 2011, pp.195-207.
[25] Ath. 4.167d–e. For further discussion, see section 2.4.1 below.
[26] Morakis 2011.
[27] van Dommelen 2012, pp.399-400 highlights the attention towards foundation dates, *polis*-foundation and the importance of the mother city as 'symptoms' of this approach.
[28] Descœudres 1990. Cf. van Dommelen 2012, p.400.
[29] See Quayson 2005 on a discussion between postcolonialism and postmodernism and Hodos 2010a, pp.81-2 on a discussion between postmodernism and globalization.
[30] van Dommelen 2012, p.403.
[31] For instance when Hermokrates, at the Congress of Gela, invokes 'Sikeliotai' as an identifier for Sicilian born Greeks in 424 BC (Thuc. 4.64.3) Lombardo 2012, p.79.

important when looking towards the reasoning behind the establishment of Greek settlements in the area, and the relationship between the Greeks and non-Greeks opposing any sort of aggression or hostility.

Malkin approaches postcolonial concepts of colonisation through the view of political culture and religion.[32] When comparing the Archaic-period Greek expansion around the Mediterranean with the European colonisation of the New World, the practices of each in establishing a settlement differ in key areas. The Greeks established settlements that were linked through ritual ties to their mother cities but were independent political units distinct from them,[33] and these communities were in already familiar areas, as trade and exploration was commonplace. Whereas over two millennia later, European settlers travelled to little-known lands with unfamiliar inhabitants, founding settlements which were political extensions of the founding countries. These settlements themselves were politically centred on monarchies. When the polytheistic Greeks came into contact with other cultures, they recognised the shared characteristics and attributes between their deities and the foreign ones, and syncretism did take place especially in later Greek religion. Monotheistic Christian Europeans, on the other hand, were not as accepting of other religious views. These differing experiences led to binary ways of thinking which demonstrate the opposing views the Greeks and later European countries had towards 'colonisation' and the idea of an 'absolute other'. To the Europeans, the new settlements were markers of a dominant culture over the local populations. The Greeks did not view such a separation and were more accepting of the indigenous peoples. From this perspective, the opposing ways in which the Greeks of the Archaic period and the Europeans during the modern colonial period addressed their settlement expansion process indicates that the more recent experience cannot be categorically applied to the ancient world.

A more contemporary approach is globalization, stressing how the world is becoming more interconnected and gradually being seen as one place.[34] This understanding at first seems to contradict postmodern views, however instead it emphasises cultural heterogeneity: connected cultures can be both dependent and independent of each other and the awareness of other cultures leads one to emphasise one's own culture more intently.[35] The impact of colonisation on and the changes in the material culture of the indigenous Sicilians have been the focus of recent studies. Hodos outlines a multifaceted adaptation of Greek culture within Sicilian society such as housing, burial, consumption patterns and art.[36] The level of adaptation

---

[32] Malkin 2004, pp.346-52.
[33] Cf. Malkin 2011.
[34] Hodos 2010a; Hodos 2010b, pp.23-5.
[35] Hodos 2010a, p.82: 'Shared practices are not the same as identically replicated practices.'
[36] Hodos 2006, pp.99-157.

was not identical in every indigenous community, nor was it always for the sole benefit of the indigenous elite. Further, the cross-cultural connections did not come at the expense of already established cultural traditions. For instance, in the first century after the arrival of the Greeks in Sicily the indigenous populations imported pottery such as drinking cups which were similar to their own, but not until the end of the seventh century BC did the *krater* begin to appear in non-Greek contexts.[37] This indicates that the indigenous Sicilians adapted Greek pottery to their own cultural uses, but did not necessarily adopt Greek practices. Greek reciprocity can be found in Sicilian and Italic-style fibulas present in burials associated with Greek settlements. While these may represent indigenous members of the community, their inclusion is better explained through contact. Interaction and adaptation by both the Greeks and non-Greeks indicates that both cultures learned to live peaceably as neighbours. This relationship is examined further below,[38] but the point to stress here is that the attention placed on the archaeology and historiography of the indigenous communities provides value towards the social, political and economic nature of the Archaic period in the region.

De Angelis brings together three scenarios highlighting other avenues through which the Greek settlers may have developed socially and economically in the early period of colonisation in Sicily.[39] These scenarios include conquest, although for a different reason than previously maintained, middle-ground co-operation and the creation of ownership of previously unworked lands. Arguing against the traditionalist conquest point of view, he stresses that coastal lands believed to have been seized by the Greeks were not always occupied in the first place, and that the synoecism of local settlements could have come about not necessarily in response to defence, as largely argued, but to the economic possibilities they opened up to the Greeks. Moreover, De Angelis estimates that Sicily was largely unoccupied and unworked even after the arrival of the Greeks, dismissing land as a motive for conflict.[40] Socially, relations between the Greeks and indigenous peoples were quite possibly in good standing, and integration was widespread.[41]

In the end, the practices driving scholarship in Ancient Sicily have been more accepting of the roles non-Greeks, more specifically the indigenous peoples, played on the island and the interaction among the various cultures inhabiting the region.[42] However, it seems that while the indigenous populations have been given more focus and credence, scholarly views on the relationship between the two cultures has remained in some respects stagnated. For example,

---

[37] Hodos 2010a, pp.86-7.
[38] See section 2.4.6 below.
[39] De Angelis 2010a.
[40] See De Angelis 2000a, pp.138-41.
[41] For further discussion, see section 2.4.6 below.
[42] De Angelis 2016, p.22.

the actions of Syracuse are often seen as being detrimental to the indigenous populations and other Greeks. In the twenty first century, Heloros is still seen as a 'fortress' in the eyes of the Copenhagen Polis Centre, or along the same lines labelled a *phrourion* by other scholars.[43] Kasmenai and Akrai, by association, continue to be painted in a militaristic light,[44] even after alternative viewpoints have been proposed.[45] Moreover, it is interesting to note that Di Vita, in defending his assertion of Akrai and Kasmenai as having '*l'originario fine militare* [the original military purpose],'[46] often invokes the views of Dunbabin.

Focusing on the motivations of the Greeks founding new settlements admittedly presents only one side of the history of Sicily. The Syracusan expansion process should be viewed through this lens *and* simultaneously keeping an eye on the interaction and relationships between the Greeks and the indigenous populations of the south-east corner of the island. Ultimately, this thesis addresses the hegemonic expansion of the Syracusan Greeks over south-east Sicily, but their indigenous neighbours are also the key to understanding what were the motivations behind the foundation of the new settlements.

2.4 Current Understanding of South-East Archaic Sicily

In research literature, conquest has been emphasised as the principal motive of Syracuse in the foundation of new settlements in the surrounding areas. In 1956, amid much work being done on the settlements of Syracuse, Di Vita published an overall view of Syracuse and its spread across south-east Sicily. The following section is typical of the historiography of south-east Sicily and brings about two issues that can be highlighted:

> 'Nessun posto meglio di Monte Casale era più idoneo, verso la metà del VII sec. a.C., sia per stabilirvi un caposaldo inespugnabile alle spalle di Akrai — **che veniva così a perdere la sua funzione di punta avanzata, mentre veniva nel contempo ad acquistare i ricchi campi che si stendevano fra essa e M. Casale ormai ben protetti** — sia per aggirare alle spalle i Siculi del massiccio di Ibla ed i forti nuclei indigeni istanziati nel triangolo Ispica-Scicli-Modica e sia per costituire una base a metà strada di quella che, poco alla volta, veniva a delinearsi come la meta ultima dell'espansione siracusana vero ovest: il possesso della pianura fra gli Iblei ed i Dirillo.'[47]

---

[43] Anello 2002, pp.65-6; Fischer-Hansen et al. 2004, p.195; De Luna 2009, p.77; Collura 2012, p.31. See section 2.4.2 below.
[44] Erdas 2006, p.46; Copani 2009, p.15. See sections 2.5.3-4 below.
[45] E.g. Greco & Torelli 1983, p.183 is argued against by Di Vita 1987, pp.78-80; Melfi 2000 is argued against by Di Vita 2003 but supported by Greco 2009.
[46] Di Vita 1987, p.81.
[47] 'No place was more appropriate, towards the middle of the seventh century BC, to establish an impregnable stronghold behind Akrai — **which was thus losing its function as a spearhead, while at the same time came to acquire the rich fields that lay between it and M. Casale now well protected** — both to circumvent behind the Sicilians of the massif of Hyblaia and the strong indigenous groups found in the Ispica-Scicli-Modica triangle, and to provide a basis halfway through that which, little by little, was to emerge as the ultimate goal of Syracusan westward expansion: the possession of the plain between the Hyblaia and Dirillo [ancient Achates].' Di Vita 1956a, p.190. The emphasis in the text is mine.

First the attitude which can be classified as 'conquest bias'. While this quote addresses Kasmenai specifically, the mention of its place within the settlement landscape and as a part of Syracuse's ultimate goal relays a succinct message: this site was part of a larger plan. To stress that the site was 'un caposaldo inespungnabile' can provide little else but an almost castle-like image to the reader. Overall, these sentences paint a picture of Syracusan aggression, one that is repeated in academic publications in the over half century that have followed. When cited by Martin *et al*. in 1980 and again by Voza in 1999, the emphasised section was omitted.[48] Through staging the quote to stress the viewpoint more intently, this also brings about the second issue: an ulterior motive for Kasmenai. Leaving out this aspect of the foundation ignores an underlying purpose to its placement: land possession. Furthermore, Martin *et al.* neglects to mention another key part of this text. Immediately before this quote, Di Vita advances that the settlement at Monte Casale afforded Syracuse the ability '*per dare terra e ricchezza ai suoi cittadini* [to give land and wealth to its citizens].'[49] In effect, while there is an aggressive undertone in the placement and development of Kasmenai, Di Vita accepts that other socio-economic motivations may have played a role in the colonisation of Kasmenai. This view has largely been later ignored, and indeed the same mentality can be detected in much of the discussion of Heloros and Akrai. In the previous section, an overview of the motivations for settlement foundation stressed land as a powerful driving force for expansion. In the next section, analysis of Archaic Greek social norms at Syracuse point towards the same direction. In pre-monetary societies and also later, land was seen as an indicator of wealth and increased the status of the ruling elite. Below, each Syracusan settlement is addressed individually, and different views and interpretations of their foundation are discussed. First, will be presented how the role of Syracuse and its socio-political context in relation to new foundations has been analysed in previous research.

2.4.1 Syracuse and Its Socio-Politics

Even though 'equality' in colonial foundations has been emphasised in relation to, for example, Metapontion, where the *chora* is regularly divided among the urban and rural inhabitants,[50] the role of the ruling elite in Syracuse has been quite systematically stressed as the main driving force behind the new settlements in south-east Sicily: the new metropolis and the elitist desire for wealth, largely through property holdings and trade, and even aggressive colonisation have

[48] Martin et al. 1980a, p.530; Voza 1999, p.141.

[49] Di Vita 1956a, p.190. Most recently, Copani 2009, p.16 does include this part of the quote, but still does not discuss the implications of it.

[50] Carter 1996; McInerney 2004, pp.22-6; Carter 2006.

been regarded as the key motivations.[51] Agriculture is the basic foundation on which most communities develop and from which cities emerge. Without adequate farming, cities are forced to take other, often drastic, measures to ensure their residents are fed.[52] The importance of arable farmland to a new settlement and later a flourishing metropolis was vital. The expansion of the city required more arable land in the territory, making land ownership a valuable commodity that never went out of demand. Further, scholarship suggests land was a key indicator of wealth coveted for the means of socio-political gain.[53]

De Angelis argues that the foundation of Syracusan socio-politics has its roots in the metropolis, Corinth.[54] The Bacchiad clan, who ruled Corinth at that time, was already later in antiquity sees as the designer of many aspects of the foundation, including the allotment of land.[55] Crouch has argued that the expedition wished even to find an area to settle geologically similar to the motherland.[56] *Kleroi*[57] were given equally to those deemed citizens prior to foundation, which can be seen, according to Athenaios, in how Aithiops bartered away his land during the voyage to Sicily.[58] This land then gave these members of the ruling faction, the *Gamoroi*, privilege and qualification to rule.[59] One interpretation of *Gamoroi* can be *land sharers*, although Burford expects the lower classes did not have as equal distribution of property as the wealthy elite.[60] Fitzjohn stresses how in the early history of Greek Sicily inequality was underscored in the community by the location and allocation of land from foundation.[61] Arkhias, founder of Syracuse and member of the Bacchiad clan, probably maintained the status of citizens based on divisions in the metropolis.[62]

Although elitist rule is inherently socially unequal, Metraux shows that the life of the ruling elite was more fair, and laws were in place to secure and promote this state of affairs.[63] For example, in the late seventh century Agathokles, a wealthy Syracusan, was chosen to oversee the construction of the Athenaion on Ortygia.[64] During this, he used marble to build a

---

[51] Finley 1980, p.89; Bravo 1996, pp.528-9; Salmon 1999, p.147; Morakis 2015, p.35.
[52] Salmon 1999, pp.157-8.
[53] Snodgrass 1993, p.38; Bravo 1996, pp.528-9; Riva 2005, p.207; Domínguez 2011, pp.195-207. Cf. Foxhall 2005.
[54] De Angelis 2016, p.139. See Malkin 2016 on the connections between mother city and colony.
[55] Ath. 4.167d–e.
[56] Crouch 2004, p.89.
[57] Singular *kleros*, which may have at times signified a specific amount of land. Cf. Burford 1993, pp.15, n.3; Murray 1993, pp.39, 175.
[58] Ath. 4.167d–e; Métraux 1978, p.88.
[59] Finley 1980, p.89; Salmon 1999, p.147; Morakis 2015, p.35.
[60] Burford 1993, pp.15-33, especially p26-9 on just how 'fair and equal' the land lots may have been.
[61] Fitzjohn 2007, pp.217-9.
[62] Thuc. 6.3.2; Lepore 1970, pp.50-3; Dunbabin 1948, p.55; Morakis 2015, p.37. Although the arguments put forward by Morakis 2015, pp.38-9 suggest Arkhias was not a Bacchiad, or at least not a member of the ruling aristocracy in Corinth.
[63] Arist. *Pol.* 1266b 19-24; Métraux 1978, pp.89-97.
[64] Diod. Sic. 8.11.1-2.

stately home for himself, angering the other families. Agathokles and his house were consumed by flames, and his property and inheritance were confiscated. Although Asheri doubts the credibility of the anecdote,[65] the literature indicates that these egalitarian codes were maintained from the foundation of Syracuse and throughout the seventh century BC. This elitist-centred form of law making has been found elsewhere in the Greek world, focused not on social injustice but the division of power.[66]

Therefore, in this socio-political environment the *Gamoroi* searched for other means through which to increase their personal wealth, influence and power. An organised foundation of a colony would provide such an opportunity, while the colonisation process would allow for the planning of a regular urban plan to divide the land into equal plots. It has been argued elsewhere that the land could then have been rented to individual citizens.[67]

2.4.2 Heloros

For much of the last few centuries, Heloros had remained relatively inconspicuous among the number of known historical sites in south-eastern Sicily. Tucked away approximately thirty kilometres south of Syracuse on the coast of the Ionian Sea, the site of the former Syracusan settlement sits at the mouth of the modern river Tellaro and was all but forgotten until Paolo Orsi's excavation in 1899.[68] This was then fully published posthumously along with a subsequent excavation 1927 by Orsi and work on the site by Elio Militello and Vito Piscione in 1958-59 and 1961 respectively.[69] Quite consistent archaeological study since has been undertaken at Heloros by the Soprintendenza (Appendix 1: H, section C).

The small Greek settlement is occasionally mentioned in literary sources from the Classical period onwards (Appendix 1: H, section B). For the most part, this attention was not for the settlement itself, but more so for its place in the background of important historical events.[70] Literary sources are rather quiet with regard to Heloros's status as a Syracusan settlement.[71] Pliny the Elder (*Nat*. 32.7) in the first century AD states Heloros as a 'fortified place in Sicily...not far from Syracuse' and later Claudius Aelianus (*Nat*. *An*. 12.30), in the third century, refers to Heloros as a former Syracusan *phrourion*.[72] It is in this mind-set that scholars

---

[65] Asheri 1980, p.121.
[66] Osborne 2009, p.176.
[67] See Solomonik & Nikolaenko 1990 for this argument at Chersonesos.
[68] Orsi 1899c.
[69] Orsi 1966b; Currò et al. 1966.
[70] Diod. Sic. 13.19.2; Hdt. 7.154.3; Thuc. 6.66.3, 6.70.4, 7.80.5; Corsaro & D'Agata 1989.
[71] Diod. Sic. 23.4.1; Livy 24.35; Fischer-Hansen et al. 2004, p.195.
[72] Nielsen's thorough overview of the word *phrourion* for the Copenhagen Polis Centre has proven useful when considering its ancient usage and its place within the Greek adjectival urban lexicon. One thing that he makes for certain is its use as a military term: a *phrourion* is a complex of buildings possibly serving both offensive and defensive purposes. Foremost in this is its connection to the verb τειχίζειν (to

have placed Heloros among the other Syracusan colonies as a military settlement for the purposes of securing south-eastern Sicily within the control of Syracuse.

Archaeological evidence shows that Heloros was not initially planned as a *phrourion*. The excavation campaign of 1958-59 established that, although Heloros was founded c. 700 BC, the city itself was enclosed by a walled fortification at the earliest in the mid-sixth century:[73] had the walls been planned from the beginning, they would have been built within the first three to six generations.[74] When the walls were built, they were constructed hastily. The reason could be that current events had quickly necessitated them being built,[75] contrary to other strongly fortified *phrouria* or similar *epiteichismata* (forts) found in other parts of the Greek world.[76]

Yet, the idea that Heloros 'may have been a dependent polis founded as a fortress' remains the predominant opinion.[77] The basis of this view is that the site was strategic in the Syracusan conflict with the indigenous Sicilians.[78] However, Greco-Siciliote relations were largely peaceful in the early seventh century as archaeological evidence indicates at local Sicilian population centres, such as Avola Vecchia, Noto Antica and Tremenzano. These settlements existed before the arrival of the settlers and later even benefited from commercial contact with the Greeks which is seen in the Sicilian ceramic assemblage.[79] Orsi first identified the site as a guard against competing Greeks, namely Gela.[80] Yet, Heloros' foundation date at the end of the eighth or beginning of the seventh century BC predates Gela's settlement forty-five years after Syracuse, c. 688 BC.[81] Syracuse likely saw Heloros as a prime location for a settlement and wished to prevent such an occurrence from a competing group[82] and this motivation fits with claiming the land along the river Heloros.[83]

It is possible that the initial agricultural settlement at Heloros comprised a large indigenous contingent,[84] which would explain why later authors did not recognize Heloros as

build a wall), and that word's often synonymous usage with derivatives of the verb such as τεῖχος (wall), τείχισμα (wall) and ἐπιτείχισμα (fort), all suggesting a walled fortification as being a key aspect.

73 Militello 1966, pp.310, 313-4; Martin et al. 1980a, p.551.

74 De Angelis 2016, p.76.

75 Militello 1966, p.313. Cf. Copani 2005, p.257.

76 Frederiksen 2011, pp.13-5.

77 Quote from Fischer-Hansen et al. 2004, p.195; cf. Anello 2002, pp.65-6; De Luna 2009, p.77; Collura 2012, p.31.

78 Sjöqvist 1973, p.37; Asheri 1980, p.119; Manni 1990, p.84; Di Vita 1998, p.8; Voza 1999, p.116; Finley 2001, p.32.

79 Copani 2005, pp.259-60. Cf. Guzzo 2011, p.202. See section 2.4.6 below.

80 Orsi 1899a, p.242; Orsi 1966b, p.215.

81 The pottery confirming the early date of Heloros was only discovered later than Orsi's initial work; Militello 1966, pp.310, 313-4.

82 Copani 2005, p.246; De Angelis 2016, p.229.

83 Asheri 1980, p.119; Martin et al. 1980b, p.246; Domínguez 1989, pp.200-3.

84 Domínguez 1989, pp.191-5; Copani 2005, pp.257, 261-2; Copani 2010.

being a Syracusan settlement. The foundation of Heloros can then be viewed as an agricultural establishment for the benefit of Syracuse and its controlling elite.

2.4.3 Akrai

Akrai was the first among the Syracusan settlements to be discovered and it garnered archaeological interest from the sixteenth century. Its identity was debated for a long time until its connection with modern Palazzolo Acreide became accepted by the eighteenth century (Appendix 1: A, section C).[85] The first archaeological monograph dedicated to Akrai was published in the early nineteenth century by Baron Judica[86] and excavations have continued rather consistently until a few decades ago. The University of Warsaw resumed work on the site in 2009.[87] The major publications focused upon Akrai are those by Bernabò Brea. A vast majority of the site has been investigated under his direction, including the Temple of Aphrodite.[88] Not much attention was given to Akrai by ancient authors, only its foundation and alliance with Syracuse during the rebellion of Kamarina was noted (Appendix 1: A, section B).[89]

In the same year as Di Vita's influential quote cited on page 37 above, Bernabò Brea published the first monograph on Akrai. In this he compares the topographical location of Akrai to that of Euryalos fortress built by Dionysios in Syracuse.[90] This invariably establishes Akrai as a stronghold guarding the Anapos and Heloros river valleys which lead to Syracuse and Heloros respectively. In addition to this, such a site guaranteed free communication and passage to the Greek city-states on the southern coast and the Sicilian settlements of the interior. Therefore, from the mid-twentieth century Akrai was labelled as a military establishment.[91]

Arguments presented in the previous section pertain equally to Akrai. The site was not fortified on foundation, and local indigenous centres suggest non-aggressive interaction. Akrai was, therefore, likely founded in order to secure the remaining hinterland that reached from the eastern coast to the Heloros (modern Tellaro) river valley. The land could then be divided among the members of the controlling elite. However, the relationship between Akrai and Kasmenai is pertinent; the two are often linked in academic work, and this has been the case since Thucydides first mentioned the settlements.

[85] Garozzo 1994, pp.190-1.
[86] Judica 1819.
[87] Chowaniec 2015.
[88] Bernabò Brea 1956; Bernabò Brea 1986.
[89] Thuc. 6.5.2; *FGrH* 3 559 F 5, respectively.
[90] Bernabò Brea 1956, p. 4.
[91] Voza 1999, pp.129, 131, who quotes Bernabò Brea; Fischer-Hansen et al. 2004, p.189.

2.4.4 Kasmenai

The third colonial endeavour set out by Syracuse was the settlement of Kasmenai, founded not far from and only twenty years after the foundation of Akrai. Unpublished excavations by Paolo Orsi in the 1920s and 1931 all but firmly identified modern Monte Casale with the ancient colonial site. However, this identification was not generally accepted for decades.[92] Archaeological work continued occasionally through the 1950s and 60s before more systematic excavations by the Soprintendenza began in the 1970s (Appendix 1: K, section C).[93]

The foundation of Kasmenai in 644/3 BC was a colonial endeavour in almost every sense. Yet, there is no mention of an *oikist* in the sources.[94] This is consistent with Syracusan aims where the new settlements would be given relative independence from their metropolis.[95] Literary evidence also suggests this: Kasmenai took the side of the Syracusans against Kamarina during the rebellion in the mid-sixth century,[96] while the *Gamoroi* fled there when expelled by the demos in 491 BC (Appendix 1: K, section B).[97] As for its role, modern scholarship leans heavily towards a defensive purpose as the motivation of its foundation.[98]

The physical location and topographical characteristics of Monte Casale, the plateau on which Kasmenai was settled, has dominated the discussion for almost a century.[99] Orsi advanced the issue of harsh environmental conditions as part of geographical discussions of Monte Casale before the confirmation of Kasmenai being located at the site,[100] which then reinforced the historical relevance of the Greek settlement within the framework of Syracusan expansion. This point is still argued to this day.[101] However there is very little information on what the plateau looked like in the Archaic period with respect to vegetation and access to resources.[102] Literary and archaeobotanical evidence indicates that Sicily was more densely forested prior to the Greek colonial movement,[103] and in fact evidence of indigenous

---

[92] The identification of Kasmenai at Monte Casale was firmly established by Di Vita 1956a, pp.185, 189, 190 n.58 and Pace 1958, pp.298-9.
[93] Rizza 1957, pp.205-7; Voza 1968-1969, p.360; Martin et al. 1980a, pp.532-3; Pelagatti 2002, pp.141-8.
[94] Asheri 1980, p.122.
[95] The degree of independence may have changed over time. By the early fifth century they were independent enough to offer asylum to the exiled *Gamoroi*. Cf. Asheri 1980, p.123; Domínguez 2006, pp.284-5.
[96] *FGrH* 3 556 F 5.
[97] Hdt. 7.155.2.
[98] Fischer-Hansen et al. 2004, p.205; Erdas 2006, p.46, Copani 2009, pp.15-20. De Luna 2009, p.77 labels Kasmenai a *phrourion*, and Melfi 2000 and Copani 2009 see the site as defensive against other Greeks.
[99] Most recently Asheri 1980, p.123; Marotta D'Agata & Moreschini 1992; Fischer-Hansen et al. 2004, p.205; Collura 2012, pp.2-3.
[100] Orsi 1930, p.144; Orsi 1931, p.51.
[101] Voza 1999, p.141; Collura 2012, p.2.
[102] Even Orsi 1928, pp.75-6 acknowledges that the site was likely quite different two and a half millennia ago.
[103] Diod. Sic. 14.42.4; Stika et al. 2008, p.147; Noti et al. 2009, p.384; De Angelis 2010b, p.33; De Angelis 2016, p.230.

settlements at Monte Casale, pre-dating Kasmenai, clearly indicates the area was by no means uninhabitable.[104]

Orsi also argued for the militaristic character of Kasmenai because of the discovery of a cache of military goods in the votive offerings found at the Temple of Ares in the early twentieth century.[105] Iron weapons (spears, javelins) among these votive offerings imply the existence of a population participating in a life engrained with military service, providing the key evidence for the entire image of the site. A different interpretation though has arisen over the last few decades suggesting these artefacts are not of aggressive nature.[106] Greco, in 1983, emphasised a religious function of the offerings, they do not necessarily indicate that the entire settlement was of a military disposition; instead he proposes that the main purpose of the settlement was agriculture, or more specifically shepherding.[107] Other scholars, however, have not been not convinced by Greco's argument.[108]

Melfi recently reopened the debate focusing on the votive offerings themselves and suggested that they represent indigenous artisanal practices taking place at Kasmenai.[109] The vast amount of various other non-weapon iron objects coupled with evidence at nearby indigenous centres support a history of metal processing in the area. Weapons of similar type to those found at Kasmenai have been documented at locations throughout Magna Graecia, including Kyme,[110] Gela[111] and Metapontion[112] and they could be representative of a conduit for the interaction between the cultures. A new image thus emerges of the settlement at Monte Casale: the motivation of Syracuse was to establish a commercial centre, focused to a degree on the manufacturing of metal products, and incorporated not only Greek settlers but members of the local population.

Another argument made recently by Copani brings to light an etymological issue rarely identified in academic work on Kasmenai: its name was likely of indigenous origin.[113] Copani makes a connection to the water nymph Camenae of Roman myth, and connects the site with the Indo-European ancestry of the Sicilians and the Latins on the Italian peninsula. The association with a water goddess is obvious in the geographical placement of Kasmenai.

---

[104] Orsi 1928, pp.76, 77); Orsi 1931, p.50; Martin et al. 1980a, p.530.
[105] Orsi 1928, pp.77-8; Orsi 1930, p.144; Orsi 1931, p.51. Cf. Voza 1968-1969, p.360.
[106] Cf. Copani 2009, pp.17-18.
[107] Greco & Torelli 1983, p.183. Shepherding is proposed in section 7.8 below.
[108] Di Vita 1987, pp.77-87, especially p 78-80 where he critiques the accuracy of Greco's publication. Cf. Erdas 2006, p.46.
[109] Melfi 2000. Di Vita 2003 argues against Melfi, reasserting his previous position, while Greco 2009 sides with Melfi.
[110] Gabrici 1913, p.70.
[111] De Angelis 2010b, pp.29-30, esp. nn. 51-2 where De Angelis cites the 'conquest deposit' as well as the status symbol interpretation, along with agricultural tools from Selinous included in a similar debate.
[112] Emanuele 1984, pp.147-9.
[113] Copani 2009, pp.18-20.

Questions were raised in the previous section over why Syracuse chose to establish Kasmenai so close to and so soon after Akrai, negating the latter's defensive purpose. Additionally, the foundations of Kasmenai, and more so Kamarina, have been regarded as tools towards halting the eastward expansion of Gela towards Syracuse.[114] If this was such a pressing problem for the Syracusans, certainly a settlement at the coastal location of Kamarina would have made a quicker impact than settling at Mount Casale before waiting almost fifty years to found Kamarina. Kasmenai provided Syracuse a well-secured plateau for a population to safely carry out trade and crafts inside the walls; Kasmenai and Akrai controlled the surrounding hinterland. This opened a pathway to the southern coast, where Kamarina was later established, and westward to other Greek sites in order to better exploit the already present trade routes.

2.4.5 Kamarina

Kamarina was founded in 599 BC at the mouth of the river Hypparis (modern Ippari).[115] In contrast to the foundations of Heloros, Akrai and Kasmenai, Thucydides provides us with two *oikists* named Daxon and Menekolos, giving the settlement at Kamarina a more politically independent status. Most recently, the establishment of Kamarina has been viewed as an organised endeavour to possess the rich nearby agricultural land, a useful river port on the southern coast, to hinder the progression eastward of Gela as well as keeping the surrounding Sicilian populations within the Greek sphere of influence.[116] Acquiring additional agricultural land is an obvious advantage, and can be seen as a prominent motivation behind other Syracusan foundations. Gaining a port on the southern coast of Sicily provided great commercial opportunities with the increase in trade following the Greek movement westward, while keeping Gela from encroaching eastward increased Syracuse's security.

Many significant, often catastrophic, events occurred at Kamarina from its foundation to the first half of the third century BC.[117] In the first two hundred years, the settlement was destroyed three times, by Syracuse (553 BC), Gela (484 BC) and Carthage (405 BC), often with a subsequent re-foundation soon after. Timoleon completely reconstructed Kamarina in 339 and the town flourished. However, it was sacked by the Mamertines in 275 and then destroyed in 258 BC by the Romans. With three and a half centuries of somewhat consistent destruction and

[114] Melfi 2000; Copani 2009, p.20.

[115] Thuc. 6.5.3. The scholiasts of Pindar place the foundation of Kamarina c. 600–598 and its destruction at the hands of Syracuse c. 552–548 coinciding with the 45th and 57th Olympics respectively, see De Luna 2009, p.78, n.71. The date of 599 for its foundation and 552 for its destruction are the most widely accepted.

[116] Domínguez 2006, pp.289-90; De Luna 2009, pp.77-8.

[117] Martin et al. 1980a, p.509.

rebuilding, archaeological remains of the Archaic period settlement are relatively scarce. The catalogue (Appendix 1: KM, section D) lists the Archaic archaeological material. The Temple of Athena has been dated to the first half of the fifth century,[118] possibly at the very end of the time period under discussion. However, since it is not part of the initial foundation, it is not included in this thesis.

Because the Archaic settlement was very short-lived (47 years), there is not enough material to have a separate chapter on Kamarina; in Chapter Four labour costs of the mid-sixth century fortifications are calculated and population numbers are estimated for use as comparative material for the other settlements discussed more in detail. This thesis will focus more on Heloros, Akrai and Kasmenai. Academic research is significantly less comprehensive on these sites than on Kamarina, leading to more open questions about their roles within the framework of Syracusan expansion in south-east Sicily.

2.4.6 Greco–Siciliote Relations

The concept that the Syracusan expansion was principally motivated by military considerations has been readily accepted in the past century, and this has followed the trend of academia to view Greco-Siciliote relations in relation to a *terra nullius* model. This model regards the superior Greek culture as a dominating force that brings about the acculturation, assimilation and even physical destruction of the inferior indigenous populations.[119] A modern backdrop has been found in the European colonial cultures of the last few centuries which has also influenced historical interpretations.[120] More specifically for the present study, Thucydides 6.4 has been labelled the ‘cornerstone text’ of a *terra nullius* model for the history of Syracuse and south-east Sicily.[121] Study of the archaeological material from Sicilian settlements in south-east Sicily, however, raises doubts of the *terra nullius* model, providing evidence that the Greco-Siciliote relations were not as violent as has been portrayed in research literature.

Opposing the *terra nullius* model, the evidence suggests that the Syracusans kept diplomatic, even peaceful, relations with the local populations and both sides maintained a mutually beneficial socio-political interaction.[122] Consistent archaeological findings of indigenous contexts near the Greek settlements in the region, as well as overwhelming

---

[118] Pelagatti 1985, p.296.
[119] Gosden 2004, pp.114-52; De Angelis 2010a, pp.28-9.
[120] The idea of property and land rights being a source of wealth can also be traced to a *terra nullius* point of view, Gosden 2004, p.114. More importantly, however, I do not subscribe to the idea of colonist-indigenous conflict as being an inherent and unavoidable consequence of colonisation.
[121] De Angelis 2010b, p.29, n.48-9. Cf. Snodgrass 2002, pp.181, 183; Guzzo 2011, pp.319-20. Di Vita 1987 invokes Thucydides 6.5 in his assertion of Akrai and Kasmenai having been founded with a defensive and military motive.
[122] Guzzo 2011, p.202.

evidence of Sicilian populations adopting Greek culture,[123] continue to suggest that into the sixth century the two cultures had lived peacefully in close proximity, even including marriage.[124] In fact, Diodorus Siculus (5.6.5) tells of their integration with their new neighbours.[125] This relationship between the two cultures was important for both sides,[126] with political, social and economic gains to be had by each.[127]

Furthermore, land use and settlement patterns indicate that the arrival of the Greeks was not as detrimental to the indigenous populations as once argued for.[128] Ancient sources comment on Sicily as having been lightly inhabited,[129] and even then generally Iron Age Sicilian communities tended towards inland occupation, near the best agricultural land, which did not extend far, likely only in the tens of square kilometres around the settlements.[130] Overall, De Angelis estimates that indigenous populations only used 12 per cent of Sicily's surface area, about three people per square kilometre.[131] Coastal settlements may have only been seasonal or temporarily occupied.[132] It is likely that most of Archaic Sicily was still densely vegetated and, therefore, free for agricultural exploitation, while the marginal lands by the Sicilians may have simply operated on an understanding of open-access. This strategy would have allowed the Greeks to freely lay claim to the coasts without much challenge or negative reactions, therefore eliminating the need for competition over land resources.[133]

In south-east Sicily, the relationship between the Syracusans, and the local population, the *kyllyrioi*, may have come about through a mutual agreement where the latter provided labour in exchange for better living conditions, access to Greek resources and protection.[134] This can be compared to the Mariandyni and their relationship with the Greeks of Heraclea Pontica.[135] This form of immigration into Syracusan society would then have been quite peaceful, and depending on how prosperous this decision became for the local populations, could even explain the disappearances of the populous Sicilian centres at Pantalica and Monte

[123] Hodos 2006, pp.99-157. See section 2.3 above.
[124] Heloros: Copani 2005, pp.257-8; Akrai: Martin et al. 1980a, p.499; Di Vita 1999, p.365; Kamarina: Cordano 1987, pp.122-3; De Luna 2009, p.79; Mosca 2010, p.62. Cf. De Angelis 2010b, p.41; La Torre 2011, pp.70-1; Guzzo 2011, p.202. Although on the subject of Greek-Siciliote intermarriage Hodos 1999, p.74 feels more evidence is needed.
[125] Cf. De Angelis 2010b, pp.34-5.
[126] Lepore 1968, pp.51-55; Malkin 1994, p.2. Cf. Graham 1984; De Angelis 2010b, pp.35-6, 39.
[127] Guzzo 2011, p.319, n.4. Cf. Hodos 2010a, pp.84-91.
[128] Lepore 2000, p.69; De Angelis 2010b, pp.31-5.
[129] Dion. Hal. *Ant. Rom.* 1.22.2; Strab. 6.2.2.
[130] Hodos 2006, p.92; De Angelis 2010b, pp.25-6; De Angelis 2016, pp.53-6.
[131] De Angelis 2010b, p.38; De Angelis 2016, p.55.
[132] De Angelis 2010b, pp.39-40 also briefly presents the theory of an immunity to malaria allowing the Greeks better access to the coasts. For obvious reasons, he suggests more research is needed.
[133] Pastore 1997, p.331. Cf. De Angelis 2010b, pp.32-3; De Angelis 2016, p.56.
[134] Ath. 6.84; Domínguez 1989, pp.191-5.
[135] Strab. 12.3.4. See Lintott 1982, p.267; Domínguez 1989, p.193, n.66.

Finocchito.[136] The rebellion of Kamarina provides a noteworthy aspect of the social relations with the Greek population and the locals in the surrounding area. Since Kamarina is known to have mustered the support of the local indigenous peoples against Syracuse,[137] one must assume that relations between the Greeks of Kamarina and the Sicilians were amicable, and indeed the exchange between the two cultures was likely strong in the preceding decades.[138] In general, both sides mutually benefitted from their interaction.[139] A middle-ground form of culture contact ('a positive synergistic scenario', as De Angelis suggests)[140] seems the best impetus in which to view the relations between the Greeks and Sicilian populations.[141]

2.5 Approaches to South-East Sicily Used in This Study

This thesis studies a range of socio-political and economic aspects which were part of the Syracusan expansion in south-east Sicily. The methodologies employed include architectural energetics, population dynamics, landscape studies and rank-size distribution. Labour cost estimates provide insight into social and economic characteristics of each site. Calculating population sizes through analysing the landscape and modelling of demographics allows for further factors to be considered in the labour costs. The regional population distribution study contributes towards a macrolevel examination of the island.

The methods behind architectural energetics have developed over the past century and a half through archaeological observations over the quantity of labour and political authority required to build great earthen mounds.[142] Anthropological analyses of architecture since the mid-twentieth century have focused on cultural implications.[143] For instance, Abrams, who coined the term,[144] utilised architectural energetics towards Late Classic Maya housing at Copan, Honduras and proved a correlation between and within the hierarchy of social and political statuses and the labour costs associated with the construction of residences.[145] The higher the status, the larger the energy expenditure and amount of resources, but among those of the same status there was little disparity. Further, in this community the access to labourers was paramount to social status in that larger structures require more labourers and thus a

---

[136] Di Vita 1999, p.367.
[137] Dion. Hal. *Pomp.* 5.4
[138] Di Vita 1956a, p.201; Di Vita 1987, p.85. Cf. Di Stefano 1987b.
[139] Di Vita 1986, p.384; La Torre 2011, pp.72-3; De Angelis 2016, pp.55-60.
[140] De Angelis 2016, p.164. Cf. Hodos 2010b, pp.21-2.
[141] De Angelis 2010b, pp.40-2; De Angelis 2016, pp.56-60. However, intermittent violence between the two populations did break out, Hodos 2006, p.7.
[142] Abrams & Bolland 1999, p.270; Devolder 2017.
[143] Abrams 1989, pp.49-59; Abrams & Bolland 1999, pp.269-72.
[144] Abrams & Bolland 1999, p.269.
[145] Abrams 1989, p.72. Cf. Devolder 2013 on her study of labour costs and social implications in Neopalatial Crete.

person of higher socio-political stature can recruit a larger workforce. This can be extrapolated to the present study in the terms of whole communities: the larger the labour costs, the more social and political power needed to gather the necessary material and labour resources needed to complete construction.

In the ancient world, architectural energetics has been employed on many occasions, although not always labelled as such. In the mid-twentieth century, Stanier reached an estimate of 500 talents to construct the Parthenon.[146] In her examination of the Baths of Caracalla in Rome, DeLaine provides an analysis of material procurement, production and construction, from stone and brick to scaffolding.[147] Detailed discussions of labour costs rates can be found in Burford's work on temple construction at Epidauros and Pakkanen's work on the Athenian shipsheds at the harbour of Zea.[148] In these studies, the energy expenditure rates are derived from a variety of sources, both ancient and modern, as will be discussed below. Furthermore, Haselberger provides econometric calculations for a rural tower on Naxos.[149] Salmon estimates the total cost of public building in Athens and Corinth from the seventh to fifth century BC.[150]

In the island of Sicily, architectural energetics has only been implemented in a handful of instances. De Angelis was the first with estimates attached to the temples at Selinous and Akragas and the third-phase city wall at Megara Hyblaia.[151] His cost analyses indicate that the construction projects were too large to be financed without a contribution of the wealthy elite. In essence, this perpetuated the social and political importance of the upper class in funding the monumental structures which gave them prestige and power to plan and initiate further monumental architecture. Fitzjohn calculates labour costs in the construction of houses at Megara Hyblaia.[152] He concludes that even the simple construction projects, the amount of time required for gathering materials, transporting them to the site, construction and maintenance cannot be separated from considerations of agricultural calendars, daily life and the weather. Neither De Angelis nor Fitzjohn label their work 'architectural energetics', but the argument they present can be considered as such. Both of these studies address the use of stone, and Fitzjohn discusses transport, but not to the extent of this thesis. The technological constraints in Archaic Sicily, Classical Greece and Imperial Rome were largely the same, so much of the rates utilised in this study are based on DeLaine, Burford and Pakkanen.[153]

---

[146] Stanier 1953.
[147] DeLaine 1997.
[148] Burford 1969; Pakkanen 2013b.
[149] Haselberger 1985.
[150] Salmon 2001.
[151] De Angelis 2003, pp.163-9; De Angelis 2016, pp.93, 106-7.
[152] Fitzjohn 2013, pp.634-9.
[153] See sections 3.3-8 below.

The implications of this methodology are abundant. One central idea in the application of architectural energetics is to deduce the social complexity within a culture through the ability to procure resources, both material and labour. While equating cost with power can be a relative condition within other cultures, it can be argued that this is a useful approach in the ancient Sicilian context. Access to necessary resources, then, is related to the political, economic and social status of the population present in the settlement and as such the settlement as a whole. Another indication generated by this means of study pertains to the assertion of power by Syracuse over its newly established settlements. Using architectural energetics, it is possible to quantify projects' complexity and access to required resources, thus reflecting the communities ability to start and finish large construction projects and potentially also the elites' will to push through such activities at any given site.[154] Specifically, major works are indications of the needs and desires of the peoples present at the start of construction, and how complex a project becomes in turn shows what was deemed necessary and appropriate at the time. Indeed, archaeological evidence suggests the first generation of colonies founded in the eighth and seventh century began monumental constructions around the same time.[155] If this was also the case in south-east Sicily, then Syracuse must have had a part in its settlements' programmes, as one cannot expect Heloros, Akrai and Kasmenai to have been economically on par with the metropolis to support these projects.

Funding for a construction project can come from a number of sources,[156] but the main possibilities are from regular funds of the city-state or its private citizens. There is evidence of private contributions for public building projects from at least the fourth century, and while there is less material for earlier periods, this is due to the lack of permanent records kept at that time.[157] In fact, evidence suggests that much of what is known about the economy of Classical Sicily can be projected backwards to the Archaic period as the basic economic structures were laid out already then.[158] Therefore, it can be expected that private contributions were a normal, if not essential, aspect of large-scale construction projects.[159] However, their extent is difficult to establish.[160]

[154] See Burford 1969; Coulton 1977, pp.20-3 on how public projects were organised.
[155] De Angelis 2016, p.99.
[156] Coulton 1977, p.20.
[157] Coulton 1977, pp.20-1. See Bringmann 2001, pp.206-7 for notable transactions from ancient sources, mostly involving tyrants or kings.
[158] De Angelis 2016, pp.225, 271.
[159] De Angelis 2016, p.88.
[160] Burford 1969, pp.222-45, in her second appendix, analyses the status, role and interest of individuals involved in the building accounts at Epidauros. These do no list what, if any contribution, was given, but it is not hard to expect the majority of those listed to have had financial ties to the construction projects.

De Angelis, in his study of Selinous, has estimated the costs in the construction of seven sixth- and fifth-century temples.[161] Temple G is calculated as 567–756 talents, while the smaller Temples A and O cost 51 and 68 talents respectively. Temples C, D, F and E3 lie on the more expensive end of the spectrum. He largely attributes the construction projects at Selinous to the tyrants and their allies,[162] or from rival factions, such as Carthage, as it is quite unlikely that the state income of Selinous would have been sufficient.[163] Further, it is important to note that this estimate is across the entire century of construction time from Temple C (550 BC) to Temple E3 (460 BC); it only accounts for one material, stone, and focuses only on the temple projects. All additional costs in constructing a temple, as will be outlined below, and any other state-initiated building plans which may have been implemented at the time raise the total cost. According to De Angelis, stone can account for 80 per cent of total temple costs[164] resulting in an annual investment of over 22 talents. The sum is very likely more than the typical annual income of a Greek settlement. At Akragas, De Angeles provides an estimate of 136 talents needed to build the temples of Juno Lacinia and Concordia, both in the second half of the fifth century. These are just two of the six temples built during the last two-thirds of the century, lending to belief that Akragas was equally at the mercy of their elite citizens for funding as Selinous a century prior. Although De Angelis uses costs expressed in terms of talents, these can easily be converted into man-days.[165]

There is abundant evidence for the status and wealth of elite classes in Sicilian Greek city-states throughout the Archaic and Classical periods.[166] Diodorus Siculus (13.81–90) provides great detail regarding the wealth of Akragas in the years prior to its sack by Carthage in 406 BC. Diodorus' anecdote on Agathokles and temple construction in Syracuse in the late seventh century is discussed above.[167] Agathokles purchased the marble with his own finances and his punishment for using it in the construction of his own house stresses the point that private funding from the elite class was a common, even expected, aspect of temple building.

In the Archaic period, members of the elite class would have funded a construction project through giving material and human resources, as it can be expected that the oligarchies controlled the majority of these.[168] The level of these contributions and the number of benefactors at any given project is not known due to the lack of written evidence. Nonetheless,

---

161 De Angelis 2003, pp.163-9. He does not provide the calculations.
162 De Angelis 2016, pp.106-7 also gives estimates on the Olympieion (Temple B) at Akragas accredited to Theron and costing at least 1,512 talents.
163 Coulton 1977, p.20.
164 De Angelis 2003, p.165.
165 De Angelis does also provide man-hour estimates.
166 De Angelis 2016, pp.116, 146-57, 199-204.
167 Diod. Sic. 8.11.1-2. Asheri 1980, p.121 doubts the credibility of the anecdote.
168 See De Angelis 2016, pp.177, 263-6 on a summary of the pre-monetary Archaic period in Sicily, including the use of weighted metals.

active involvement of the elite class in funding monumental construction projects, including temples but quite possibly also fortifications, very likely took place. It is also possible that large-scale projects for building individual houses, for example at the time of the settlement foundation and rebuilding, would have benefited from elite involvement.

Any help requested by the community from the metropolis reflects the acceptance, and even desire, of the role of the metropolis in the affairs and large-scale projects. For example, fortifications become necessary when a settlement requires protection, regardless whether it is a question of real or perceived danger. In addition, evidence suggests that walls quickly became a symbolic feature,[169] even considered as an essential aspect of a polis by the Classical period.[170] Therefore, the presence of a wall, or lack thereof, played a part in a settlement's place within the cultural landscape. Akrai and Kasmenai were likely fortified at or soon after foundation, while Heloros was not encircled by a stone wall until almost two centuries after it was settled. Although various factors may have been involved in such a delay, for instance lack of available resources, it is probable that Syracuse did not consider Heloros essential enough for such a costly expenditure until its development or current events deemed such an undertaking viable. This expenditure can be largely estimated by architectural energetics, providing a calculation of the economic value of such a project.

Along similar lines, construction projects may be seen as a strategy to strengthen political cohesion, especially in times of stress. One such event where Syracuse may have wished to reinforce political ties was during the rebellion of Kamarina in the mid-sixth century. This is the most well-known example of political unrest at this time in the region, yet other such instances may have occurred. It is obvious that Syracuse wished to maintain control over Kamarina, even though it appeared at foundation to have been independent. Perhaps similar desire for autonomy was present to some extent in the other settlements of south-east Sicily. As a means to quell such desires and to fortify ties with its colonies, Syracuse could have provided resources, implementing building projects as a strategy. Again, the fortification of Heloros in the third quarter of the fifth century may have been a reaction to just this. The conflict with Kamarina, as well as the democratic revolution in Syracuse in the fifth century, demonstrates that political flux was a real threat in the Archaic period.

[169] A phenomenological approach to entrances (Adams 2007), and specifically fortification gates (Osborne & Summers 2014), may provide additional motivations behind monumental architecture, for instance through the physicality of the structure within the surrounding landscape. While this is beyond the scope of this thesis, such an approach does offer further cultural, political and/or social motives behind large-scale construction projects.

[170] Frederiksen 2011, pp.34-8.

In addition, Abrams suggests residential architecture could be used as a measure of social stratification within a settlement and by extension a society.[171] Specifically with regard to architectural energetics, the labour costs, aside from expressing the resources available to a community, can be directly related to aspects of social control of living. For example, the sizes of plots and residences at Kasmenai were strictly controlled. Such a construction project could possibly be indicative of the social class of people settled at the site and the economic level to which Syracuse wished to maintain there. Already the first construction project reflected the role of the community within the entire cultural landscape at foundation. As a settlement grew, or even as current events shaped a society, large-scale investments of man-power and materials may signal that change. These are issues to which architectural energetics can lend an insight. Because of the lack of textual material, interpreting the archaeological data may provide new interpretations with regard to the political, economic and social dynamics in play during the Archaic period.

Once econometric calculations are derived for each construction project, it is possible to investigate the impact each venture had on the community by estimating the population figures and the number of labourers available at any given time. Based on these calculations it is feasible to approximate a plausible timeline for each project. The size of a workforce available is tied to social stratification and agricultural needs. For example, the availability of members of the rural population to participate in a building programme is dictated by the local agricultural calendar.

Attempts to estimate the population of Greek Sicily began in the late nineteenth century AD with Beloch's publications.[172] As more archaeological work has been completed throughout the Greek world, population studies have increasingly developed and new methods and evidence published regularly.[173] Yet, apart from some apt observations of the importance of, but lack of conducted projects on, survey archaeology in Sicily,[174] these studies have focused upon mainland Greece or the entire Greek Mediterranean.[175] However, two recent methodological studies include Sicilian city-states and they have been chosen for use and comparison in the attempt to find population figures for the Syracusan settlements: Muggia's *L'area di rispetto nelle colonie magno-greche e siceliote* and Hansen's Shotgun Method. These two methods analyse the urban area of a settlement, but from different angles: Muggia looks at

[171] Abrams 1989, p.59. Cf. De Angelis 2016, pp.152-5.
[172] Beloch 1889; Beloch 1895. See Hansen's summary of notable past population studies: Hansen 2006b, pp.4-14.
[173] Among the most recent and relevant are Scheidel 2003; Scheidel 2004; Scheidel 2009b. Cf. Hansen 2006b, pp.14, n.48; Scheidel 2009a, p.674 and the introduction chapter of Holleran & Pudsey 2011.
[174] Cf. De Angelis 2000a, p.115.
[175] As pointed out in the Introduction chapter of Holleran & Pudsey 2011, the latest demographic studies are largely focused upon Athens, Rome or Egypt. Those chosen here provide evidence of Sicilian population estimates.

the uninhabited space, while Hansen bases his work on habitation zones.[176] To modify this methodology to fit Archaic Sicily, known archaeological evidence at each site is compared to that at other Sicilian Greek sites. This establishes regional guidelines.

Growth rates allow for extrapolation of population models in time. Scheidel has estimated that the approximate annual growth rate of mainland Greece from the tenth to the fourth centuries BC was 0.25 or 0.30 per cent.[177] He also assumes that this same rate occurred in the Greek colonies after foundation, if not at a higher rate. Indeed, De Angelis prefers an annual growth rate of 0.50 per cent for Sicily, arguing that it best fits the colonial situation in the western Mediterranean.[178]

To account for rural populations, the size of the *chora* must be found for each site. In landscape archaeology numerous methodologies have been developed to estimate territory sizes attached to settlements.[179] Catchment Analysis,[180] for example, estimates the size based on walking distance of an hour for small agro-pastoral settlements, roughly translating to a radius of 5–6 kilometres.[181] This distance could be halved for a coastal location such as Heloros or just extended further inland. An approach using Thiessen polygons suggests that small settlements occur at intervals in order to allow a stable system of land and resource sharing.[182] These intervals could occur at up to 5–6 kilometres or, also likely, half this distance depending on the society's size and resource needs.[183]

A study by Bintliff based on human geography asserts that regional market centres tend to lie within a 15 kilometre or 3-hour walking radius.[184] This radius includes small rural communities around a medium-sized central place which then feeds into the market centre. This settlement pattern has been studied in Bronze Age Mesopotamia,[185] Etruscan Italy[186] and Western Roman Europe[187] and it is likely that a similar natural human geography developed in Greek Sicily. The Etruscan settlement system beginning in the ninth century BC was one of five major centres over 100 ha in size and smaller sites of decreasing size mostly below the 50-ha

[176] See section 3.8 below.
[177] Scheidel 2003, pp.122-6, 134.
[178] De Angelis 2003, pp.46-7; De Angelis 2016, p.145; taken from Hansen 1986, p.11 and Hansen 1988, p.21.
[179] Cf. Bintliff 2009, pp.107-10 for summaries of the landscape archaeology and human geography methodologies discussed here. In a comparable analysis, Spencer 1998, p.7 gives a half day's travel from the regional centre as the most efficient territory size for a chiefdom.
[180] Vita Finzi & Higgs 1970.
[181] Osborne 2009, p.63 suggests poor transport facilities even had an effect on agriculture, shadowing the natural human constraints.
[182] Haggett 1965; Ruschenbusch 1985; Hansen 2004.
[183] Bintliff 2009, p.111.
[184] Bintliff 2002; Bintliff 2009, p.110.
[185] Wilkinson 1994.
[186] Barker 1988.
[187] Bekker-Nielsen 1989.

mark.[188] These smaller sites which fed off of the market centres were dispersed equidistant from each other and the centres. Syracuse (120 ha), Kasmenai (59.6 ha), Akrai (36.5 ha) and Heloros (9 ha) fit well into such a system, albeit on a smaller scale, with the mother city and the settlements as the centres. Such territorial patterns require a substantial rural population to which the market centre provides political, judicial and economic services.

Important within Greek landscape studies is de Polignac's work on territory.[189] His work defined sanctuaries on the edges of territories as markers of a polis and its area of influence, foci of conflict between communities and even places to facilitate peaceful relations between indigenous populations and their Greek neighbours. Although beyond the scale of this thesis, the claiming of land and interaction with the local indigenous peoples is a relevant extension of colonisation. The Olympieion, on the river Kyane (modern Cyane) around three kilometres south-west of Ortygia, across the Porto Grande, has been suggested as being placed in part for marking territory,[190] although by the time it was built Syracuse had already begun its territorial expansion. The hinterland sizes attached to the Syracusan settlements are estimated below, and further studies within this landscape, including boundary markers, are complimentary avenues of future research.

Assessments of likely population figures in conjunction with the estimates of minimum numbers of workmen needed in the construction of the large urban building programmes allows for new ways in which the Syracusan colonies can be studied. Based on econometric calculations it is possible to calculate how many able-bodied workers would have been needed in the construction projects and population modelling can help in estimating how many workmen were available for these projects at each location. Beloch made early attempts to solve this problem, mainly working backwards from army figures mentioned in classical literary sources to deduce population totals.[191] His estimates have been reassessed over time by Hansen and De Angelis, while Abrams approaches this from an anthropological angle.[192]

In quantifying the size of the workforce, the number of available labourers would largely be dependent upon the agricultural calendar. Field cultivation demanded much time and effort, and depending on the chosen crops, those involved in the agricultural landscape would have been preoccupied for the majority of the year.[193] Pastoralism and the movement of livestock equally required attention.[194] Fitzjohn addresses this issue through the landscape and

[188] Barker 1988, pp.774-6.
[189] This discussion largely begins with de Polignac 1995, but see also Carter 1996.
[190] de Polignac 1995, pp.99, 103.
[191] Beloch 1886.
[192] Abrams 1987, p.493; Hansen 2011, p.241; De Angelis 2016, p.145.
[193] Isager & Skydsgaard 1992, pp.162, fig. 11.1; Fitzjohn 2013, pp.627-9.
[194] Isager & Skydsgaard 1992, pp.83-107.

the temporality of building houses at Megara Hyblaia.[195] The time consuming task of building with limestone would likely require the task to be relegated to agricultural off-seasons, while hewing timber may have been most productive in the autumn.[196] The seasonality of the environment even affects the construction project timeline through temperature, daylight hours and precipitation. Further, the periods when livestock, specifically oxen, were available for transport were similarly influenced by the environmental factors and labour constraints.

Population estimates can also be analysed by comparing the figures using a broader regional view. Rank-size distribution, introduced into the field of Human Ecology by Zipf,[197] has been a common methodology. Over the past half-century, this approach to settlement systems and urban theory has been adapted for historical studies in an effort to deduce the nature of human settlements and any factors that may have led ancient populations to choose where to settle with regard to urban versus rural environments. Primacy values analyse settlement systems in the same way, but towards a numerical value which demonstrates the degree of relative size variation among all the sites.[198]

The majority of studies that incorporate rank-size patterns analyse modern countries or past societies outside the Western Mediterranean. Yet, two such studies on first millennium BC Italy indicate that this methodology can be applied to the present research.[199] Guidi looks specifically at Etruscan settlement sizes in hectares from the tenth to eighth century distinguishing three periods of development corresponding closely to each century. A 'proto-urban' eighth-century development stage in the settlement system is pertinent: during this time, territories are formed, the emergence of class differentiation is seen in grave goods, the first civic cults are created, there is growth in the flow of goods and services within the area and with neighbours, presence of large-scale defences (requiring collective labour) and spread of full-time craftsmen.[200] These last two points adhere closely to what architectural energetics suggests were present in Syracuse at the same time, although the comparisons between the Etruscan and Syracusan societies may not end there. Vander Poppen continues this by addressing the Etruscan settlement landscape from the seventh century BC to the first century AD.[201] He presents a hierarchy of sites within the region of Etruria not dominated by the largest cities with a periphery of non-influential villages, as is traditionally believed, but rather a society of integrated settlements of varying size existing alongside one another and playing significant

---

[195] Fitzjohn 2013.
[196] Hes. *WD* 414-20;
[197] Zipf 1949. He used his mathematical evaluations of rank-size on speech patterns as well as micro- and macro-analyses of geography. For obvious reasons the latter use is what has been adapted to urban archaeology.
[198] El-Shakhs 1972, pp.18-20.
[199] Guidi 1985; Vander Poppen 2008.
[200] Guidi 1985, pp.232, 237.
[201] Vander Poppen 2008, p.452.

roles in the overall social and economic aspects of the area. This is what is suggested here for Archaic Sicily.

The methods employed in this dissertation analyse the archaeological remains of the region through new approaches. The use of architectural energetics generates numerical values for labour costs which, in conjunction with population estimates, indicate the ability for settlements to complete these projects. Through this, it becomes apparent the extent to which each new settlement relied upon Syracuse and by extension also its wealthy individuals. The populations are evaluated further using the rank-size distributions and by studying the impact each foundation had upon the region and the island. In the end, the employed approaches enable the emergence of a fuller picture of Syracusan expansion in south-east Sicily: it is possible to evaluate the different motivations, whether they were aggressive or spurred by the desire to accumulate wealth and increase prosperity. This comprehensive methodological study has the potential to expand the overall understanding of the archaeology of the region.

Chapter 3: Methodology

Multiple methodologies are used in this thesis to argue for the roles each settlement played in the expanding Syracusan hinterland of south-east Sicily. Architectural energetics and landscape studies provide different views of archaeological material, while population assessments estimate and analyse the probable ranges of inhabitants during the Archaic period at each settlement. In the following chapters the material remains of the Archaic settlements are analysed using the methodologies presented here.

3.1 Architectural Energetics

Any building can be regarded as the sum of a specific number and type of actions and their relation to a precise volume and variety of materials.[1] It is possible, therefore, to work backwards from the finished structure to its core components. This is fundamental in the application of architectural energetics which reduces a building into various elements, quantifying its construction in terms of cost.[2] In a pre-mechanized world, these construction costs can be figured in terms of labour time spent: converted into a unit of energy cost, man-days (md), this equals the amount of work a single man could accomplish in a common work day.[3] Comparative assessments using man-days can then be made on the status and total costs of the structures and by extension their political, economic and social effects of the people and places within a society.

Labour cost figures used herein are derived from two sets of information: architectural data and energy costs per task.[4] Architectural data is largely obtained through archaeological research and subsequent reconstruction and supplemented by relevant ethnographic studies. This includes the type and volume of materials required, the skill level of workers needed and the particular architectural features of the building. Energy costs can be obtained in part through the written historical record, although this is not without significant challenges.[5] First, much of the available evidence derives from later Greek and Roman sources largely involving manual labour in agricultural activities; for example, Columella's *Res Rustica* gives information on ancient farming, though its actual relevance to agricultural practices naturally needs to be carefully studied.[6] *The Ten Books on Architecture* by Vitruvius does provide information on

[1] Price 1982, p.720.
[2] Abrams & Bolland 1999, p.264.
[3] What constitutes a common work day is problematic in itself. This is addressed below.
[4] Abrams 1989, p.64.
[5] DeLaine 1997, p.104, n.2; Abrams & Bolland 1999, p.265.
[6] White 1965.

construction methods and architectural design but omits most of the specific details, such as the time required to complete the various construction tasks.

Secondly, where written records of ancient construction projects have been discovered, energy costs are often given in monetary value. Noted examples of this are found in the epigraphic records of Classical Athens[7] and Epidauros.[8] Although early Athenian coins are found in Sicily, and a few communities in eastern Archaic Sicily may have minted coinage in the late seventh century, it is generally accepted that most Sicilian trade before 600 BC was non-numismatic.[9] To overcome this, day-wages and material costs documented in construction contracts are converted into man-days.[10]

In conjunction with the written record, modern ethnographic investigations and experimental archaeology are utilised.[11] DeLaine, in her account of third century AD construction processes in Imperial Rome, used Pegoretti's *Manuale pratico per l'estimazione dei lavori architettonici, stradali, idraulici e di fortificazione, per l'uso degli ingegneri ed architetti*,[12] supplemented with information from other handbooks.[13] These handbooks of architecture and engineering projects provide cost figures relating to the pre-mechanical techniques of workers and artisans from data of the early twentieth century and prior.[14] Wright also used these with archaeological reports in his study on ancient building technology.[15]

Ethnographic approaches can be problematic in finding the direct, or as near to, correlation between the observed process and that carried out in prior millennia. Because of this, modern observations must be both detailed to include each specific task in the construction process as well as explicit in describing each task. The researcher should make sure to include everything as would have been present to those in the investigated time period, including authentic tools and even timed breaks.

Overall, the relationship between the ethnological findings and the limited ancient evidence must be presented in a general way, and must rely upon certain essential assumptions:

---

[7] Randall 1953; Stanier 1953; Burford 1963.

[8] Burford 1969. Building inscriptions are also well documented for Classical Delphi and Hellenistic Delos. For an overview, see Scranton 1960.

[9] Hill 1903, pp.36-7; Jenkins 1976, p.8.

[10] For example, using average daily wages at Athens and the costs of different categories of building material, Pakkanen 2013b has estimated the construction costs in man-days for a typical Classical monumental, utilitarian building programme.For the Late-Bronze-Age construction project of the citadel walls at Tiryns, see Brysbaert 2015.

[11] There are a number of publications providing overviews of experimental archaeology: Coles 1979; Stone & Planel 1999; Cunningham et al. 2008; Outram 2008; Marshal 2011; Thomas 2012.

[12] Pegoretti 1865.

[13] DeLaine 1997, pp.104-5, n.4.

[14] Hurst 1937; Kidder & Parker 1947; Rea 1956. Cf. Wright 2005a, p.xxxiii.

[15] Wright 2005a.

1. Men constituted the entire construction labour supply. Energy costs can be expressed in labour-time units of 'person-days' (p-d) or 'person-hours' (p-h).[16] These are somewhat subjective in conditions of the choice of the researcher. While using the word 'person' in these terms seems politically correct and allows for both men and women in the calculations, instead man-days is preferred here.[17] This is largely due to the physically demanding nature of building construction, making it a reasonable supposition that the labour force was entirely made of men.[18] Cultural tradition also dictates that the vast majority of projects calling for strenuous labour would have been largely undertaken by men, although woman and children could have contributed in producing light materials such as ropes and baskets, or even brick making. In addition, skilled workers were trained on the job; young men at this stage would have been present. However, specifying the number of men follows the normal practice of architectural energetics to provide a minimum estimate of the work required to complete a project. A man on average can do more strenuous work then a woman or adolescent. Finally, no distinction between free-born and slave labour will be made. The legal status of a workman is unlikely to have affected his potential output, and while it is likely that slaves were present in the settlements and on the construction projects, without written sources it is not possible to distinguish them from free manual labourers.

2. The length of the average working year for construction can be estimated as 9 months, totalling 220 days. This is based on DeLaine's detailed assessment on the construction of the Baths of Caracalla built AD 212–216.[19] The figure is derived from the seasonably acceptable weather in Rome between March and November, taking into account days of adverse weather condition and public holidays (*feriae*), averaging at least one day off in eight. Gathering of resources (quarrying, harvesting trees, etc.) could have been performed up to 290 days a year.[20] In architectural energetics it is often assumed that the workmen were employed full-time and not accountable for any other duties (e.g. agriculture). This issue is discussed further below and with regard to each site's population assessment.[21] Further, ethnographic studies suggest that construction projects were predominantly scheduled for agricultural off-seasons.[22] A typical working day in antiquity can be estimated as 12 hours, including 2 hours of breaks, presuming

[16] Abrams & Bolland 1999, pp.264-9; Devolder 2013; Fitzjohn 2013.
[17] De Angelis 2003, p.166, as an example, prefers man-hours in his estimates at Selinous. Cf. most recently Buccellati & Kansa 2016.
[18] DeLaine 1997, p.106.
[19] DeLaine 1997, pp.105-6.
[20] De Angelis 2016, p.285 suggests 250 working days a year for agriculture.
[21] See section 3.8 below.
[22] See section 3.8 below.

all daylight hours were normally utilised.[23] It is not uncommon to apply an eight-hour working day, although this can be ethnocentric.[24] Other studies, such as that in Latin America, have estimated as low as 5–6 hours of intensive labour a day due to excessive heat, limiting work from early morning to midday.[25] While this may have been likely during the hottest days of summer, DeLaine's estimations based on Frontinus and the climate of Rome are closer to the geographical region and time period of this study.[26] For this reason the figure of 220 days of 12 working hours will be taken as average.[27]

3. The average output of a workman in the Archaic period is comparable to that of a man in any later period up to the twentieth century: manual labour, the tools and their use have remained basically constant.[28] Further, DeLaine concludes that the dietary habits of a workman in the Roman period would not have provided any less benefit towards productivity than those in the later periods. Modern ethnographic studies, therefore, can be taken as further support towards the expected labour output of workers at each stage of construction.

Architectural energetics is not without its criticism. Doubts surrounding the information used in the calculations can lead to a reluctance to accept this methodology: if a number of unknown specifics of the ancient world must be satisfied by modern observations or simple assumptions, then the validity of the final cost estimates can be questioned. However, as Abrams and Bolland argue, this criticism is a perceived rather than real flaw of architectural energetics.[29] A perfect knowledge and understanding of all the aspects of a construction process is an unreasonable expectation, just as it would be for any archaeological reconstruction. In fact, only two aspects are realistically required: a general knowledge of the elements of the building itself and an awareness of the costliest tasks in its construction. Through the breadth of archaeological data acquired since eighteenth century, Greek architecture is well documented, and comparative analysis can provide much in the way of building reconstruction even from relatively little material due to its conservativism.[30] In terms of cost, focus is placed on the most substantial steps, particularly when some tasks do not add much to the overall estimates. Abrams, for example, concluded that water-related tasks in Late

[23] Fitzjohn 2013, p.638, Table 3 provides average hours of daylight at Augusta, Sicily ranging from 9 hours 38 minutes in December to 14 hours 42 minutes in June; the median being just over 12 hours. See also DeLaine 1997, p.106; Pakkanen 2013b, p.56.
[24] Burford 1969, p.247; Abrams & Bolland 1999, p.265; Devolder 2013, p.166; Buccellati & Kansa 2016, p.93. Cf. Erasmus 1965, p.283.
[25] Erasmus 1965, pp.283-4. Cf. Abrams 1989, pp.69-71.
[26] *De aquaeductu* 123; DeLaine 1997, pp.105-6. Cf. Brysbaert 2013.
[27] Salmon 2001, pp.201, 206, n.16 calculates his figures based on 250 working days a year; De Angelis 2003, p.166, estimates 200, eight-hour days a year for his reconstructions of the temples at Selinous.
[28] See DeLaine 1997, p.105. De Angelis 2016, pp.232-3 expects that iron tools were not prevalent enough in the seventh century BC, but became common in the sixth. This issue is partly accounted for in the rates described below.
[29] Abrams & Bolland 1999, pp.266-7.
[30] Salmon 2001, p.195; Pakkanen 2013b, p.55.

Classic Mayan construction processes ultimately accounted for approximately 1 per cent of the total costs and, therefore, were excluded.[31] Finishing costs, including unknown decorative elements not found in the archaeological record, can also be dismissed.[32] Furthermore, the detailed experiments through which labour costs are derived can be tested by multiple researchers using multiple variables, thus arriving at an acceptable figure.

The labour costs used herein signify a range of rates of output by a workman. The most skilled craftsman would be able to finish a cubic metre of his material in less time than someone less proficient. This is presented in the lowest number of man-days per cubic metre. A workman less experienced would require more time to complete the same task, represented by a higher labour-cost rate. A range of expected labour costs is, therefore, presented for each construction project discussed.

'Architectural energetics' was coined by Abrams and is used heavily in many North and Central American historical and cultural studies.[33] Until recently there has been little crossover between New and Old World uses of the methodology.[34] While the findings towards labour costs from these studies should not be dismissed by any means, here studies applied to ancient Mediterranean societies are favoured. Anthropological publications are referenced,[35] but, in general, original calculations are based largely upon ethnographic sources within or near to the specified geographical region and time period. Therefore, when conflicting figures are found among assorted archaeological, anthropological and ethnographic records, the figures most relevant to this study are used as the basis of calculations presented in this thesis.

This methodology does rely on a very good knowledge of the totality of steps involved in construction, with the most multifaceted of these projects being temple complexes. To complete such an endeavour, a settlement must provide for as many aspects of the process as possible, from an adequate number of workmen to an ample amount of material resources. These resources include, for example, stone of various types, wood and crude material such as clay. Within the workforce, unskilled workmen are essential, but equally important to the process are the skilled craftsmen, from joiners and stone masons to supervisors. It was not always possible for a settlement in the Archaic period to be able to provide all the materials to complete the most demanding projects, such as temple building.[36] To overcome this, certain materials and the necessary skilled workmen had to be imported. At Epidauros, in the fourth

[31] Cf. Abrams & Bolland 1999, p.267.
[32] This point also holds relevance to tasks impossible to calculate; De Angelis 2003, p.163.
[33] See Abrams & Bolland 1999, pp.269-70.
[34] However, Pakkanen 2013b provides several examples comparing data from the Central American contexts with the Greco-Roman world.
[35] Erasmus 1965 and Abrams 1994 being among the most cited.
[36] 'No community in the Greek world, not even Athens, could completely provide for every requirement of temple design from its own resources.' Burford 1969, p.9. However, by reducing complexity of the project it was possible to be self-sufficient.

and third centuries, materials and workmen were being brought in during practically the entire construction period.[37] This was undoubtedly the case at the Syracusan settlements, and so the lowest cost estimates below suggest an influx of skilled workmen to the construction site. Also similar to Epidauros, the settlements likely relied upon contributions from benefactors, such as the wealthy members of the city-state, for receipt of materials not locally sourced. These benefactors could have been wealthy individuals within the settlement, although a sort of tax revenue is equally likely.[38]

Calculations herein focus on the use of the most important construction materials in the Archaic period: stone, mudbrick, terracotta roof tiles and wood. The labour costs associated with each material will be outlined specifically with regard to each step of the building process, from gathering and production to its use in construction. The rates given below are outlined in Table 3.2 and used as basis for the labour cost calculations in the following chapters.

3.2 Stone

Stone was recognised by man early on as a durable material and utilised for that reason in tools and buildings.[39] Extracting stone requires a fair amount of work in order to quarry it from its natural setting, and large pieces take a great amount of effort to move, shape and set into place. Stone became necessary when an object needed to support a great weight and last a long time, such as in the fortifications. However, in cases where a lighter, less laborious material could be utilised, for example mudbrick, stone was often only used for the foundations and socles, such as with private houses. Its durable nature quickly allowed it to be prized over organic materials, leading to the preference of stone in monumental architecture.

Quarrying techniques became common practice from prehistorical times and the essential method of the practice has remained the same.[40] Quarries at new settlements were often found as close to the building site as possible; in general, only after the source was exhausted would outcrops further afield be selected, depending on available resources and necessity. However, for large building projects reliable delivery of building material and politics could be more important than distance to the quarry: the building programme at the sanctuary of Asklepios at Epidauros is perhaps the best example.[41] Also, for higher prestige, expensive

[37] Burford 1969, pp.35-6.
[38] Pakkanen 2013b, p.73 has estimated that the eisphora at Athens was likely sufficient for the construction of the shipsheds.
[39] Wright 2005a, pp.31-3.
[40] Explained in detail by Wright 2005a, pp.33-9. Cf. Adam 2013, pp.20-40.
[41] Burford 1969, pp.159-66.

marble was imported even from far away.[42] Within the total costs of man-days one must include the quarrying and working of the stone as well as dressing it to the desired surface finish. This latter step could have been done at the construction site and is included as part of the construction costs.[43]

Calculated costs in man-days to quarry limestone in the Classical period vary greatly based on political and economic conditions. For example, the Athenians paid little, if anything, beyond quarrying costs for large blocks from the Akte peninsula, yet the Epidaurians paid substantial sums for the Corinthian limestone used in the sanctuary of Asklepios.[44] Therefore, the costs of stone sourced within the *chora* of a polis would derive from the laborious tasks involved (quarrying, transport, construction, etc.).[45] The same can reasonably be said for any other material. It can be expected that quarries within the vicinity of the Syracusan colonies supplied all the necessary stone for each community's building projects. This expectation then lowers the overall costs of stone to simply the labour involved for its extraction, as well for all material resources which can be found within the Syracusan hinterland.

The quarrying costs paid by the Athenians for stone from the Akte peninsula in 329/8 BC can then be used as a reasonable minimum expectation; the equivalent cost in man-days has been estimated at 2.1–2.5 man-days per cubic metre (md/m³).[46] While these block sizes are specific to the building projects at Athens, the labour costs provide the best comparison for the present discussion: construction at Athens was well organised and employed local quarries and craftsmen, and it is likely that the circumstances at Syracuse and its settlements were quite similar. These costs are used for the calculations below, although the lower rate is rounded to 2.0 md/m³ to allow for softer stones than in the Akte. When setting the blocks in place, a minimum of 4.0 md/m³ is estimated when only the top and bottom of the blocks need to be cut smoothly. At Epidauros, this was found to be 3.5 md for the simplest foundation stone; however, some blocks required more finishing than others depending upon their place within the structure, such as in the fortification construction, hence the average of 4.0 md. This rate

[42] In general, see Adam 2013, p.20; for instance, the proximity to quarries can be recognised as a factor at Megara Hyblaia; Fitzjohn 2013, p.634. On the use of Corinthian limestone at Epidauros, see Burford 1969, pp.32-39, 168-175, 193-194. On marble, see e.g. Lawrence & Tomlinson 1996, p.99.

[43] De Angelis 2003, p.163.

[44] Pakkanen 2013b, pp.64-5. This also raises the question over whether or not stone had a price in addition to its quarrying costs, Burford 1969, pp.172-3.

[45] De Angelis 2003, p.164.

[46] *IG* 2² 1672.131–2; for a detailed analysis and further sources supporting the price range, see Pakkanen 2013b, pp.64-5.

doubles to 8.0 man-days when all visible sides need to be dressed, such as during temple construction.[47]

With regard to residential construction, less intensive labour costs would be required. Rubble wall construction, common in the Archaic period houses, does not require each individual block to be the same size and shape, lowering the labour costs. Fitzjohn, using anthropological sources, estimates 0.52 md/m³;[48] however more contemporary contexts use a lower rate of 0.25 md/m³.[49] Observing local Maya building contractors, Erasmus estimates around 4.0 md/m³ to construct a stone wall working five-hour days;[50] in a ten-hour day this is 2.0 md/m³. This rate is doubled for an elaborate wall or halved for a wall built 'fast and crudely'.[51] Little to no dressing is required for a rubble construction, and so the rate is expected to be significantly less than that for dressed masonry. Residential construction is not expected to have been done 'fast and crudely', but, nonetheless, towards that end of the spectrum: the minimum rate estimate here will be 1.0 md/m.[52]

The first step in construction is the digging of foundation trenches prior to setting the stone socles. In most cases there is a layer of earth above the bedrock, and then once reached, the trenches do not proceed much further down with the exception of levelling the bottom. DeLaine estimates 0.14 md/m³ for foundations less than 1.6 m deep and 0.15 md/m³ for those of greater depth, with an additional 10 per cent for shoring foundations.[53] The variable ratio of earth and bedrock to be excavated would alter the rate, but these rates serve well for the purposes here.

This rubble, once removed from the earth, needs taken away from the construction site if it cannot be used in the project. The material would need to be carried to an ox-carriage, loaded, transported a distance, then unloaded and carried to the disposal site. DeLaine provides a rate of 0.163 md/m³ for material carried up to 25 metres, while loading onto the carriage can be calculated at a rate of 0.06 md/m³.[54] The transport costs are discussed in more detail in section 3.7 below. Double-curtain walls, as found at Heloros, Kasmenai and Kamarina, would have required additional labour costs to fill in gaps between the inner and outer foundation

[47] *IG* 4² 106A.41-6; Pakkanen 2013b, p.65, n.81. Bessac 1986, p.281 estimates 8–22 hours, around 2 work days, per m³ to face raw blocks of stone, but this does not include setting it into the foundation nor does he determine specifically the type of stone.
[48] Fitzjohn 2013, p.632.
[49] DeLaine 1997, p.111. Cf. Pakkanen 2013b, p.61.
[50] This average figure was also found by Erasmus at Uxmal, but under different working conditions, Erasmus 1965, pp.291-2.
[51] Erasmus 1965, p.291.
[52] If any minimal dressing is required, it will be expected to have been done during construction and considered part of the rate. For comparison, Fitzjohn 2013, p.632 estimates 1.25 md/m³ using anthropological contexts.
[53] DeLaine 1997, p.268.
[54] DeLaine 1997, pp.110-11, Table 6 provides a range of rates depending on the locally available stone, up to 0.180 md/m³ for carrying and 0.07 md/m³ for loading.

walls. This would likely have been done using this loose material already excavated, and has been estimated by Pakkanen at 0.07 md/m³.[55]

Limestone has been the primary type of stone used to calculate the man-power figures above; however, the same man-day rates are kept when constructing and quarrying local igneous rocks and sandstone. Additionally, the rates given above are largely derived from ranges,[56] and it is more consistent to keep to the same figures for various stone types when their differences are not very pronounced.

3.3 Mudbrick

Mudbrick was a common material in Greek architecture, both monumental and domestic.[57] In contrast to stone, which is used in its pure form, making the finished product requires an earth/clay mix,[58] straw, water, a fourth material such as sand or chaff, depending on the location and its accessibility, and most importantly time.[59] These factors allowed its availability as a construction material virtually everywhere. Because of the commonality and early usage of mudbrick in construction, the weights and relative advantages of other ancient building materials have been compared with mudbrick construction.[60]

Modern ethnographical studies have followed the mudbrick manufacturing process, and from these can be gathered possible techniques and timelines for the region under consideration.[61] In Persia, a brick maker can make bricks at a rate of about 250 bricks an hour.[62] These are then left to dry for 3–5 hours before being set on edge to dry for another day or two. The bricks produced were 8 in x 8 in x 1.5 in, up to half the size used in ancient Babylon or Persepolis. Approximately 625 bricks of this size would equal one cubic metre,[63] equalling 2.5 hours of work. A twelve-hour workday (ten working hours) would allow for more production in a shorter amount of days. This rate, therefore, can convert to a range of roughly 0.50 (five-hour day) to 0.25 (ten-hour day) man-days per cubic metre.

---

[55] Frederiksen 2011, pp.86-7. Pakkanen 2013b, p.66 estimates a range up to 0.11 md/m³ with 0.07 md/m³ being the lower end.
[56] DeLaine 1997, p.110, Table 6; Hugues et al. 2005, pp.15, 18.
[57] Vitr. 2.8.9-10. Cf. Martin 1965, p.50; Lentini et al. 2008, p.359; Adam 2013, p.59; Tsakirgis 2016, pp.273-4.
[58] See Wright 2005a, pp.77-9 on the nature and qualities of earth as a building material.
[59] Cf. Martin 1965, pp.49-50.
[60] Wright 2005a, p.12.
[61] The most recent publication of this is the AP Palace at ancient Urkesh, but the full study has yet to be published; see Buccellati & Kansa 2016.
[62] Wulff 1976, pp.109-11.
[63] 1 inch ≈ 0.0254 metres. 8 x 8 x 1.5 in. brick ≈ 0.2 x 0.2 x 0.04 m. 1 brick ≈ 0.0016 m². 625 bricks ≈ 1 m³.

Greek parallels for brick size have come in the form of 26.5 cm x 26.5 cm x 8.4 cm (fourth century BC Olynthus) up to 65 cm x 32.5 cm x 8 cm (Elis).[64] For residential construction, mudbrick sizes fall along a similar, slightly smaller, range. Perhaps a better correlation for the purposes here can be found in the fortifications of ancient Smyrna, built between the ninth and eighth centuries, where bricks were found c. 50 cm x 30 cm x 8–13 cm.[65] At this time, Greek bricks were more commonly rectangular in shape, gradually changing to a square standard by the fifth century. As of now, one cannot know for certain the size of the bricks manufactured for use in the Syracusan colonies, but the production rate would most likely not have been affected by higher volume bricks, as long as they can be held in one hand.[66]

A slightly different process in Egypt leaves the mixture to soak and ferment for at least two days.[67] Then after manufacture, they are left to dry for six days, being turned half way through. Even after the six days, they may be left for months in brick stacks before being used for construction, if only to ensure thorough drying. This six-day cycle involved a consistent rotation with six mixing troughs and six moulding grounds. From this process, an estimated 3,000 bricks could be made each day by a team of four men, or 750 per man. If the blocks are of comparative size as those in Persia,[68] the rate would be slower at around 0.83 md/m³.

Other studies have given estimates on either end of these figures. Wright recently asserted that an experienced brick maker could, with an assistant, produce 'say something like up to 20 m³' of bricks a day, which equates to 0.1 md/m³.[69] He provides this figure without any further justification, including drying time, and so his rate will be disregarded as it seems unreasonably low. As discussed above, the ethnographic example from Persia suggests a minimum cost of 0.25/m³. By contrast, a twentieth-century Greek context suggests that mudbrick making can be estimated as 0.9–1.5 md/m³, using three to four men but lasting seven days.[70] Therefore, based on the lowest and highest rates from ethnographical studies, a range of 0.25–1.5 md/m³ will be used in the current study. The possibility of a longer drying time cannot be dismissed; for instance, Vitruvius (2.3.2) warns against using mudbrick not allowed to dry for at least two years.[71] Devolder, using the same two ethnographical studies above, arrives at 0.14 md/m³ extraction and 0.38 md/m³ for collection, although she does not explain how she

---

[64] Martin 1965, pp.55-6; Orlandos 1966, pp.58-60; Malacrino 2010, p.50. For comprehensive surveys on the use of mudbrick in the Greek period see Martin 1965, pp.46-63 and Orlandos 1966, pp.51-66.
[65] Nicholls 1958/1959, p.102; Malacrino 2010, p.50.
[66] DeLaine 1997, p.268, n.5.
[67] Fathy 1989, pp.89-91. Cf. Kemp 2000, p.83; Emery 2011.
[68] Brick sizes were often based on local customs and experience, Adam 2013, p.61.
[69] Wright 2005a, p.99.
[70] Skafida 1994, p.184.
[71] Malacrino 2010, p.49. DeLaine 1997, p.115 figures at least a month of drying time total.

reaches these conclusions.[72] Instead of individualising each aspect, the estimations above include these steps of the manufacture process. Adding to this, construction projects would have most often included skilled workers building at a rate estimated to 0.4 md/m³.[73] This rate is used here as the minimum time spent in the construction of walls using mudbrick.

3.4 Terracotta Roof Tiles

Generally, roof tiles are sizable and heavy, and they can hold the weight of a man, but he must tread carefully.[74] On average, the size of a typical terracotta tile can be estimated as c. 70 cm x 50 cm, with a thickness of about 2–3 cm. Using 3 cm as its thickness, the average volume of a single tile would be 0.0105 m³. A cover tile can be expected to be about half the volume, and can be either semi-circular or polygonal. To ensure that the tiles remain in place they are constructed with interlocking edges, while the sheer weight of each tile also goes far in preventing them from slipping down the slope. 'Laconian' and 'Corinthian' roof tiling systems are the most commonly known in the Classical period, while the 'Sicilian' system is a combination of the two (Fig. 3.1). These systems were fully developed by 600 BC.[75] Laconian pantiles are concave, with the semi-circular cover-tile placed over the joint of two tiles. Corinthian pantiles are large and flat with lateral flanges at each side. A ridge on the upslope end prevents water flowing upward in heavy winds, while a downturn edge on the bottom rests on the downslope tile, encouraging water drainage in that direction. The cover-tile has a pointed edge, mimicking a ridged roof. In the Sicilian system the pantiles are flat, but the cover-tile is semi-circular. Manufacturing the Laconian tiles slightly was simpler than their Corinthian counterpart.[76] There is some evidence that the Sicilian system dominated the construction in the region of focus here: for example, the roofs of the temples of Apollo at Syracuse and of Aphrodite at Akrai were constructed using the Sicilian system.[77] Available evidence is insufficient to determine the tiling system used on the Temple of Ares at Kasmenai, although a Sicilian system can be expected given its use at Syracuse and Akrai. No evidence is known of the roof of the Koreion at Heloros, and comparanda suggests it was flat, without the use of tiles.[78] However, the estimates below will be based on tile sizes, not their specific characteristics. Outlined below is the amount of labour required to produce 1,000 tiles of each type: pantiles, cover-tiles and ridge-tiles.

---

[72] Devolder 2005, pp.169, Table A.
[73] Devolder 2005, pp.169, Table A.
[74] Wright 2005a, pp.125-6.
[75] Winter 1993, pp.12-18; Wright 2005a, pp.127-9.
[76] Winter 1993, p.305.
[77] Temple of Apollo: Holloway 1991, p.69; Temple of Aphrodite: Bernabò Brea 1986, p.26, n.9.
[78] See section 5.7 below.

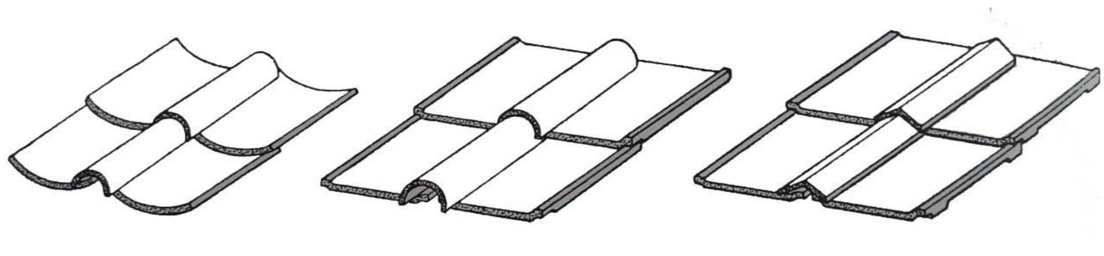

Fig. 3.1: Greek roof tiling systems. Left: Laconian; centre: Sicilian; right: Corinthian. Wright 2005b, Fig. 183.

In calculating flat Roman bricks, DeLaine uses a kiln with the dimensions of 5 m x 5 m x 4 m, estimating its firing capacity as 65 per cent (65 m^3) of its total capacity.[79] The volume of quarried clay is approximately 1.43 times the volume of the end product, resulting in 93 m^3 of clay needed per kiln load.[80] However, Pakkanen, working with tiles, has estimated an additional 20 per cent of room needed to fill a kiln with tiles.[81] This latter estimate will be followed lowering the firing capacity to 52 m^3 with 74 m^3 of clay per kiln load.[82] Firing time has been estimated at 60 hours, while the cooling period is at least 3–5 days.

There are, however, more steps to this process which increase the labour costs.[83] It will be presumed that the kiln was made specifically for roof-tile manufacture, and these were not made in the same kilns as pottery. Further, the tile sizes will be estimated based on a pantile of ca. 70 cm x 50 cm x 3 cm, and the cover-tile at half that volume.[84] Along the top of the roof, the ridge-tiles prevalent in Sicily at this time were basically cover-tiles, and as such the same measurements will be used here.[85] Tiles of these sizes estimate to 4,950 pantiles and 9,810 each of cover-tiles and ridge-tiles per kiln load.[86] Quarrying the 74 m^3 of clay would take 11 md at a rate of 0.15 md/m^3, while loading and carrying the clay to the kilns, at a rate of 0.63 md/m^3, equals 47 md.[87]

In preparing and forming the clay to the tile shapes, labour costs vary. Based on Pakkanen, it can be expected to take approximately 0.02–0.03 man-days per pan-tile and 0.01–0.02 man-days per cover-tile and ridge-tile.[88] Labour costs per kiln load, therefore, are 99–149

---

[79] DeLaine 1997, p.117. Cf. Pakkanen 2013b, p.69.
[80] 65 m^3 x 1.43 = 92.95 m^3.
[81] Pakkanen 2013b, p.69.
[82] 65 m^3 x 80% = 52 m^3; 52 m^3 x 1.43 = 74.36 m^3.
[83] DeLaine 1997, pp.114-8; Pakkanen 2013b, p.69, Table 5.2.
[84] Pan-tile volume: 0.70 m x 0.50 m x 0.03 m ≈ 0.0105 m^3; cover-tile volume: 0.0105 m^3 x 50% ≈ 0.0053 m^3.
[85] Winter 1993, p.280.
[86] Pantiles: 52 m^3 / 0.0105 m^3 = 4,950 tiles per kiln load; cover-tiles: 52 m^3 / 0.0053 m^3 = 9,810 tiles per kiln load; ridge-tiles: 52 m^3 / 0.0053 m^3 = 9,810 tiles per kiln load.
[87] DeLaine 1997, p.118; Pakkanen 2013b, p.69, Table 5.2. 74.36 m^3 x 0.15 md/m^3 ≈ 11.15 md. 74.36 m^3 x 0.63 md/m^3 ≈ 46.85 md.
[88] Pakkanen 2013b, p.69, Table 5.2. This rate comes from the estimated number of man-days per kiln load preparing the clay and forming the tiles divided by the number of tiles per kiln load. Pantiles: 60 md / 1,900 tiles ≈ 0.03 md/tile; cover-tiles: 90 md / 4,100 tiles ≈ 0.02 md/tile. However, since the roof-tiles in Archaic Sicily are more simple than at Classical Athens, the rates have been reduced.

md, 98–196 md and 98– 196 md for pantiles, cover-tiles and ridge-tiles, respectively.[89] The remaining steps vary marginally depending on the amount of required material for each step of the process, but the estimates used here are 10 md to carry and load the kiln, 10 md to fire the kiln and 6 md for unloading. Thus, each kiln load requires 11 md to quarry the clay, an additional 73 md to carry, load, unload and fire the kiln, and at least 7 days for firing and cooling. This is in addition to the time spent preparing and forming the clay into the tiles. The week it takes to fire and cool the tiles can be ignored for larger projects as kiln loads can be staggered to allow an adequate supply to always be on hand.

Additionally, an estimated 23.4 tonnes of firewood per kiln load is needed for fuel. DeLaine, citing Diocletian's *Price Edict* (14.8), settles on a rate of roughly 8 md/tonne, while Pakkanen finds a range of 13–32 md/tonne from contracts at Hellenistic Delos.[90] Instead, however, he settles on 10 md/tonne for his estimates at Athens as that city-state was likely in a better position than most to import firewood. Since the nearby areas surrounding the settlements of south-east Sicily were likely well-forested and also able to provide ample firewood, the labour costs can be reduced to half compared to Athens. Therefore, each kiln load of roof tiles took 117–234 md to fuel. Table 3.1 lists the range of labour costs per 1,000 tiles manufactured of all three tile types.

By comparison, in modern Italy, it has been estimated that a single moulder with assistant could produce 800–1000 curved roof tiles a day, or 400–500 a person.[91] This modern process incorporated moulds, the use of which in ancient times is not determined. The firing season has been proposed by DeLaine to run from mid-April to mid-October, possibly adding further time restraints on the entire process.[92]

Table 3.1: Labour costs for roof tiles per 1,000 tiles

	PANTILES	COVER-TILES	RIDGE-TILES
TILES PER KILN LOAD:	4,950	9,810	9,810
QUARRIED VOLUME OF CLAY (M³):	74	74	74
QUARRY (MD):	11	11	11
CARRY AND LOAD CLAY (MD)	47	47	47
PREPARING CLAY AND FORMING TILE (MD):	99-149	98-196	98-196
CARRY AND LOAD KILN (MD):	10	10	10
FIRE KILN (MD):	10	10	10
FIREWOOD FOR FUEL (MD):	117-234	117-234	117-234
UNLOAD KILN (MD):	6	6	6
TOTAL MD:	300-467	299-514	299-514
TOTAL MD PER 1,000 TILES:[93]	61-94	31-52	31-52

[89] Pantiles: 4,950 tiles x 0.02 md/tile ≈ 99 md; 4,950 tiles x 0.03 md/tile ≈ 149 md; cover-tiles and ridge-tiles: 9,810 tiles x 0.01 md/tile ≈ 98 md each; 9,810 tiles x 0.02 md/tile ≈ 196 md each.

[90] DeLaine 1997, p.212; Pakkanen 2013b, p.70.

[91] Winter 1993, p.305; DeLaine 1997, pp.116, n.64.

[92] DeLaine 1997, p.117.

[93] Pantiles: (300 md / 4,950 tiles) x 1,000 tiles ≈ 61 md; cover-tiles and ridge-tiles: (299 md/ 9,810 tiles) x 1,000 tiles ≈ 31 md each.

The process of laying the tiles on the temple roofs can be taken from the tiling of the Erechtheion.[94] Beginning with the corners of the roof and working towards the centre, pantiles were placed working up the slope with each successive tile placed overlapping the top of the previous.[95] The process was then repeated with the cover-tiles followed by the ridge-tiles. Pakkanen derives a rate of 15 m²/md (or 0.07 md/m²) from the Erechtheion tiled area of c. 365 m² and the documented cost of 24 drachmae.[96] Roof reconstructions employed below are not complex enough to warrant any additional fasteners.[97]

The first recorded instances of roof tiles are in the area of Corinth in the first half of the seventh century, and their use spread rapidly into Sicily by the end of that century.[98] However, during most of the Archaic period, the Greeks limited their use of roof tiles to monumental buildings, only beginning to employ them in private houses late in the sixth century BC.[99] For this reason, the use of terracotta tiles will be limited to the calculations of temples. At Heloros, the early construction of the Koreion was likely without roof-tiles, but it is likely that they were employed in the temples at Akrai and Kasmenai.

3.5 Wood

In antiquity, good-quality timber could be rare in places, and the task of sawing wood was also time-consuming and expensive.[100] However, given Sicily's abundance of forests in the Archaic period, it is expected that wood was readily available. Fir (softwood) and oak (hardwood) are both abundant throughout Europe and accounted for in the econometric calculations below.[101] If the timber could be used without squaring it and thus avoiding the costly length-wise sawing, it was often simply a matter of felling the trees, seasoning and preparing the wood for transport.

Ethnographic and experimental studies have provided comparanda for over a century,[102] but the number of variables in processing trees make direct usage of these experiments more of a challenge than with other materials. These variables include, but are in no way limited to: age of tree, blade shape, expertise of the fellers, available tools, technique

94 *IG* 1³ 475.251-3.
95 Winter 1993, p.306.
96 Pakkanen 2013b, pp.70, n.128.
97 Balancing the tiles due to deformities developed in the tile manufacturing process and adjustment of misalignments between tiles must have been part of the standard laying out of the roof, Winter 1993, pp.306-7.
98 Wikander 1990, p.285.
99 Winter 1993, p. 273.
100 At Epidauros, wood cost up to two-thirds the price of stone. Burford 1969, p.178.
101 Meiggs 1982, pp.43, 45 respectively.
102 For an overview, see Mathieu & Meyer 1997, pp.333-4.

and even luck. Variables which are considered here are the wood type and diameter of the tree. For example, in a Danish experiment in the mid-twentieth century two archaeologists succeeded, after a few failures and after 'the two archaeologists reached peak form', in felling oak trees more than a foot in diameter in half an hour using stone tools.[103] This took place in a forest of mixed oak.

For the prices of both hard- and softwood in Greece and Rome there is quite sufficient textual evidence.[104] The price ranges in Greece in the fourth century BC for different lengths of timbers have been estimated by Clark for 22-foot long softwood at 11–27 drachmae per timber, and the price of shorter timbers (10–14 feet long) is only a third of the longer ones; hardwood is 1.5 times as expensive as softwood.[105] Pakkanen for fifth-century Athens adjusts Clark's price to 16.2 md/m³ for the long softwood.[106] Since these prices reflect Greek market prices where the individual entrepreneurs were making a sizable profit,[107] and since timber was abundantly available in Sicily near the settlements,[108] the cost of local timber expressed in man-days should be reduced compared to mainland Greece: here is estimated the minimum Sicilian cost for locating, felling, trimming and seasoning of softwood in place as 8.2 md/m³ for long softwood timbers and 2.7 md/m³ for the short ones, roughly half that of Pakkanen.[109] For hardwood, these values should be multiplied by 1.5. In practice, these estimates reflect that a team of two foresters would have been able to deal with three to four short 12-foot fir timbers in a day at a nearby forest of one of the settlements but that locating and processing the taller 22-foot ones was a highly more demanding task.[110] To account for the varying lengths of timber, short timbers will be those under 14 feet (4.27 m), long timbers over 22 feet (6.71 m), while those in between will be estimated at a rate of 5.5 md/m³. The majority of econometric calculations involving wood will be using softwood, with temple doors as the only exception.[111]

---

[103] Iversen 1956, p.38.

[104] For a recent summary of the discussion, see Pakkanen 2013b, pp.61-2.

[105] Clark 1993, pp.247-9. For comparison, DeLaine 1997, p.215 gives the price of oak as 0.42 md/Roman ft³ or 16.2 md/m³. The higher price likely reflects both the more finished nature of the timber (squared instead of round) and hardwood as raw material.

[106] Pakkanen 2013, p.61.

[107] See Koskela, forthcoming.

[108] Meiggs 1982, pp.208-10.

[109] Cost of a single 22-foot softwood timber: 0.75 (cost reduction for Sicily) x 11 dr. x 0.5 md/dr. (cost of a day's skilled labour) ≈ 4.125 md; estimated volume of a 22-ft timber: $\pi \times (0.30 \text{ m} / 2)^2 \times 22 \text{ ft} \times 0.325 \text{ m/ft} \approx 0.5054 \text{ m}^3$. Minimum cost: $4.125 \text{ md} / 0.5054 \text{ m}^3 \approx 8.16 \text{ md/m}^3$. Minimum cost of short 10–14 feet timbers: $^1/_3 \times 8.162 \text{ md/m}^3 \approx 2.72 \text{ md/m}^3$. For the labour costs in Greece, see Loomis 1998, pp.104-20; Pakkanen 2013b, pp.61, n.39.

[110] $2 \text{ md} / 2.72 \text{ md/m}^3 / (\pi \times (0.30 \text{ m} / 2)^2 \times 3 \text{ m}) \approx 3.47$ timbers (2 workmen, timber height 3 m and diameter 0.30 m).

[111] At the temple of Asklepios at Epidauros, fir was used extensively, with elm and boxwood for the doors, Burford 1969, p.176.

Seasoning the timber will be assumed to have taken place where felled.[112] Depending on the climate and the time of felling, drying the timber may take many months to years.[113] Autumn was likely the best time to fell and season timber,[114] however it can be expected that from foundation there was a process of timber felling in place and so the supply of timber would not have been determined by the availability of seasoned wood, except in dire circumstances. Therefore, the time it takes to season timber will not be accounted for in the calculations. The same can be said about the time of year and climate.[115]

The process of squaring a log must begin by setting the wood on two cross beams on the ground to allow for greater freedom of movement and to eliminate hitting the floor.[116] A different axe than that used during the act of felling is implemented, if not a straight saw. Cutting against the grain, all exposed sides are cut before turning the log over, a process which in itself can be difficult and even dangerous.

There is a wide range of estimates for squaring wood into timber and planks once they have been seasoned.[117] Ancient sources from the Erechtheion, Delphi, Diocletian's *Price Edict* (12.17) and Columella's *Res Rustica* (11.2.13) provide rates of 0.14–0.26 man-days per square metre, or 0.28–0.52 for a pair of sawyers.[118] Columella also gives a rate of 0.35 md/m² which Meiggs believes is far too long, yet this may be an acceptable rate for sawing as evidenced at Delphi in the third century.[119] DeLaine follows more modern estimates from nineteenth century figures that range from 0.048 to 0.067 man-days per square metre, choosing 0.06 md/m² in part due to questions about the ancient written sources.[120] However, DeLaine admits that her choice of rate could be merely a quarter of actual figures in the ancient world. Pakkanen presents a re-examination of the available evidence which is followed here, and the lowest rate of 0.14 md/m² taken for minimum calculations. This rate is per sawyer but using a pair of sawyers taking a seasoned log and reducing it to the usable size which requires a minimum of four cuts for larger timber, most often used in temple roofing structures, or more for planks, such as for doors (Fig. 3.2). This rate can also be used for cutting planks from squared logs, most useful for manufacturing doors for the houses and temples: three cuts are needed to make four planks from a squared timber. Below doorways are calculated at an opening of 1 metre; each door will be estimated to have comprised three planks of around 0.33 m in width attached together by

---

[112] Pakkanen 2013b, p.61.
[113] Adam 2013, p.91.
[114] Hes. *WD* 414-20; Fitzjohn 2013, p.635.
[115] Adam 2013, p.87.
[116] Adam 2013, pp.93-4.
[117] Pakkanen 2013b, pp.61-2.
[118] *IG* 1³ 475.57-63; *FD* 3.5.41; 3.7-14. Cf. Pakkanen 2013b, pp.62, n.48, 50.
[119] Meiggs 1982, pp.368-9, n.145.
[120] Pegoretti 1865, v. 2, p.291; Hurst 1937, p.222. Cf. DeLaine 1997, pp.268-9, n.8.

wooden pegs. Piecing the three planks together to finish the door can be disregarded due to minimal time used in the process.

The harvested wood would have been used for roofs of the residences and temples. Greek houses largely incorporated flat roofs at a gentle angle to allow for rain runoff, and as such would have needed only principal beams and lintels over the doorways. Further, it can be expected that for houses the beams were kept rounded.[121] On top of the timber framework was commonly placed layers of plant material and mud to form a waterproof ceiling,[122] although the use of terracotta tiles cannot be excluded, especially for the later periods.[123] Archaeological reports at the Syracusan settlements neglect to mention any remains of tiles in relation to domestic architecture, and since at Megara Hyblaia tiles can only be identified in sixth century constructions,[124] it is presumed that the houses of the settlements at Heloros, Akrai and Kasmenai had flat roofs. Laying the organic material will be considered as part of the overall roof-building process and likely only added 1–2 man-days.

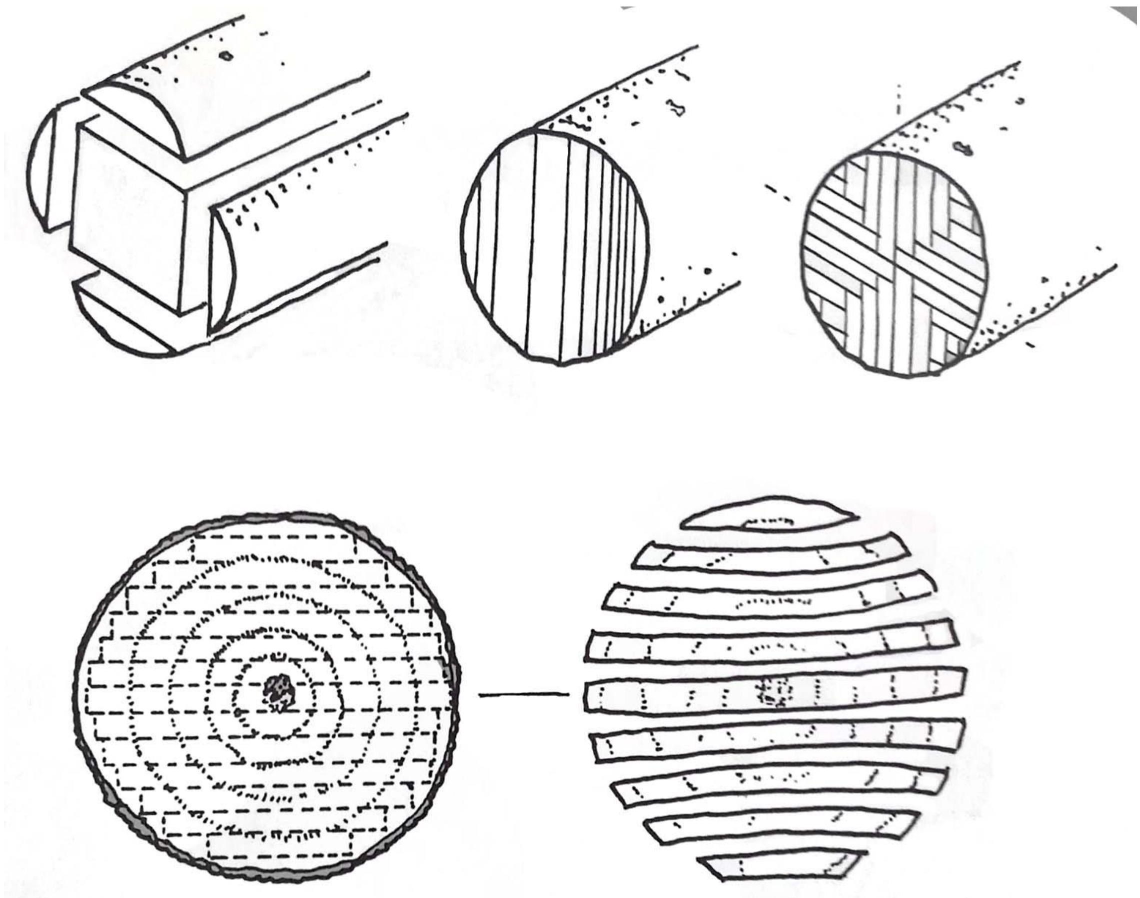

Fig. 3.2: Conversion of a log. Squaring, quartering and sawing for planks and boards. Wright 2005b, Fig. 10.

[121] Adam 2013, p.93.
[122] Fagerström 1988, p.102; Meiggs 1982, p.191; Kemp 2000, p.93.
[123] Wright 2005a, p.126.
[124] Vallet et al. 1976, pp.255-7.

Temples, beginning in the seventh century, were most often constructed with ridged roofs, with rafters running perpendicular to the highest point at which a ridge beam was placed. The available wood in Archaic Sicily may have been superior to that of mainland Greece, allowing for beams to span larger distances (up to 11.84 m) without support from posts or columns.[125] Evidence also suggests that the mid-sixth century Megaron of Demeter (II) at Selinous may have been one of, if not the, earliest use of a truss in Sicily and even Greek architecture.[126] Even though cuttings for timbers can be detected in monumental stone architecture, presenting precise roof reconstructions is difficult, and by extension also estimating the amount of wood incorporated in it. Furthermore, the adaptation of a truss likely did not become prevalent in roof design until after the Archaic period. For these reasons, the most basic ridge roof design will be employed in calculations below. This design (Fig. 3.3) consists of primary ridge beams and purlins running parallel to the long walls of the temple. These latter beams supported secondary timbers (rafters, battens and sheathing), and the ridge beams were supported by vertical props; all of which carried the terracotta roof tiles.[127] This design is also referred to as prop-and-lintel (Fig. 3.4). Fitting the wooden roof frames together involved notches in the stone blocks supplemented by wooden pins, wooden swallow-tailed clamps and likely tied with leather thongs.[128] Glue made from hides and hoofs of cattle was also a likely bonding agent. However, some studies argue that bonding agents were not necessarily required, and tiles were even placed directly on the rafters without the use of sheathing or battens.[129] The calculations below are based on this minimalist approach, using only the rafters as secondary timbers, leading to a reconstruction less complex than that shown in Fig. 3.3 and Fig. 3.4.

Ridge beams and purlins, based on the measurements of sockets, have been found as small as 0.10 m and upwards of a little under a metre in width and height.[130] Very large timbers were used in more monumental architecture and the timbers of the more modest temples, as presented here, were likely between 0.10–0.50 m in section.

[125] Unsupported spans of over eleven metres are documented at Selinous (11.70 m) and Agrigento Herakles (11.84 m). Hodge 1960, pp.38-40; Coulton 1980, p.164; Klein 1998, pp.338-9
[126] Hodge 1960, pp.40-1, n.4; Klein 1998, p.351.
[127] Cf. Hodge 1960, pp.35-44, 77.
[128] Wright 2005a, p.22.
[129] Hodge 1960, pp.67-75.
[130] Hodge 1960, p.46, Table 2.

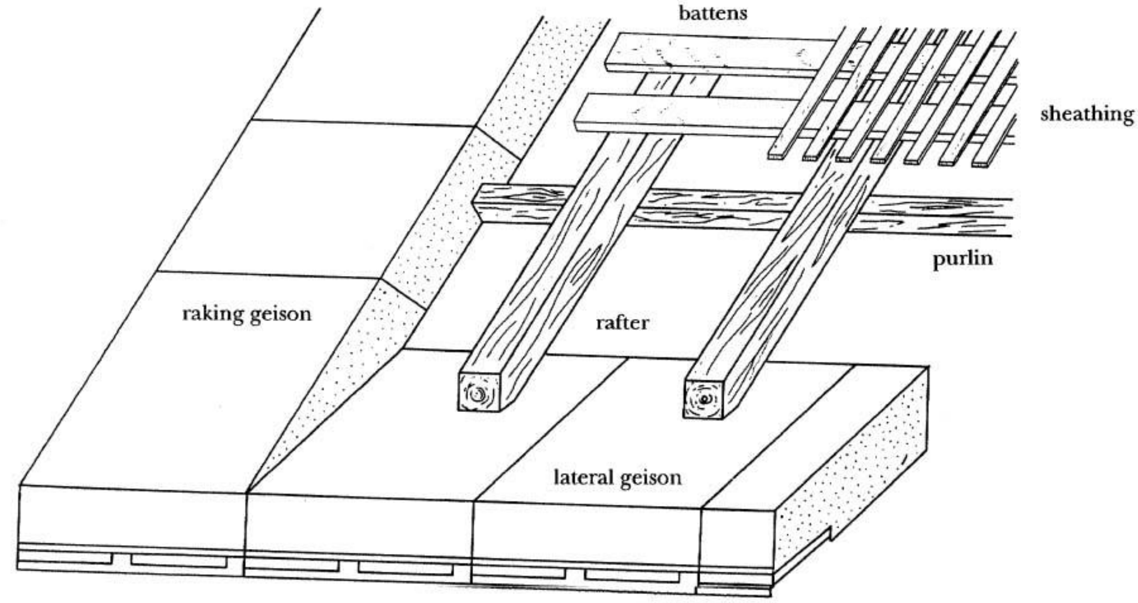

Fig. 3.3: Basic Greek roof design in monumental architecture. Klein 1998, p.336, Fig. 1.

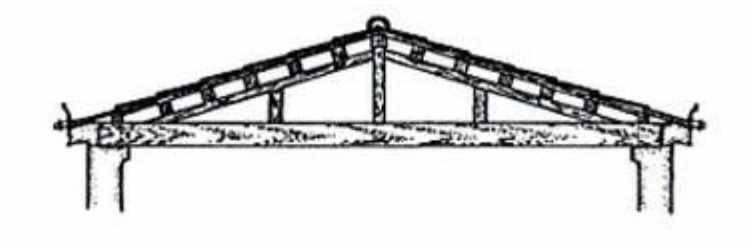

Fig. 3.4: Example of Prop-and-Lintel design roof construction. Hodge 1960, p.23, Fig. 8 (b).

Constructing the roof of a monumental building such as a temple would require a major undertaking. The larger, primary timbers would require more work using more labourers as compared to the smaller, secondary timbers. Burford estimates 2 md/m² of roof,[131] yet such a straightforward rate could underestimate the difficulty in installing large, weight-bearing ridge beams like those found in temples. Clark, on the other hand, breaks up the primary and secondary timbers into separate rates.[132] He emphasises the complexity in mounting a major beam, estimating a single instance could take up to 60 md to complete.[133] A major beam would be those over 0.50 m in width as seen in the more substantial instances of monumental architecture.[134] Of the two, Clark's rates are preferred for temples as his method does not generalize the roof construction, but instead adapts to the range of requirements in handling different sized timbers. Largely, the construction projects discussed here are not as monumental. One comparison may be found in the shipshed constructions in Classical Athens

[131] Burford 1969, pp.213, 249 (Contract 23).
[132] Clark 1993, p.256. Cf. Pakkanen 2013b, p.68.
[133] The construction costs include raising, fitting, coupling and bevelling of a major beam.
[134] Cf. Hodge 1960, pp.45-7, Table 2.

where beams were placed totalling 45 m in length.[135] There the 60 md/beam rate was used. The Temple of Aphrodite at Akrai runs almost 40 metres in length, and using the shipsheds as standard, a rate of 53 md/primary timber is used here.[136] At Kasmenai, the Temple of Ares is only around 26 m in length leading to a rate of 35 md/primary timber.[137] However, the Temple of Apollo at Syracuse is almost 55 m long, and so a higher rate of 73 md/primary timber is used.[138] Therefore, the rate for setting large primary timbers will be estimated specific to each temple size. A smaller secondary timber, such as a rafter, by contrast would then only take a pair of workmen a quarter of a day to install.

For residential construction, with the walls being lower and the roof system figured as flat, the rate will be substantially lower. In this instance then, a reasonable rate of 0.1 md/timber will be implemented. Placing the weather-proofing material over the roof likely took an additional 1–2 md, a minimal cost compared to monumental architecture.

3.6 Skilled Labour and Supervision

One of the most important issues in the econometric calculations of labour costs is its effect on the settlement initiating the construction and that community's necessity for outside help. Skilled labour is a requirement of certain aspects of monumental construction, and providing for this resource inevitably called for the import of workmen from outside the settlement. This was the case at Epidauros in the fourth century BC where the local craftsmen could only provide for a certain amount of less complicated work, and many, if not all, of the skilled temple builders came from elsewhere.[139] A similar case can be expected with early Syracuse and its settlements. In the sixth century Syracuse was thriving and could provide much of the skilled workmen needed for the construction of fortifications and temples at its settlements.

Supervision costs must also be included, although the supervisors were not necessarily skilled themselves. This often depended upon the skill required for the work itself.[140] Nineteenth and twentieth century estimates used by DeLaine provide a range anywhere from 3–25 per cent of the initial costs, which she averages to 10 per cent.[141] This is the percentage used by Pakkanen as well.[142]

[135] Pakkanen 2013b, p.68.
[136] 40 m (Akrai) / 45 m (Athens) x 60 md/beam ≈ 53 md/primary timber.
[137] 26 m (Kasmenai) / 45 m (Athens) x 60 md/beam ≈ 35 md/primary timber.
[138] 55 m (Syracuse) / 45 m (Athens) x 60 md/beam ≈ 73 md/primary timber.
[139] Burford 1969, p.191.
[140] DeLaine 1997, pp.268-9.
[141] DeLaine 1997, p.107.
[142] Pakkanen 2013b, pp.60-1.

3.7 Transport

Essential to the construction process is the transportation of the materials from the place of extraction to the building site. While human porterage was a factor, oxen provided the best mode through which to move the materials in bulk, and written sources emphasise the importance of the animal in antiquity.[143] The human aspect of transport increases the overall labour costs, but it was likely reserved only for short distances.[144] Gathering of materials, such as clay for mudbrick and roof-tiles, stone and wood, often took place a distance from the site of construction, thus necessitating heavy transport. For these reasons, focus will largely be on the labour costs of heavy transport travelling long distances. Transport costs are calculated primarily through pairs of oxen pulling a carriage[145] and how much each pair can pull a day, the unit of which is referred to as ox-carriage days (od).[146] Moving bulk materials by water did lower the costs as ships could hold much more cargo and only need a handful of men.[147] It can be expected that Syracuse would have had ample connections through which to acquire any resource, including building materials for more complex structures; however, nearly all materials required for building in south-east Sicily were readily available in the region: only marble for high-status projects was imported from Greece. Therefore, all of the transport costs figured below will be calculated using heavy land-based transport.

The costs associated with oxen vary, and indeed it is difficult to find any fixed scale of fees per team. At Eleusis in the 320s BC, the inscriptions document a range of 19–37 yokes used in any one load.[148] Burford expects this was not due to need per load, but instead it depended upon how many were present at the time.[149] Costs stipulated by the Epidaurian inscriptions are highly valuable, but they need to be used carefully to provide a basis for comparison.[150] The transport cost rates of the contracts varied, and the factors are related to both the contractors, the city-state, the distances covered, modes of transport and resources needed to complete the task. For example, there are instances where the time taken to move fragile materials purposefully took longer to ensure safe transport. However, the inscriptional evidence does give valuable indication for determining the minimum labour costs. This cost of land transport

---

143 Cato *Agr.* 10; Plin. *Nat.* 18.48-9; Plut. *Lyc.* 9.1; Xen. *Cyr.* 6.1,52; 54. Cf. Burford 1960, pp.5-6.
144 DeLaine 1997, p.107.
145 The four-wheeled ox-carriage provides the ability to transport more materials at once as opposed to a two-wheeled ox-carriage, Brysbaert 2013, p.83.
146 Donkeys and mules very likely could have been used as modes of transport, but these animals cannot carry near the same amount as oxen can pull. Because of this, they would have been used for small loads, and likely not long distances, DeLaine 1997, p.210, n.16.
147 DeLaine 1997, pp.108, 210-1; Klein 2016, p.108.
148 Burford 1960, pp.14-5.
149 Cf. Salmon 2001, p.200.
150 Burford 1969, p.190.

in antiquity was very high and in many cases the overall transport costs were at least a third of the total construction budget.[151]

Written sources provide a range of c. 400–640 kg for the pulling power of a pair of oxen.[152] At Epidauros, much of the stone was seemingly transported in loads of 500–1000 kg using a single yoke, while Burford has calculated a load of timber there at 1,098 kg, suggesting a pair could realistically pull around a tonne.[153] Here will be utilised 0.9 tonnes as the average carriage load for the calculations below. Pakkanen has provided density figures for four materials: the average density of limestone is 2.6 tonnes/m³, clay 1.75 tonnes/m³, while 'tolerably seasoned' European oak is c. 900–930 kg/m³ and fir c. 560 kg/m³. [154] For igneous rock, which is the primary source of stone used at Kasmenai, density ranges from 2.2–2.4 tonnes/m³.[155] Sandstone, the material used in the construction of the Temple of Apollo at Syracuse, has a density range of 2.0–2.7 tonnes/m³.[156] Given the use of clay in mudbrick to a large degree, the density of clay will be associated with the transport of mudbrick as well.

On average, one pair of oxen could complete eight trips of 0.5 km (i.e. 1 km round trip), or 8 km total, per day.[157] Taking into consideration the time needed for loading and unloading, this rate matches DeLaine's maximum speed of 1.67 km per hour, up to 12 hours a day.[158] Both of these figures are specified for areas where the road from the source to the construction site is relatively flat. However, much of the area of south-east Sicily under consideration involves travel over varying slopes. Using Google Earth, the plateau at Heloros is at an approximate incline of 10 per cent, while that at Kasmenai is to be almost 20 per cent.[159] At Akrai, the stone was most likely quarried from within the urban centre, but material gathered from outside the area would need to be transported up an incline around 15 per cent. Changes in elevation affect the speed at which material is transported: a full carriage going up a hill and controlling an empty carriage going down. The closest examination to this effect on movement speed has been done with horses, where speed is compared on a flat surface versus an 11.8 per cent incline.[160] On average, the horses in the study walked 15 per cent slower up this incline as opposed to the flat surface. Since the friction of pulling the load up the slope is the same as on flat ground, the additional minimum force required can be estimated as $P = mg\sin\theta$ where m

[151] Wright 2005a, p.43.
[152] *Price Edict* 17.3, cf. 14.8; *Theodosian Code* 8.5.30; Xen. *Cyr.* 6.1.54. Cf. Isager & Skydsgaard 1992, pp.104-7; DeLaine 1997, p.108; Salmon 2001, p.200; Wright 2005a, p.42.
[153] Burford 1960, pp.9-10; Burford 1969, pp.186-7.
[154] Pakkanen 2013b, p.65, n.76; p.70, n.122; p.61, n.43; p.68, n.110. Cf. Hugues et al. 2005, p.18 for limestone.
[155] Hugues et al. 2005, p.15.
[156] Hugues et al. 2005, p.17.
[157] Pakkanen 2013b, p.70, n.131.
[158] DeLaine 1997, pp.108, 128.
[159] As calculated in June, 2015.
[160] Wickler et al. 2000, pp.2195-200.

is the mass of the load, g gravity and θ the angle of the slope. The increase is directly proportional to the angle, so e.g. a 10-degree slope requires an additional force of $\sin(10) \approx$ 17.4%.[161] The calculations simplify the situation, but they are sufficient for the purposes of this study. These figures will then be used below to calculate the amount of ox-carriage days required to transport the material to the worksite.

In the econometric calculations below, often the smaller tasks require less than an ox-carriage day of work. In these instances, the cost will be rounded to 1 od. As each aspect of the construction process is explained in detail, all ox-carriage days will be accounted for with the understanding that many smaller tasks may have been accomplished simultaneously, essentially eliminating some ox-carriage days.

The use of oxen in heavy transport presents another obstacle in the construction process. As oxen were essential in agricultural practices, their availability was limited to times of the year when they were not otherwise occupied. Through inscriptions at Eleusis, it seems much of the heavy transport was undertaken between July and September.[162] There is little agricultural work during this period, and, equally important, the dryer conditions were best for transport. This issue is addressed further in the next section. Table 3.2 contains the rates discussed above and is used as basis for the labour cost calculations in the following chapters.

---

[161] Heloros: $\sin(10) \approx$ 17.4%; Akrai: $\sin(15) \approx$ 25.9%; Kasmenai: $\sin(20) \approx$ 34.2%.

[162] Isager & Skydsgaard 1992, p.104; Salmon 2001, p.200.

Table 3.2: Rates used in architectural energetics calculations

MATERIAL		ASPECT	BASE RATE	HIGHEST RATE
STONE:	Fortifications and Temples:	Quarry:	2 md/m³	2.5 md/m³
		Construction:	4 md/m³ or 8 md/m³	
		Loose fill:	0.07 md/m³	0.11 md/m³
	Residences:	Quarry:	0.25 md/m³	0.52 md/m³
		Construction:	1 md/m³	4 md/m³
	All:	Foundation:	0.14 md/m³ (< 1.6 m deep)	Shoring foundation (+ 10%)
			0.15 md/m³ (> 1.6 m deep)	
		Load and Carry 25 metres:	0.163 md/m³	0.18 md/m³
		Load into Carriage:	0.06 md/m³	0.07 md/m³
MUDBRICK:		Manufacture:	0.25 md/m³	1.5 md/m³
		Construction:	0.4 md/m³	
TERRA-COTTA TILES:		Pan tiles:	61 md per 1,000 tiles	94 md per 1,000
		Cover tiles:	31 md per 1,000 tiles	52 md per 1,000
		Ridge tiles:	31 md per 1,000 tiles	52 md per 1,000
		Tiling:	0.07md/m²	
WOOD:	Felling:	Softwood:	2.7 md/m³ (< 4.27 m length)	5.39 md/m³
			5.5 md/m³ (4.27 to 6.71 m length)	10.8 md/m³
			8.2 md/m³ (> 6.71 m length)	16.2 md/m³
		Hardwood:	md rate x 1.5	
		Squaring:	0.14 md/m²	0.35 md/m³
	Temples:	Construction:	73 md/primary timber (Syracuse)	
			53 md/primary timber (Akrai)	
			35 md/primary timber (Kasmenai)	
			0.5 md/rafter	
	Houses:		0.1 md/timber	
SUPERVISION:			10% Added costs	25%
TRANSPORT:	Density of material:	Limestone:	2.6 tonnes/m³	2.9 tonnes/m³
		Igneous Rock:	2.2 tonnes/m³	2.4 tonnes/m³
		Sandstone:	2.0 tonnes/m³	2.7 tonnes/m³
		Clay:	1.75 tonnes/m³	
		Softwood:	0.56 tonnes/m³	
		Hardwood:	0.9 tonnes/m³	

3.8 Population Assessments

In this section, the methodology used to arrive at population figures for each site is outlined, taking into account the research by Muggia and Hansen.[163] This is followed by a discussion on workforce size and the impact agriculture likely had on it. Population estimates and modelling allow for further analyses of the econometric calculations on the building projects. In addition, rank-size and primacy analyses using these estimates, discussed in the final section, present new possible ways of studying hierarchies of the Greek settlements on the island of Sicily.

In 1997, Muggia published her study based on the undeveloped open areas inside the city walls in Greek settlements, defined as the *area di rispetto*, which continued from Nenci's work on the *zona di rispetto.*[164] Work on undeveloped intramural spaces has largely been ignored by archaeologists for obvious reasons, but examining the size of the *area di rispetto* and its purpose can prove to be equally important. If the open space can be assumed to have been saved for emergency use as housing for refugees and/or extra agriculture in times of crisis, then comparisons could be made connecting the *area di rispetto* to possible rural or total population sizes of city-states.[165] Unfortunately, the information is not uniform over different periods of time, which can create some comparison issues.[166]

Studies by the Copenhagen Polis Centre have concluded that the majority of small and midsize polis populations lived in urban centres with their hinterlands only inhabited by a minority.[167] This was likely the case in the Archaic period,[168] and it is the view held by Hansen, who has provided the most recent and in-depth survey of both populations. In 2006, he suggested a different process for calculating population figures in the ancient world: the Shotgun Method.[169] He focuses his study on the degree of urbanization as a source for population figures of a Greek site, principally through physical remains of walled cities and the archaeological landscape surveys of hinterland settlements.[170] In terms of a Greek city-state, the habitation area is a percentage of the walled area from which a presumed number of inhabitants are averaged per hectare of occupied space. This is done in four parts: finding the inhabited percentage of urban space, then deducing an average house size, number of houses

---

163 Muggia 1997; Hansen 2006b.
164 Nenci 1979, pp.465-6; Muggia 1997, pp.13, 16.
165 Muggia 1997, p.34.
166 Among other issues, see De Angelis 2000a, p.139.
167 Hansen 2006b, p.28.
168 Greco 1992, p.312; Osanna 1992, pp.234-5; cf. Muggia 1997, p.137.
169 Hansen 2006b. In 2008, Hansen updated his Shotgun Method (Hansen 2008) with more evidence leading to the conclusion that his estimates were low. This update does not largely affect the present study, more the overall image of the Greek world. For this reason and the sake of estimate ranges, I refer largely to the original study.
170 Methods resembling the Shotgun Method have been used previously in some local, semi-regional and regional studies within the Greek world, but not for its entirety. See Carter 1990; Jameson et al. 1994; Bintliff 1997; Corvisier 1991. Cf. Hansen 2006b, pp.15-6.

per hectare and median household size. It must also be mentioned that his estimations include, as far as possible, 'Hellenized communities', foreign residents and slaves,[171] While notable for the focused area of this thesis, he does not include the Sikels or any other indigenous population of Sicily, as is now customarily done in Sicilian population estimates. This then makes any Greco-Siciliote cohabitation at the settlements more relevant, as a relative degree of indigenous immigration must be considered when considering a site's population. However, this is a source for future work in the area; in the assessments below, the populations will not differentiate between Greeks and non-Greeks.

The Polis Centre's inventory of 1,035 poleis is the basis for Hansen's study, but he can only definitively calculate the size of the territory of 636 poleis and the extent of the urban centre for 232 poleis; for 194 both figures are known. That these examples can be applied for the entire Greek world is a hypothesis Hansen must make for his method to be functional.[172] Other general suppositions involve the inhabited urban space, number of people per hectare and urban to rural population ratio. The classifications in which Hansen orders the sites are listed in Table 3.3 with Syracuse and its settlements identified with their category. Although general in nature, this methodology provides the most thorough study of demography in the Greek world.[173]

Table 3.3: Syracuse and its settlements in Hansen's Shotgun Method[174]

Inhabited Urban Space:	Poleis up to 10 ha: 66%	Poleis 10–150 ha: 50%	Poleis over 150 ha: 33%
	Heloros	Akrai, Kamarina, Kasmenai, Syracuse	
Urban Density:	Average 150–200 people/hectare		
Urban to Rural Population Ratio:	*Chora* of 25–200 km^2: 66% : 33%	*Chora* of 200–500 km^2: 50% : 50%	*Chora* of over 500 km^2: 33% : 66%
	Heloros, Kasmenai	Akrai, Syracuse	Kamarina

Furthermore, Hansen admits that the Greek colonial areas, especially Sicily, are underrepresented archaeologically. Partially the reason for this are the events surrounding the Second Sicilian War which began in the late fifth century and destroyed many of the large city-states of Sicily. Because many were rebuilt in the following century, Hansen assumes that the population of Sicily at the end of the fourth century was close to that of 100 years before, and for this reason he uses this Sicilian source material together with the rest of the late-Classical Greek world. Since Hansen's method is aimed at the late fifth century BC and the end of the

[171] Hansen 2006b, pp.26-7. Cf. Fischer-Hansen 2002, p.125; Fischer-Hansen et al. 2004, p.176.
[172] Hansen 2006b, p.28.
[173] Although the sites in the present study cannot all be considered 'poleis', it is clear that Hansen consideres it applicable to all urban settlement types.
[174] Hansen 2006b, pp.23-4, 60.

Classical period, careful individual considerations on each site must be considered in order to use the method for Archaic settlements. Hansen's study provides the evidence for the entire Greek world, from which averages and general trends can be evaluated, and more importantly he includes many Sicilian city-states from which comparisons with the Syracusan settlements can be made.[175] For these reasons, his method is used as a starting point for this study, following which suitable amendments are made according to the archaeological record of each site and comparanda from other Sicilian sites.

Muggia's list includes the Sicilian city-states of Syracuse,[176] Kamarina, Gela, Akragas, Himera and Selinous; added to these are Kasmenai and Megara Hyblaia based on Hansen's data (Table 3.4).[177] Hansen further stipulates that the *area di rispetto* was more common in western colonies, and this is indeed evident in a number of Sicilian sites which had an inhabited intramural space of only 55 per cent or less.[178] Of these eight Sicilian sites, the average minimum percentage of inhabited urban territory is 53 per cent.

Table 3.4: Area di rispetto and inhabited areas of Sicilian Greek city-states in the Archaic period, given in percentages.

CITY-STATE	MUGGIA'S AREA DI RISPETTO (%)[179]	HANSEN'S INHABITED AREA (%)[180]
SYRACUSE	0	20
KASMENAI	-	75
KAMARINA	52	48
MEGARA HYBLAIA	-	41[181]
AKRAGAS	62	55
GELA	44	-
HIMERA[182]	19	75
SELINOUS	74	50[183]

For population density, Hansen only mentions two Sicilian city-states: Himera has 33 houses and Megara Hyblaia 31 houses per hectare.[184] Hansen lists the members of an average

175 Hansen does not take Muggia's data at face value, and adjusts her results in his study, Hansen 2006b, p.41.
176 Muggia uses evidence from Syracuse in the Archaic and Classical periods. For obvious reasons only the data from the Archaic period is included.
177 Naxos and Gela were not included by Hansen, the latter of which because he felt the modern city precluded sufficient study. Cf. Hansen 2006b, pp.41-5, esp. p.41 n.22.
178 For the sake of clarity, it must be specified that Muggia's *area di rispetto* figures, i.e. open intramural space, are directly opposite Hansen's habitation area percentages.
179 Muggia 1997, pp.125-6, Fig. 5.
180 Hansen 2006b, p.42, Table 2.1.
181 Cf. De Angelis 2003, pp.33, 38.
182 Muggia includes the lower residential area and a nearby third smaller site giving a total area of 95 ha, 19% of which being the *area di rispetto*; but Hansen focuses just on the acropolis where the habitation area was at a minimum 75% of the area, but he admits could be up to 90%. See Muggia 1997, p.86; Hansen 2006b, p.43, n.29. Cf. Allegro 1999, pp.282-92.
183 Cf. De Angelis 2003, p.143.
184 Eight houses on 0.24 hectares and 55 houses on 1.75 hectares respectively. Hansen 2006b, p.51, Table 2.3, n.80.

household size in the Classical period as comprising the parents, two or three children and a slave, equalling an average of 5–6 members per household.[185] This is based on an earlier study by Gallant[186] with some modifications to a thirty-year generation, including the addition of non-nuclear family members and older relatives who were to be taken care of by law. Therefore, based on Hansen, Himera has 165–198 people per hectare and Megara Hyblaia 155–186 people per hectare. Both are inside his range of 150–200 people per hectare, the average for the Greek world.

At Megara Hyblaia, De Angelis gives a household size of 4 people and 23 houses per hectare for 92 people per hectare in the third quarter of the sixth century BC.[187] Additionally, during the foundation period at Megara Hyblaia, De Angelis estimates 9 people per hectare.[188] There is no demographic study on the household size specific to the western Greek world. De Angelis' lower number is probably more representative of the Archaic period because it takes into account the circumstances in Archaic Sicily. Hansen's estimates are based on his general study of the Greek world in the Late Classical period. Further, De Angelis gives the annual growth rate for Sicilian Greeks settlements as 0.50 per cent, and it is used here as it originates in Sicilian scholarship.

In assessing the rural hinterland, Muggia analyses the *chora* of fifteen Greek colonies in Magna Graecia and Sicily, including Syracuse and Kamarina.[189] The six Sicilian sites are listed in Table 3.5. Independent estimates are made in this thesis, but what is notable is that they correspond closely to Hansen's list of city-states and urban to rural population ratios.

Table 3.5: Rural settlement densities of Sicilian city-states, given in sites per square kilometres[190]

CITY-STATE	RURAL SETTLEMENT DENSITIES (SITES/KM²)
SYRACUSE	2.6
KAMARINA	4
AKRAGAS	0.9
GELA	0.9
HIMERA	1.5
SELINOUS	1.5

This evidence suggests that the settlements of south-east Sicily likely had a large rural population, but this is problematic. The evidence for the Kamarina settlement density dates to the fifth- and fourth-century Geloan reconstruction of the site, while that of Syracuse cannot be dated more precisely than being from the Greek period. Even then, the sample size is only 0.75

[185] Hansen 2006b, pp.59-60.
[186] Gallant 1991, pp.11-33.
[187] De Angelis 2003, pp.41-4. De Angelis uses Gallant 1991, the same study which is the basis of Hansen's reconsideration.
[188] De Angelis 2003, p.44, Fig. 24.
[189] Muggia 1997, pp.140-3.
[190] Muggia 1997, p.140, Fig. 9.

km², located near the modern city of Cassibile, meant to represent the entire Syracusan *chora*. In fact, De Angelis does not expect that a dispersed settlement system existed in the Archaic period; instead farmers lived near to or within the nearest polis or city-state.[191] For these reasons, additional assessment is therefore necessary to find out population ranges for these two areas. An average of 15 inhabitants per *chora* settlement has been argued for Metapontion, and although Sicilian rural density was not necessarily similar,[192] this is the best estimate available. While the evidence found near Cassibile is far enough from Syracuse to warrant a nucleated settlement, it does not negate the view that farmers closer to the urban centre commuted daily from the urban centre. Moreover, Muggia's figure for Metapontion's settlement density (5.3 sites/km²) is the second highest in the study, uncharacteristic of western Greek city-states, and in fact an average of one site per square kilometre seems more likely.[193] Therefore an important point to take from Muggia's study of the *chora* is her average settlement density of one site per square kilometre. Frequently found in city-states with smaller populations, like Heloros, it may more closely follow the common situation of the period where farmers commuted daily from the urban centre to their fields. Therefore, until more studies are conducted to this specific region and relevant time period, following Hansen's methodology is the most suitable application.

Theories in landscape archaeology have developed numerous methodologies to estimate territory sizes attached to settlements.[194] Catchment Analysis[195] estimates an hour walking distance for small agro-pastoral settlements, roughly 5–6 kilometres in radius.[196] Thiessen polygons may mirror the nucleated settlement pattern where small settlements occur at intervals in order to allow a stable system of land and resource sharing.[197] These intervals could occur at up to 5–6 kilometres or half this radius depending on the society's size and resource needs.[198] Bintliff asserts that regional market centres tend to lie within a 15-kilometre or 3-hour walking radius.[199] This would include small rural communities around a medium-sized central place which then feeds into the market centre providing political, judicial and economic services. This does not prevent farmers from commuting daily from the urban centre, it just

---

191 De Angelis 2016, p.100.
192 Muggia 1997, p.52.
193 Muggia 1997, pp.140-3.
194 Cf. Bintliff 2009, pp.107-10 for summaries of the landscape archaeology and human geography methodologies. In a comparable analysis, Spencer 1998, p.7 gives a half day's travel from the regional centre as the most efficient territory size for a chiefdom.
195 Vita Finzi & Higgs 1970.
196 Osborne 2009, p.63 suggests poor transport facilities even had an effect on agriculture, shadowing the natural human constraints.
197 Haggett 1965; Ruschenbusch 1985; Hansen 2004.
198 Bintliff 2009, p.111.
199 Bintliff 2002; Bintliff 2009, p.110.

suggests the existence of rural settlements beyond a one-hour walk. Blintliff's 15-kilometre radius is used below in estimating the size of the hinterland connected to each site of this study.

De Angelis' most recent population estimates follow Hansen's Shotgun Method, although not precisely.[200] He provides urban and rural estimates for ten Sicilian poleis at the end of the Archaic period, including Syracuse, using the urban settlement size, 150–200 people per hectare density and a one-third urban to two-thirds rural population distribution (regardless of the *chora* territory size). However, he does not factor in Hansen's percentage of inhabited urban space based on intramural area, which would lower the figures to half or one-third of the total. Further, his rural to urban distribution totals are percentages of the urban total, not in addition to. For example, for Syracuse he gives an estimated total population of 7,500–20,000 resulting in an urban-to-rural split of 2,498–6,660 and 5,002–13,340 respectively. Instead, strictly following Hansen would produce urban totals of 3,750–10,000 with a rural population of 7,500–20,000; 11,250–30,000 total. The Syracuse population estimates discussed in the next chapter vary in methodology from De Angelis.[201] For instance, De Angelis includes the territory of all Syracusan settlement sites as part of the population of Syracuse, while here each site is addressed independently. In the last chapter, his estimates are included for comparing all the Greek Sicilian settlements but adjusted to follow Hansen's approach.

The question of calculating the Syracusan population is closely related to sequential estimation of population sizes;[202] however, since the size of the foundation party cannot be directly calculated from the populations in 485 BC, an influx of people moving both into the urban and rural areas must be introduced as a new variable. Also, it is not possible to calculate statistical confidence intervals for these estimates: the figures do not satisfy the minimum statistical requirement of being normally distributed (following the bell-shaped Gaussian curve).[203] Therefore, lower and upper ranges of the population estimates will be used in the later analyses.

From the population analyses an estimated workforce size can be ascertained. Beloch has suggested that able-bodied men between the ages of 20–60 counted for a quarter of the total population.[204] Hansen lowers the age range to 20–49 and estimates that up to an additional 25 per cent of all adult males could be deemed unfit or dispensable.[205] De Angelis follows Beloch in his most recent population analysis.[206] With regard to Late Classic Mayan

[200] De Angelis 2016, pp.142-3.
[201] See section 4.10 below.
[202] Cf. Samuel 1969; Freeman 1972.
[203] Shennan 2004, pp.102-8.
[204] Beloch 1886, pp.42, 53 attempted to link the army figures mentioned in literary sources with population size. Cf. Hansen 2006b, p.4, n.15.
[205] Hansen 2011, p.241.
[206] De Angelis 2016, p.145.

construction practices, Abrams estimates a workforce of 20 per cent of the total population, roughly the amount of adult males, or up to 33 per cent if adult females and 'sub-adult males' are included.[207] The lower 25 per cent will be taken as the percentage of the population of able-bodied workforce, with one caveat: De Angelis also proposes that the elite classes formed about 10 per cent of the total population, which likely did not participate in manual labour.[208] Therefore, in the following chapters 22.5 per cent of the population estimates will be utilised as the workforce size.

Among the workforce would be required a significant number of skilled labour which was likely scarce in Archaic Sicily outside the major polis centres.[209] This fact is noted in ancient literary sources discussing public works that were completed quickly, for instance at Periclean Athens.[210] It would have been difficult to find skilled labour outside Syracuse as craftsmen tended to congregate in larger city-states where the economic demand would have been more favourable.[211] As such, the most likely source of skilled workmen would have been Syracuse, not only because of its proximity, but because of the ties between metropolis and settlement. Furthermore, with a fully supplied workforce, questions still remain whether the number of required workmen could have been sustained consistently throughout the entirety of the project. For example, medieval building sites often had a widely fluctuating labour supply, sometimes differing by hundreds of workers from one week to the next, for many reasons from inability to pay to agricultural commitments.[212]

Any inconsistencies in the Sicilian workforce size would be due to the agricultural calendar and its demand for attention when the time was right to sow and harvest, not to mention any acts of maintenance.[213] Ethnographic studies in Egypt and Central America suggest that construction projects in agrarian societies were predominantly scheduled for agricultural off-seasons.[214] In this case, construction was limited to 60–120 days a year. By contrast, in New Guinea a range as low as 40–45 days per year was available to a chief for communal projects.[215] DeLaine's estimate of 9 months totalling 220 days does not take into account agricultural seasons since the Roman workforce in monumental building was entirely employed in

[207] Abrams 1987, p.493. Cf. Devolder 2013, p.246.
[208] De Angelis 2016, p.146.
[209] Skilled labour was scarce even later in fourth-century Greece in a small polis such as Epidauros; see Burford 1969, p.191.
[210] Thuc. 1.93; Plut. *Per.* 13.1-2. Cf. Classical Sicilian example of Dionysios I. (Diod. Sic. 14.41); Burford 1969, p.201, n.4.
[211] Burford 1969, p.199.
[212] Salzman 1967, p.34.
[213] Halstead 1987; Isager & Skydsgaard 1992, pp.160-2; Burford 1993, pp.120-43; Fitzjohn 2013, pp.627-9, Table 1.
[214] Abrams 1987, p.490.
[215] Erasmus 1965, p.280.

construction projects.[216] Even then she admits it was likely a shorter period with the allowance for weather and feriae to disrupt working schedules.

Fitzjohn, in his estimations of three houses at Megara Hyblaia, stresses that the time expected to build a number of houses in a relatively short period of time would have demanded a larger number of people working simultaneously.[217] At the very least, it cannot be expected that a single man completed a house alone, even one of a single room. Building a house, which pales in comparison to temples and fortifications, may have taken over a year to complete. The reason for this, he emphasises, is due to every aspect of the process, from acquiring resources to construction, being largely at the mercy of other tasks, for instance agriculture. Equally pertinent, once a house is constructed, as with any other building, it then requires routine maintenance which adds to the list of responsibilities to which priority must be given before other projects may be carried out. Overall, this took long-term planning.

An exact calendar for the farms in south-east Sicily would be difficult, if not impossible, to construct as various crops required different timelines, let alone any adaptations for animal husbandry and regional weather variations. Archaeobotanical studies have been conducted elsewhere in the Greek Mediterranean, and they can be used, for example, in tracing vegetation history through several millennia of pollen samples in a single area,[218] or interpreting historic olive cultivation and olive oil production throughout Greece.[219] Similarly, zooarchaeological interpretations can provide a wealth of knowledge from faunal assemblages.[220] Extensive studies, like those applied in these instances, could go a long way towards a better understanding of the exploitation of the natural resources surrounding each settlement and in turn provide evidence of the relationship between the Greek urban centre and its rural hinterland. For instance, the land between Akrai, Heloros and Syracuse would have provided ample sources of agriculture for the Syracusans and future population growth. The undulating terrain south of Kasmenai, at the northern reaches of the Heloros river valley, would have fit well within a pastoral economy, argued below.[221] In addition, the flat coastal plain around Kamarina was not as limited by the Hyblaian Mountains as the other settlements. This allowed for the development of a much larger *chora*, as is also archaeologically attested,[222] a study of which could go a long way in establishing the agricultural economy of Kamarina.

---

[216] DeLaine 1997, p.105. See Brysbaert 2013 for a discussion of the Bronze Age construction period.
[217] Fitzjohn 2013, pp.634-9.
[218] Bottema & Sarpaki 2003.
[219] Margaritis & Jones 2008.
[220] For the ‘divide’ between zooarchaeology and archaeozoology, and its fundamental East vs. West origins, see Bartosiewicz 2001. Brewer 1992 provides an in-depth overview of the methods, theories and goals of zooarchaeology.
[221] See section 7.8 below.
[222] Pelagatti 1980-1981; Di Stefano 1987b; Di Stefano 2001; De Angelis 2016, p.119.

For now, a relatively basic idea can be gained from literary sources and recent agricultural studies.[223] A field must be prepared for cultivation (i.e. stone and weed removal), ploughed multiple times a year, with supplementary digging if needed, and maintained free of growth if in a fallow cycle, while poor soil would require extra attention. Critical tasks include planting, harvesting and upkeep of the cultivated fields which includes tilling, drainage and fertilizing. For example, grain-based agriculture such as barley, which was cultivated in abundance throughout Sicily,[224] required ploughing at least three times a year, not to mention sowing, harvesting and threshing.[225] The timelines of these steps differed according to the needs of the crop, and so a farmer could be occupied by multiple 'calendars' each year.

One would be hard pressed to find in the Greek world a farm that did not include livestock or other faunal components.[226] From oxen and mules to cows, sheep, goats, pigs and even hives of bees, animals provided a valuable source of fertiliser and served as a means of food and currency when necessary. Every year, seasonal transhumance required the movement of certain livestock to be moved to better grazing lands at higher elevations. With the Hyblaian Mountains, this migration did not need to be a long one, especially for Akrai and Kasmenai, but nonetheless demanded a dedicated herdsman. The routine upkeep of livestock, from feeding to milking and shearing, was also laborious.

On a large estate there would have been multiple employees to handle these various tasks; but even then, the sheer amount of work involved in agro-pastoralism did not allow for much else. It is not likely that slaves were as commonplace in south-east Archaic Sicily as Hansen determined was the case for Classical Greece, and furthermore, a farmer or herdsman that owned slaves did not do so to allow himself time to relax and live a leisurely lifestyle.[227] Therefore, even though a slave population has not been included in the population figures presented above, their presence did not necessarily ensure that a larger workforce was available for construction and much of the rural workforce would have been too preoccupied by their daily tasks to participate fully in the large-scale construction projects.

Equally important, the number of available oxen to transport materials to the work site would have been predicated on the agricultural cycle as well. The primary purpose of these animals would have been to serve the farmers in the fields, and 'free time' is generally accepted to have been between July and September.[228] However, this could have been less depending on the crops that were grown in the nearby fields. Therefore, it cannot be assumed that an

[223] Hes. *WD* 382-694; Theophr. *HP*, *Caus.*; Halstead 1987; Isager & Skydsgaard 1992, pp.160-2; Burford 1993, pp.120-43; Fitzjohn 2013, pp.627-9, Table 1.
[224] Gallo 1989; De Angelis 2006; Stika et al. 2008.
[225] Isager & Skydsgaard 1992, p.162, Fig. 11.1.
[226] Isager & Skydsgaard 1992, pp.83-107.
[227] Lawrence 1997, p.313; Scheidel 2003, p.136.
[228] Osborne 1987, pp.14-5; Salmon 2001, p.200; Fitzjohn 2013, p.631.

adequate number of ox-carriages were always available throughout the construction project, affecting the accessibility of materials on the work site. Because of these obstacles, not all able-bodied workers or their oxen would have been available to work every day until the project was completed, nor would their available time be aligned so the entire workforce was simultaneously present.[229]

There are various challenges in estimating population sizes, rural versus urban percentages, accessibility to and availability of a labour supply, and comparisons between city-states are necessary to gain a full picture of the available workforces. Although population assessments do not furnish definitive settlement numbers, these studies can provide useful information on which to base further research. In the following chapters, population estimates are given in tabular form from that settlement's foundation to the end of the Archaic period in periodic intervals. The accompanying charts graphically demonstrate the population modelling in average yearly increments across the same timeline.

3.9 Rank-Size Studies and Primacy

Rank-size distribution, introduced by Zipf,[230] has been a common methodology over the past half-century through which population estimates are organised numerically indicating an order of sites based on a broader, regional view. Always starting from the point of view of the largest settlement, the rank-size rule expresses a society in which the population centres of a given area can often be found to follow a pattern where each settlement (n) is 1/nth the size of the largest (e.g. the second largest population is half the largest, the third is one third of the largest, etc.). There are several historical instances which follow this rule.[231]

Yet, it is unlikely that such a settlement structure was pertinent to every past or present case study. Therefore, variations to the rank-size rule have been established (Fig. 3.5). Berry identified a pattern, which he termed 'primate' (also referred to as 'concave'), whereby small settlements are dominated by one or more very large population centres with few to no sites of intermediate size.[232] To distinguish between the two groups, he adapted the label 'log-normal' to Zipf's standard scale. Johnson added a third, 'convex' model in which the population sizes beyond the largest are generally larger than a log-normal standard would predict.[233]

From a colonial viewpoint, the primate model is largely, although not exclusively, indicative of the initial stages of colonisation whereby a single settlement is the centre of new

[229] Brysbaert 2013, pp.59-60.
[230] Zipf 1949.
[231] Among others: Nottinghamshire in 1831, Laxton & Cavanagh 1995, pp.329-31; United States in 1940, Haggett et al. 1977, p.111.
[232] Berry 1961, p.573.
[233] Johnson 1980, p.234.

migration into an area.[234] This settlement pattern has been found in ninth-century-BC South Etruria.[235] Based on examples from nineteenth-century United States, Jefferson characterises the growth of a settlement to a primate city through using factors such as employment opportunity.[236]

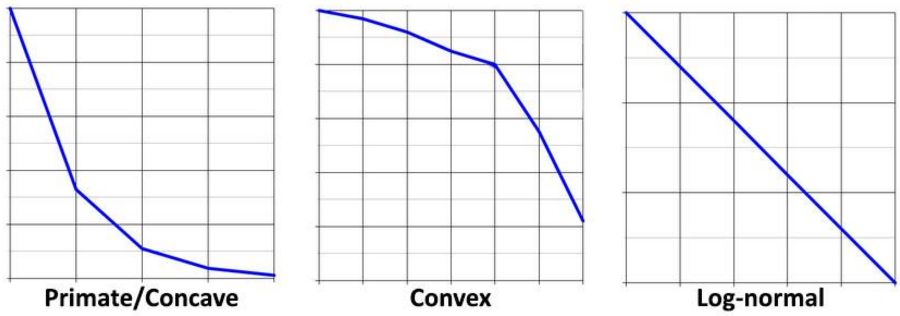

Fig. 3.5: Rank-size graph distribution models.

Primate and convex distributions have been identified by Johnson as instances of low system integration within a region and/or a society.[237] As a set of settlements become more integrated, they then tend to exhibit a near log-normal rank-size scale.[238] Unfortunately, the term 'integration' cannot be easily defined by any measurable means since variability in system scales and the political, social and economic organisation of any society prohibits general cross comparisons. However, working backward by establishing a rank-size distribution pattern, and then attempting to identify key factors present in the settlement system, may go a long way in presenting plausible characteristics of organisation within a specific society; for example, when domestic trade and resource management within a group of settlements creates an organized exchange network.[239]

As expected, a high level of integration suggests greater interdependence of settlements with each other, while conversely low integration would indicate relative autonomy and independence of the sites within the system. If viewed through statistical dependence, a highly integrated society could presumably produce a series of political, social and economic processes, some reciprocal, which would affect the fertility, mortality and migration of the entire population within the system. This approach is promising for hierarchically organised systems, where the level of integration can allude to the amount of governance the larger settlement has over those smaller; the potential of this methodology can be applied to south-

---

[234] Guidi 1985, pp.222-3. Cf. Jefferson 1939. Colonial enterprises can later lead to a convex pattern, as found in United States around 1750; Johnson 1980, pp.234-5.
[235] Barker 1988, pp.774-5.
[236] Jefferson 1939, p.227. St. Louis as the 'Gateway to the West' during the westward expansion and even Detroit at the birth of the automotive industry are two instances.
[237] Johnson 1980. Cf. El-Shakhs 1972, p.14.
[238] This trend towards high integration can be found in the United States from AD 1750 to 1850 and the Susiana plain in south-west Iran between 3800 and 3400 BC, Johnson 1980, pp.234-40.
[239] Also found in the colonial United States and south-west Iran in the fourth millennium BC, Johnson 1980, p.245.

east Sicily. While a log-normal settlement distribution pattern may be considered a standard model towards which many societies have evolved, or in the case of historians and archaeologists a model by which to compare specific past societies, such a highly integrated interdependence may not always be found.[240]

Attempting to establish the roles of the settlements in the Syracusan hinterland, the methodology of rank-size distribution can present a further illustration of the system as a whole. The method can only provide an overall image of the settlement structure. Specific aspects of the sites, such as economic development and degree of urbanisation, cannot be deduced from this as studies have found no relationship between these individual aspects and city size rank.[241] From here, however, a different understanding of the relationships at work during this period could allow for changes in the interpretations of the settlements and their mother city.

Spatial organisation is highly variable with regard to each specific society, and rank-size distribution studies can be criticized as rather formulaic: a society is expected to go through three stages on its way towards a state of equilibrium.[242] The first stage is indicative of inequality whereby the core settlement becomes the centre of the political, social and economic communities leaving the peripheral populations heavily dependent upon that site, allowing the core area to adopt great authoritative powers and control. The second stage finds an increase in awareness by the periphery of that unbalance, leading eventually to a resolution in favour of the outlying sites, either through peaceful or forceful means, which ushers in new forces that begin to bring about a societal balance. The Kamarina rebellion in the mid-sixth century BC is characteristic of an attempt for societal change. The last stage sees the society develop into a stronger state of equilibrium. It should be expected that these stages have no definitive timeline, nor are they immune to outside factors disrupting the development process or even bringing about a new spatial situation that requires a reset to stage one. In south-east Sicily, the defeat of Kamarina by Syracuse suggests the desire of Syracuse to prevent any societal change, maintaining the social organisation.

Supplemental to rank-size distribution is the measurement of a primacy value. Measuring primacy in a system of settlements involves finding the degree of relative size variation among all the sites.[243] Plainly, the degree of primacy of a given city within its system is the average ratio of size differences in populations between that city and each smaller city in the same system. What this does is provide a value to stress how dominant a city with a large

[240] A primate pattern has been considered to be the norm in the case of modern period Australia, Haggett et al. 1977, p.123. Cf. El-Shakhs 1972, p.14.
[241] Berry 1961, p.587; Mehta 1964, p.143; El-Shakhs 1972, p.13; Johnson 1980, p.240.
[242] El-Shakhs 1972, pp.15-6.
[243] El-Shakhs 1972, pp.18-20.

population is within that settlement system. A system with cities of equal size would result in a primacy value of zero, while a single large site within a system void of other settlements would approach an infinite value.[244] For reference, a system of log-normal distribution as first attested by Zipf, if calculated to a degree of primacy, would result in a value of 0.33.[245] Mathematically, primacy can be expressed by the following equation:

$$P_i = \frac{1}{(n-i)}\left[\frac{C_i - C_{(i-1)}}{C_i} + \frac{C_i - C_{(i-2)}}{C_i} + \cdots + \frac{C_i - C_n}{C_i}\right]$$

C = city's population size
n = number of cities in the system
i and j = ranks of cities by size in a descending order so that the largest city is ranked 1 and the smallest city is ranked n
P_i = primacy of city with rank i over all smaller cities

Fig. 3.6: Equation used to measure primacy in a settlement system. El-Shakhs 1972, p.18.

It is suspected that archaeological and historical knowledge of the region is too underdeveloped to provide many definitive answers; a problem which will hopefully be resolved by future work. For now, the population estimates garnered from the methods outlined above as well as the calculated sizes of Syracuse and its settlements will be used to demonstrate a spatial organisation likely present in the formative years of the eighth through sixth centuries BC in south-east Sicily. This will then aid in presenting the overall relationships found between the settlements and the roles each played in the Syracusan hegemony of the area.

[244] El-Shakhs 1972, p.18.
[245] Zipf, 1949.

Chapter 4: Syracuse and Kamarina

Before analysing Heloros, Akrai and Kasmenai, here an eighth-century residence and the Temple of Apollo from Syracuse and the fortifications from Kamarina are presented for comparative analysis. While the Island of Ortygia was likely fortified upon foundation,[1] remains from the Archaic period were lost with the refortification of the island and Akradina during the Athenian siege between 416 and 413 BC.[2] Conversely, due to consistent occupation at Kamarina the wall system is the only Archaic period structure reliable for reconstruction. This is beneficial to compensate for that lacking from Syracuse. These three examples, then, provide construction projects from settlements founded in the more traditional Greek sense to which that from the other settlements can relate. Below, the sites and specific archaeological material is presented, if known, before implementing a reconstruction through architectural energetics and population assessments. This pattern repeats over the following three chapters.

4.1 Syracuse

The initial point of foundation for the colonists from Corinth was the island of Ortygia (Fig. 1.4). Only about 50 ha in size, the Greeks quickly spread onto the mainland with the new community of Akradina and reaching 120 ha by the end of the Archaic period.[3] Having possession of this area allowed for the use of two harbours, the 'Small' harbour facing east to the sea and the 'Great' harbour opening west to the modern Baia del Porto Grande. The limestone Epipoli plateau allowed for good protection from the north, and only a thin area for easy passage onto the island by land. Fresh water was available from the mouth of the river Anapos (modern Anapo) approximately 3 km away walking distance,[4] the source of which reached the Hyblaean Mountains near the future locations of Akrai and Kasmenai. The extent of archaeological knowledge of the Archaic period houses and the Temple of Apollo is provided in Appendix 1 (S, sections D and E) and presented here.

4.2 Syracuse: Archaic Housing

As can be expected, housing structures on the island of Ortygia are scarce, and what information obtained from the few remains do not provide a complete picture. Beneath an unfinished Ionic temple were discovered three eighth-century residences (Fig. 1.4: SH).[5] Of

1 Diod. Sic. 11.67.8; 11.73.1.
2 Thuc. 7.4.1.
3 Area measured using Google Maps Area Calculator, Daft Logic 2014b.
4 Distance measured using Google Maps Distance Calculator, Daft Logic 2014a.
5 Martin et al. 1980a, p.666; Pelagatti 1982b, pp.126-9.

these three, House A (Fig. 4.1) is the only one with four preserved sides, and as such provides the best evidence from which to base a reconstruction. This house was of a single room, measuring 3.50 m on all sides, built in orthostat technique using small, thin, irregular stones placed upright with only a single facing side. It is expected that the door faced to the east and opened onto a small courtyard, although the size of this is unknown. Further, no evidence of a roofing structure was found. However, what is lacking from material remains can also provide information: there was no associated mudbrick, which leads to the structure likely being built entirely with stone.

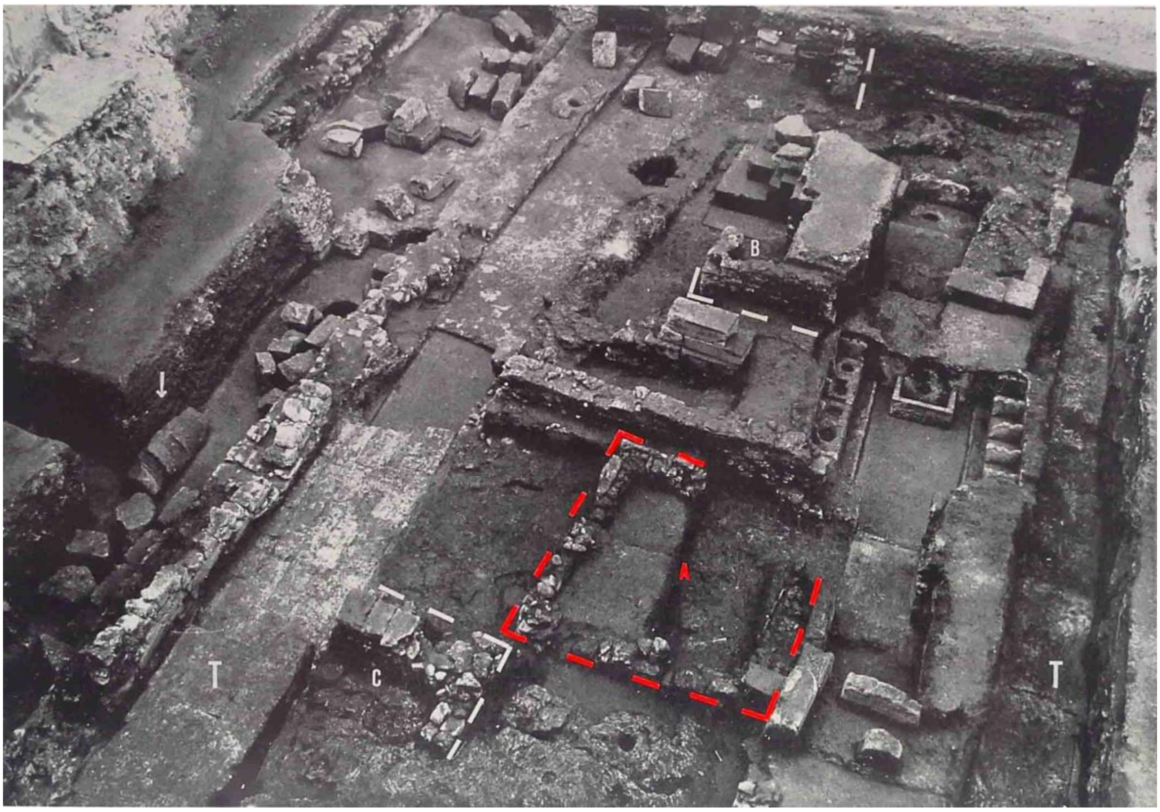

Fig. 4.1: Syracuse. Excavated area next to Ionic Temple, House A (SH) highlighted. Pelagatti 1982b, p.118, Fig. 1.

Comparisons have been made between these foundation period residences and the early houses at Megara Hyblaia.[6] There, the houses constructed at the end of the eighth century all have several commonalities (Fig. 4.2).[7] Consistent of irregular orthostat stones comprising a base on average 0.45 m thick, the single-room layout is almost square with sides somewhere around 4.50 m in length. The lack of mudbrick around the structures also suggests these were, too, built wholly of stone. The earliest houses are assumed to have been constructed with a roofing structure without tile, instead with a slight incline to prevent water from accumulating.[8]

[6] Martin et al. 1980a, p.666; Pelagatti 1982b, p.127.
[7] Vallet et al. 1976, pp.268-9. Cf. Gras & Tréziny 2004, pp.465-6.
[8] Vallet et al. 1976, pp.255-6; Gras et al. 2004, p.459.

In the calculations below, the residence will be reconstructed both entirely of stone and with mudbrick walls over a stone foundation; both with a flat roof. Greek houses most commonly were made with mudbrick, and even though no mudbrick was found in archaeological contexts here, the construction style cannot be dismissed.[9] Although it is quite possible the Syracusan settlers built their houses with a roof at a slight incline, like at Megara Hyblaia, the overall costs would not be much greater than a flat roof, and the latter is the simplest form to reconstruct, allowing minimum labour costs figures. In the next chapter, the residences at Heloros are close in comparison to those here and at Megara Hyblaia.[10] For this reason, the analysis of a house from the foundation period at Syracuse will provide a template for that of a house at Heloros.

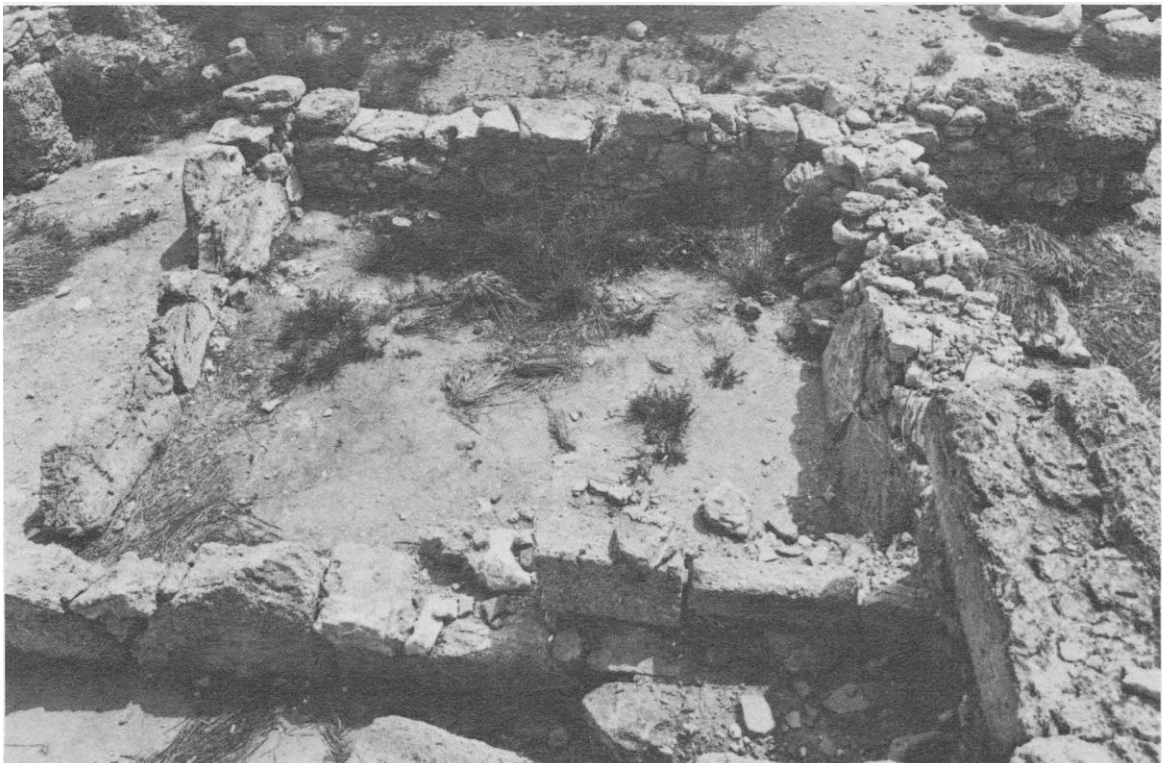

Fig. 4.2: Megara Hyblaia. Eighth century house. Martin et al. 1980a, p.607.

4.3 Syracuse: Temple of Apollo

Located on the northern edge of the island of Ortygia (Fig. 1.4: ST), the Temple of Apollo is dated to the first half of the sixth century and expected to be the first Doric temple in the west.[11] The most thorough report comes from Cultrera and the excavations in 1943, and this

[9] Gras et al. 2004, p.459; De Angelis 2016, p.84.

[10] Martin et al. 1980a, p.551; Tables 65-7; Voza 1980-1981, pp.685-6. See Mertens 2006, pp.64-90 and De Angelis 2016, pp.85-8 for an overview of foundation era and Archaic period house structures.

[11] Holloway 1991, p.68; Mertens 2006, p.104. Dates vary from c. 600 BC: Cultrera 1951, p.851; Holloway 1991, p.68; Zirone 2005, p.156, to first quarter: Marconi 2007, p.50; Woodward 2012, p.482, or second quarter sixth century: Dinsmoor 1975, Catalogue; Spawforth 2006, p.122.

serves as the basis for reconstruction here.[12] Much of the lower half of the temple remained at the time of excavations, however many aspects remain hypothetical. This issue has been overcome by subsequent scholarship with temples of comparative style, era and region.[13] The temple stands on a crepidoma of four steps with stereobate axis of 58.10 m by 24.50 m leading to the stylobate at 54.90 m by 21.50 m.[14] The foundation beneath the stereobate is estimated to the depth of 2.30 m. This depth with the height of the crepidoma (each step approximately 0.50 m in height) is estimated at 4.30 m from the peristasis. It is approximated that the foundations below the sekos walls and interior stylobate reach the same level. With a 0.09 m rise in the flooring from peristasis to pronaos and 0.22 m rise from pronaos to cella, the depth reaches 4.61 m below the interior columns. The foundation is not complete below the entirety of the temple, instead only where support is necessary. The first step of the crepidoma reaches approximately 3.50 m into the substructure, and using the cross-section plan by Carta (Fig. 4.5),[15] the supports under the sekos walls and interior colonnades can be estimated at 2 m wide. Crawl spaces between the crepidoma and sekos walls substructures, 2.20 m in width, from there to interior stylobates, 0.75 m, and between the interior stylobates are filled with stone, debris and occasional stone slabs. This last crawl space in the centre of the temple is estimated at 3.60 m.[16]

Peripteral in design, seventeen columns line the sides with four additional on each end. A second row of four columns on the east end, and fourteen (two rows of seven) within the sekos and two in the pronaos, make sixty-two total columns. These monolithic columns outside the sekos measure 7.98 m high (shaft: 6.62 m, capital: 1.36 m) and 1.85 m in lower diameter, except the eastern front six columns which are on average 2.01 m.[17] The upper diameter of the side columns is 1.50 m, giving a lower diameter to upper diameter ratio of 1.23, not far off the average of around 1.27 for first half sixth-century temples.[18] Keeping the ratio, the front column

[12] Cultrera 1951.
[13] Holloway 1991; Mertens 2006.
[14] There are discrepancies to the stylobate axis: 55.33 m x 21.57 m, Dinsmoor 1975, p.337, 55.36 m x 21.57 m, Mertens 2006, p.107, 55.36 m x 21.47 m, Burham 2015, p.24. Although these three may come from transcription errors between them, the dimensions preferred here are taken from the archaeological report.
[15] While there is danger in basing these figures off an imprecise drawing, Carta's drawings remain the best available evidence known to us. Indeed, these assumptions are not far off others forced to be taken above and below.
[16] Taking the given width of the stereobate, approximate width of the stereobate step, estimate widths beneath the sekos walls and interior columns and known crawl space distances: 24.50 m – (3.50 m x 2) – (2 m x 4) – (2.20 m x 2) – (0.75 m x 2) ≈ 3.60 m.
[17] Only the two corner (north-east: 2 m and south-east: 2.02 m) column lower diameters were measured by Cultrera. The average of these two is taken for the diameter of all six of the front row. Cultrera 1951, p.819.
[18] Woodward 2012, pp.370-81, Appendix 4.2.

upper diameter can be found to be 1.63 m.[19] Second row and pronaos columns follow the measurements of those on the side; interior columns are hypothetical in nature given evidence of the interior stylobate and spacing. These will be addressed below with the sekos. Cultrera was able to measure the distance between the eastern front columns and a few columns along the south side of the temple.[20] Along the front, the centre columns are separated by about 2.30 m while the rest are only around 1.80 m apart (Fig. 4.3). Down the long side, these varied from 1.40 m to 1.50 m in seemingly no particular order. In order to fit the known length of the stylobate, and averaging 1.45 m between each column along the long side, only a few centimetres remain, leaving the columns effectively placed at the stylobate edge.

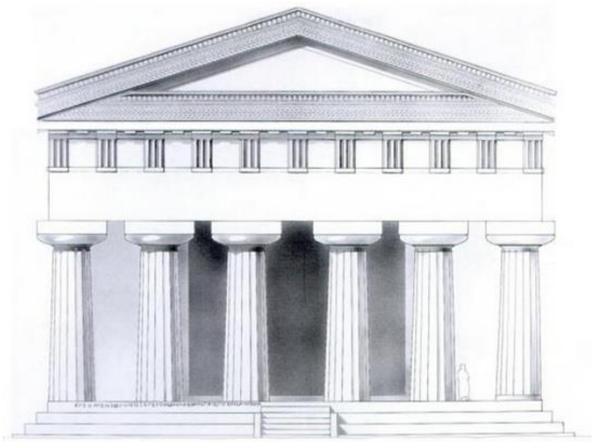

Fig. 4.3: Syracuse. Front of Temple of Apollo. Mertens 2006, p.109.

Above the column drums, the capitals include an abacus 0.60 m high, 2.86 m wide at the top, with an echinus and hypotrachelion 0.76 m in height. These capitals are tightly spaced, only 0.50 m apart on average. Further up, the architrave is uniquely 'L'-shaped (Fig. 4.4), each 3.52 m in length, although they are placed abutting one another. These reach 1.82 m wide and 2.15 m high. Of the 'L', the horizontal arm is approximately 0.70 m thick, while the vertical arm is about 0.63 m. Above this, the taenia is thin, only 0.275 m in height, but double that in width, 0.57 m. The length reaches 1.02 m, but again this is moot as they are set together without spacing. The rest of the entablature is largely guesswork from little evidence, and so again Carta's reconstruction is the best available basis from which to proceed (Fig. 4.4). The frieze, therefore, is estimated at 2 m in height and 0.75 m in width; the cornice 1.40 m in height at its highest point (along the bottom of the pediment). Projecting outward about 0.50 m, the cornice will be assumed to have the same width as the frieze, and this projection, for a total of 1.25 m. At the temple ends, the cornice following the roof slopes will be presumed to have the same dimensions.

[19] 2.01 m / 1.23 ≈ 1.63 m.

[20] Cultrera 1951, p.818.

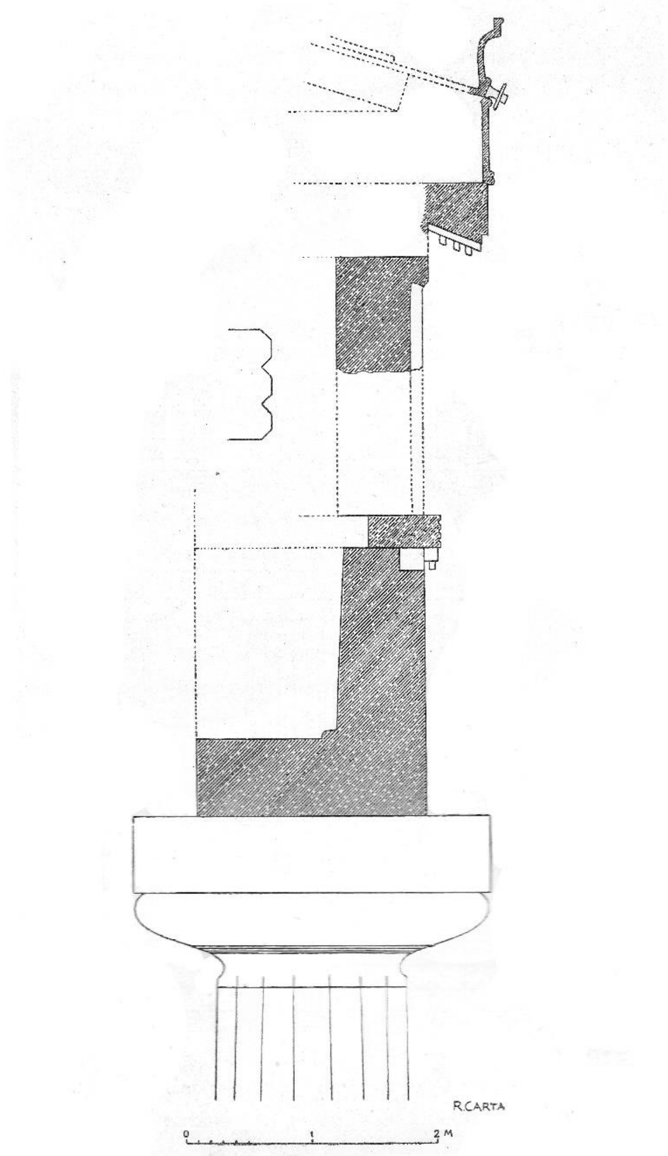

Fig. 4.4: Syracuse. Temple of Apollo, upper column and profile. Cultrera 1951, p.826, Fig. 100.

Returning to the surface and moving inward, the sekos consists of three rooms: a pronaos, cella and adyton. Extending 37.30 m in length, the rooms respectively cover 6 m, 24.60 m and 3.70 m, with two 1 m thick walls on both ends of the cella. The sekos is 11.60 m wide. There is a slight inclination between the peristasis and pronaos (9 cm) and between the pronaos and cella (22 cm), the latter requiring a step up. Remaining measurements taken from the temple plan place the walls separating the rooms as extending approximately 3.75 m. For the internal colonnades, based on the same cross-section plan (Fig. 4.5), the interior columns (set upon a stylobate 1.40 m wide, but at floor level) are expected at a lower diameter of that same width, 1.40 m, with upper diameter of 1.14 m, keeping the same ratio of 1.23 addressed above. Given the column height (including capital) to lower diameter ratio of 4.31 for the external side columns,[21] this can extrapolate a corresponding total column height for the interior colonnade

[21] Woodward 2012, p.380, Appendix 4.2.

of 6.03 m.[22] Following the same line of thought, best expectation of the inner capitals and architrave is through comparison with the external remains. From this, the capitals represented 17 per cent of the total column height, an abacus to lower diameter ratio here is 1.55, while the architrave width to upper diameter ratio is 1.21.[23] Therefore, the interior capitals are estimated at 1.03 m high, the abacus is 2.17 m in width, and the architrave width is 1.38.[24] Also present in Fig. 4.5, Carta placed another architrave with a taenia upon each capital with a second column above. Assuming this to be the case, the architrave will not be considered 'L'-shaped like the external, but instead rectangular. The outer architrave height (including taenia) to width ratio is 1.33, leading to the inner architrave height at 1.84 m.[25] The roofing structure is designed to support cross beams extending from cornice to cornice the width of the temple, and these beams would have been placed within the cornice stones, resting on the frieze. For the interior columns to be a part of the supports for the roof, they must reach the same height as the frieze above the outer colonnade. Outside the sekos, the columns up to the frieze rise 12.41 m in height, to reach this in the interior, the upper column must be 4.32 m high.[26] Using the same correlations as above, the lower diameter will be 1 m, upper diameter 0.81 m, capital height 0.73 m and capital width at 1.55 m.[27]

With the interior columns up to the height of the roofing structure, this suggests each column supported a cross beam. Although this seems excessive, this would make sense in the overall style of construction, recognizing that the size and number of the exterior columns and height of the architrave were likely due to an overreaction by the builders in the change from wood to stone.[28]

Based on the cornice stone recovered, the roof was at an inclination of eighteen degrees. It is expected that the entire roofing structure was supported in part by wooden beams resting on the horizontal arm of the architrave, another example of excess reinforcement designed in the construction. This will be placed below the cross beams. Roof tiles have been determined by Cultrera at 0.70 m wide. Nothing more can be said securely about the roofing structure.

---

[22] 4.31 x 1.40 m ≈ 6.03 m.

[23] 1.36 m / 7.98 m = 17%; 2.86 m / 1.85 m = 1.55; 1.82 m / 1.50 m = 1.21. The upper and lower diameters are taken from the side columns as these were more common and would reflect better the interior columns.

[24] 6.03 m x 17% ≈ 1.03 m; 1.55 x 1.40 m ≈ 2.17 m; 1.21 x 1.14 m ≈ 1.38 m.

[25] 2.425 m / 1.82 m = 1.33; 1.33 x 1.38 m ≈ 1.84 m.

[26] Outer columns: 7.98 m (column and capital) + 2.15 m (architrave) + 0.275 m (taenia) + 2 m (frieze) ≈ 12.405 m; Inner columns: 6.03 m (lower column and capital) + 1.84 m (architrave and taenia) + 0.22 m (rise in elevation of sekos) ≈ 8.09 m; 12.405 m – 8.09 m ≈ 4.315 m.

[27] 4.32 m / 4.31 ≈ 1 m; 1 m / 1.23 ≈ 0.81; 4.32 m x 17% ≈ 0.73 m 1.55 x 1 ≈ 1.55 m.

[28] Mertens 2006, p.105.

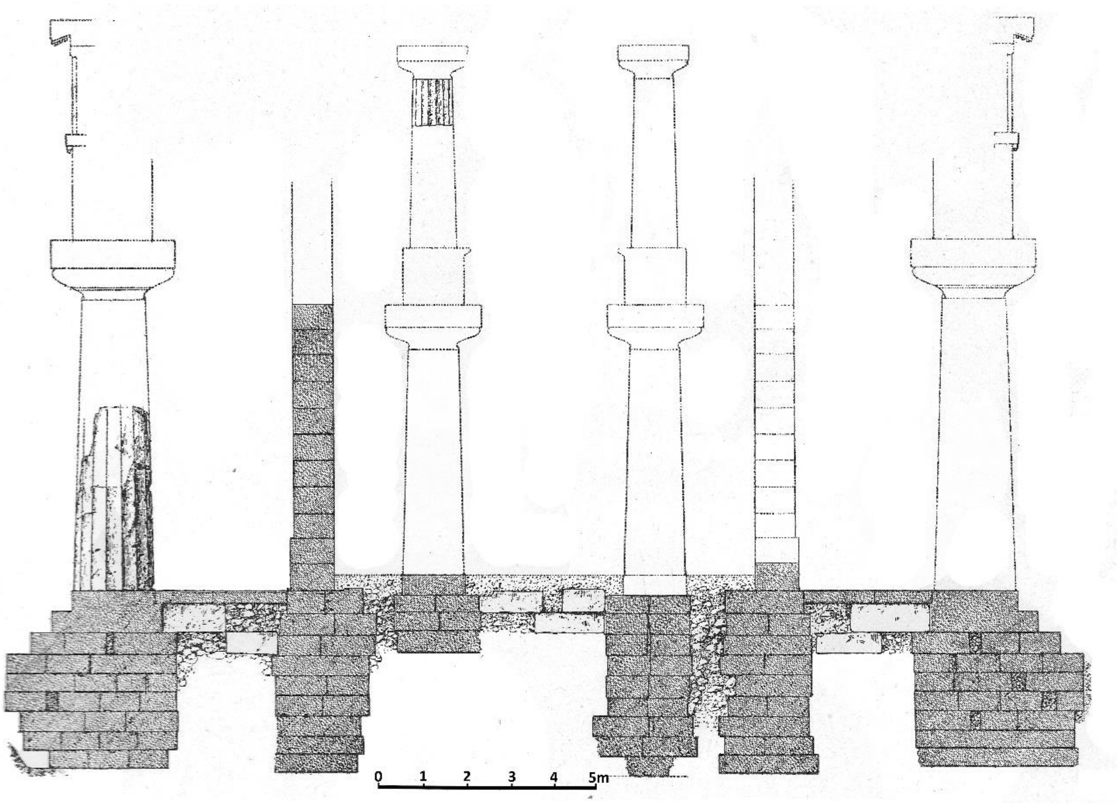

Fig. 4.5: Syracuse. Temple of Apollo cross-section. Cultrera 1951, pp.815-6, Fig. 90.

4.4 Kamarina

Chronologically the last of the Syracusan settlements discussed in this thesis, Kamarina was founded c. 599 BC before experiencing a tumultuous history, being destroyed and resettled multiple times in just a few centuries. The site is located on the southern coast of Sicily and between the mouths of the rivers Hypparis (modern Ippari) and Oanis (modern Rifriscolaro). Fortifications have been dated to the mid-sixth century, near the date of the first destruction at the hands of its mother city. The area within the fortifications has been estimated to about 150 hectares (Fig. 1.8).[29] Due to the consistent occupation and destruction of this area, the fortifications provide the only feature from the first settlement period that can be judiciously reconstructed. Archaeological knowledge of this is found in Appendix 1 (KM, section D) and presented below.

4.5 Kamarina: The Archaic Wall

In a north-eastern sector of the plateau an Archaic section of fortifications, only 6 m in length, was first excavated by Paolo Orsi in 1896.[30] The socle of the wall is of double-curtain construction with an infill of rocks and earth (Fig. 4.12), ranging from 2.20 to 2.60 m thick.

[29] Pelagatti et al. 1976, p.124; Martin et al. 1980a, pp.511-2.
[30] Orsi 1899b, p.209-10.

Remains found during excavation indicate that this socle likely supported a mudbrick superstructure (Fig. 4.6).

The fortifications are considered of poor construction with a wide variety of larger to small stones, similar to Mycenean construction technique. Further, the remains suggest that the wall was built quickly and using stone found in the immediate vicinity, not quarried from a larger source as would be expected. Dating has placed the construction from early to the mid-sixth century which immediately draws correlations to the foundation period (c. 599 BC) or later rebellion against Syracuse (553 BC). The likelihood of the latter is discussed further below. Based on excavations of later fortifications, the wall is expected to have stretched around the entire inhabited area, 7 km in distance. Three gates are also suggested in the north-west, south-east and east.

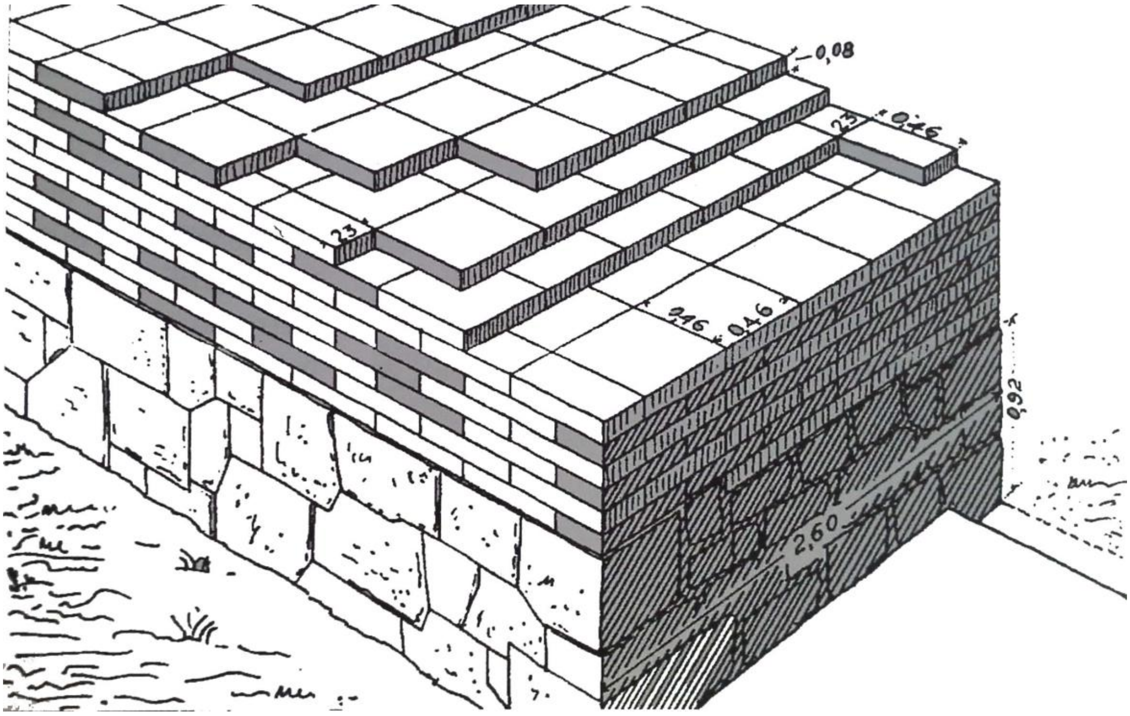

Fig. 4.6: Eleusis. Reconstruction of stone socle with mudbrick superstructure. Orlandos 1966, p.60, Fig. 36.

4.6 Architectural Energetics and Econometric Calculations

Using the information given of the archaeological remains from the Archaic period, the estimates for a residence from the foundation period and the Temple of Apollo, both from Syracuse, will now be given, followed by the fortifications from Kamarina.

At Syracuse, for the houses local limestone likely originated just off the island 2 km away at the latomia in the modern archaeological park.[31] The Temple of Apollo, however, was built entirely in sandstone.[32] The closest source for this material is approximately 28 km away

[31] Distance measured using Google Maps Distance Calculator, Daft Logic 2014a.
[32] Cultrera 1951, p.813.

near the south-eastern edge of the Hyblaean Mountains, south of Akrai (Fig. 4.7).[33] For obvious reasons, then, the transport costs will increase dramatically for the temple in comparison to the other sites. As stated above, a pair of oxen on average could travel 8 km a day, therefore three and a half ox-carriage days are needed for a single pair each way, or seven round-trips.[34] For mudbrick, fresh water must be used. The river Anapos is approximately 3 km walking distance from the centre of the island of Ortygia,[35] and so this will be the transport distance for mudbrick in the house reconstruction. Diodorus Siculus (13.113.1) mentions how the Syracusans utilised reeds from the swamps near Akradina, and this could have been gathered during transport. No additional costs will be added for this. The same 3 km distance will be said for the transport of clay for roof tiles. Given that the degree of forestation of the area in the Archaic period is unknown, 1 km provides a general base from which the timber could have been harvested. However, since the Temple of Apollo was built around 150 years after foundation, it can be expected that the residents would have needed to travel further for the timber supply. In this case, 2 km will be used for timber transport costs. Being a coastal location, transport within the island or from outside the urban centre for mudbrick, timber, clay and limestone will not incur additional cost from incline. Yet, for the sandstone utilized in the construction of the Temple of Apollo, the gradual incline leading to 600 metres above sea level averages at 1 per cent. This adds a 1.7 per cent increase to the number of ox-carriage days for this construction project.[36]

Fig. 4.7: Syracuse. Expected location of sandstone quarries. De Angelis 2016, p.67, Map 4 with additions.

[33] Great Britain Naval Intelligence Division 1944, p.392, fig. 65; De Angelis 2003, p.79, fig. 29. Distance measured using Google Maps Distance Calculator, Daft Logic 2014a.

[34] 56 km round-trip / 8 km a day ≈ 7 days; 1 od / 7 days per trip ≈ 0.14 trips a day. This figure will be used in calculations.

[35] Distance measured using Google Maps Distance Calculator, Daft Logic 2014a.

[36] $\sin(1) \approx 1.7\%$; see section 3.7 above.

For the Kamarina fortifications, it has been suggested that the stone was gathered locally, on site, due to the short time period in which it was likely built.[37] Therefore, the source of limestone will be figured only 0.50 km from the site. While this may even be too far of a distance, it provides a good area and accounts for the various distances from source throughout the length of the wall. Because the stone is considered to be readily available, no additional transport cost will be given for any rise in elevation. For the mudbrick, on the other hand, the nearest source is the river Hypparis. This is about 250 m from the urban centre, an average distance again compensating for the varying distances to the different spans of the wall. From this source, an incline of 5 per cent will be taken on average, adding a 7.5 per cent increase to transport costs for mudbrick. Calculations of labour costs are given in the accompanying footnotes and they are presented in the text as rounded figures, while the total numbers are in the supplementary tables.[38] These costs are calculated in groupings but itemized in greater detail in the tables.

4.7 Syracuse: Houses

While there is limited information available for the foundation period housing on the island of Ortygia, taking that which is known and the comparison with Megara Hyblaia, a reasonably secure reconstruction can be calculated. The most complete floor plan of 3.50 m by 3.50 m will be taken, with walls 0.50 m thick. Most commonly, Greek residences during this period were constructed with mudbrick above a stone socle.[39] No evidence of such has been found at Syracuse or Megara Hyblaia, but here both an all-stone and a mudbrick example will be reconstructed.

First, the ground will need to be levelled down to a foundation depth. This depth would not have been too deep as the walls likely did not rise to a great height, and the initial settlers would not have created more work for themselves than necessary. The expected height of the walls is discussed further below. Here the foundations will be taken down to 0.25 m. At a rate of 0.14md/m^3, 1.38 m^3 of earth is removed at a cost of 0.19 md.[40] This includes a gap of 1 m to account for a doorway. While the Greeks may have placed stone around the entire foundation, instead leaving the gap undug lowers the amount of labour required.

[37] Orsi 1899b, pp.209-10.
[38] For this and the following three chapters, calculations for the fortifications, due to the large number of days, are rounded to the nearest integer. Calculations for residential and temple constructions are rounded to the second decimal place.
[39] Gras et al. 2004, p.459; De Angelis 2016, p.84.
[40] ((0.25 m x 0.50 m x 3.50 m) x 2 walls) + ((0.25 m x 0.50 m x 2.50 m) x 2 walls) – (0.25 x 0.50 x 1 m (doorway)) ≈ 1.38 m^3; 1.38 m^3 x 0.14 md/m^3 ≈ 0.19 man-days.

The 1.38 m³ of earth then needs to be removed from the construction site. Its reuse could be for any purpose including levelling terrain, increasing the size of the island or in another construction process. In the beginning stages of colonisation, it is a reasonable assumption that the material would have be reused within 250 m of the site. This is also an average distance from the centre of the island of Ortygia to the coast. This volume of earth then involves both manual labour and transport costs. First the material is to be gathered, carried and loaded onto a cart, then transported to be unloaded, carried and deposited at its final destination. At an average of 8 km a day, in a single ox-carriage day a team of oxen can make 16 trips of 250 m each way. All these steps require labour costs for a total of 1 md and 1 od.[41]

For obvious reasons, the height of the house is unknown. However, at Zagora a fully intact wall was uncovered that rose to 2.50 m to 2.75 m in height (Fig. 4.8).[42] For the calculations here, this 2.50 m height, taking the lower measurement, includes 0.50 m in which the roofing structure will be placed consisting of a lintel over the doorway, under the roofing beams, each measuring 0.25 m in diameter. Under this is the doorway. A simple route to account for this would be through leaving the opening in the wall during construction. The width of the doorway can be reasonably sized at a third to quarter of the length of the wall, or 1.16 m to 0.88 m for a 3.50-m long wall. An average of 1 m will be used (Fig. 4.9), and this doorway size will remain consistent at the other sites discussed below. The 0.50 m of roof eliminates the use for stone above the doorway, essentially splitting the front wall into two stone walls. Each lintel will also be calculated at 1.50 m in length. This area comprising the door lintels would obviously lower the total amount of stone required but only by a small amount, and within the context of the entire construction process the difference in labour cost would be negligible. Using these figures as a common basis for the building style, the stone walls incorporated a total of 14.38 m³.[43]

This brings about a few points that must be addressed. The foundations were dug down 0.25 m, excluding the entranceway, while the wall height reached 2.50 m yet the doorway only rose 2 m. This creates a passage in and out of the house 1.75 m high. This is not unreasonable as at Zagora the doorway height was anywhere from 1.60 m to 1.80 m.[44] The entrance is excluded from the foundation levelling process as the entire interior of the residence would

---

[41] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 1.38 m³ x 0.386 md/m³ ≈ 0.53 md; 1.38 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 4 carriage-loads. (4 carriage-loads / 16 trips per day) ≈ 0.25 od. Although only a quarter of a day, it will be considered a single ox-carriage day.

[42] Cambitoglou & Coulton 1988, pp.149-50; Morris 1998, p.22. There was also found at Zagora a small triangle window at the top of the wall, but we cannot assume there was any window present at Syracuse. For more on the appearance of windows in Greek architecture see Parisinou 2007, pp.215-7.

[43] ((2.50 m x 0.50 m x 3.50 m) x 2 walls) + ((2.50 m x 0.50 m x 2.50 m) x 1 wall) + ((2.50 m x 0.50 m x 1 m) x 2 front walls) = 14.38 m³.

[44] Cambitoglou & Coulton 1988, p.150.

have needed levelling as well; all of this creating a step down from the ground level into the house. This is simply illogical, and such a doing would have been more labour intensive for little reason.

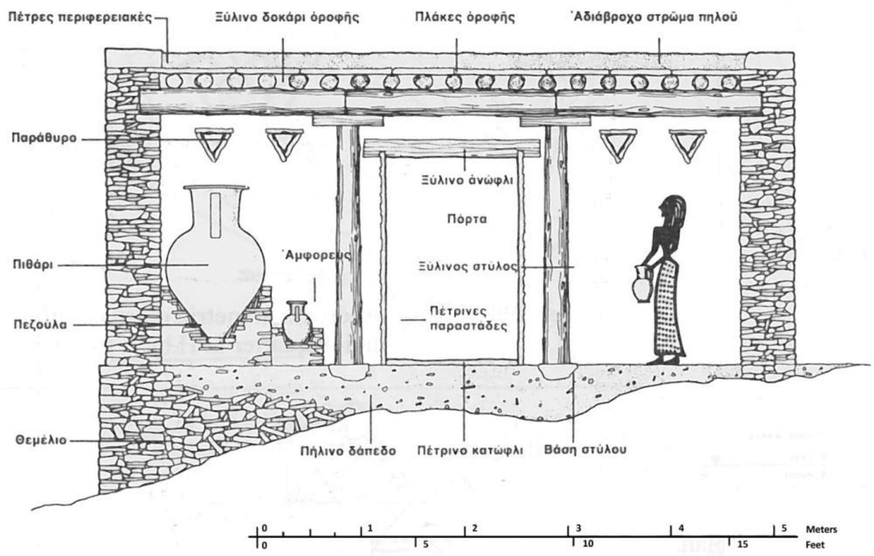

Fig. 4.8: Zagora (Andros). House construction based on Coulton. Mazarakis Ainian 1997, Fig. 303.

For construction in the orthostat technique, a 0.25 md/m³ rate is used for quarrying the stone, reflecting the irregular stone shapes and the reduced care in acquiring the material, and a 1.0 md/m³ construction rate is used, again showing the minimal need for stone dressing. Quarrying 14.38 m³ of irregular stone is estimated at 4 md.[45] Transporting it from 2 km away adds 21 od.[46] The final step, building the walls, then would take 14 md.[47] Up to this point, the labour costs associated with building stone walls add up to 19 md and 22 od.[48]

Next will be considered the cost expenditures of a house with walls primarily of mudbrick. This incorporates a stone socle upon which the mudbrick is placed. The height of the foundation would not have been too great, as, besides the structural advantages, a stone socle is regarded as principally designed to keep the mudbrick off the moist ground.[49] For this reason, a stone foundation no higher than 0.50 m can be expected, and will be adapted here. At this size, only 2.88 m³ of stone is needed.[50] With the same rates as before: 1 md quarry, 4 od

[45] 14.38 m³ x 0.25 md/m³ ≈ 3.60 md.
[46] 14.38 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 42 carriage-loads. (42 carriage-loads / 2 trips per day) ≈ 21 od.
[47] 14.38 m³ x 1 md/m³ ≈ 14.38 md.
[48] 0.19 md (levelling) + 1.20 md (disposal of rubble) + 3.60 md (quarry stone) + 14.38 md (construction) ≈ 19.37 md.
[49] Fagerström 1988, p.99.
[50] ((0.50 m x 0.50 m x 3.50 m) x 2 walls) + ((0.50 m x 0.50 m x 2.50 m) x 1 wall) + ((0.50 m x 0.50 m x 1 m) x 2 front walls) = 2.88 m³.

transport and 3 md construction.[51] Now 11.50 m³ of mudbrick is calculated for the rest of the walls.[52] This volume of material needs gathered, manufactured and transported, then placed on the foundation walls. The river Anapos is the closest source of fresh water in great quantity, and no matter if the mudbrick was made next to the river or on the island, the labour costs are included together. Gathering and forming this amount of mudbrick would take 3 md.[53] Transporting it 3 km to the construction site adds 17 od.[54] Completing the walls increases the costs by 5 md,[55] making the total thus far for a mudbrick house 12 md and 21 od.[56]

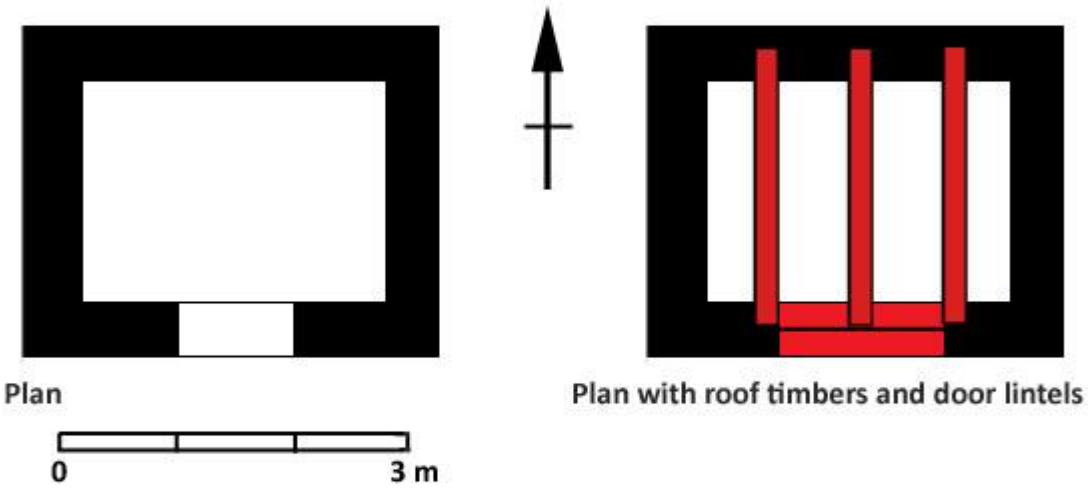

Fig. 4.9: Syracuse. House plans (SH) used in the econometric calculations.

These calculations do not include a roof. The archaeological reports do not mention roofing tiles, which become more common later in the Archaic period, and so it is expected that the eighth century houses were built with a flat roof. At Megara Hyblaia, the earliest houses are assumed to have been constructed in the same manner, possibly with a slight incline to prevent water from accumulating.[57] This slope would have been higher at the end with the door, which was normally the south side at Megara Hyblaia, declining away to the opposite end. Building the flat roof slightly sloping or perfectly flat makes little difference to the calculations, so a flat roof is assumed here. Timber would be placed spanning the area (Fig. 4.9), but unlike the squared lintels, these would have likely remained rounded. While the reconstruction of the houses at Zagora (Fig. 4.8) places the support beams within slots spaced in the stone walls, the

---

[51] Quarry: 2.88 m³ x 0.25 md/m³ ≈ 0.72 md; transport: 2.88 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 8 carriage-loads. (8 carriage-loads / 2 trips per day) ≈ 4 od; construction: 2.88 m³ x 1 md/m³ ≈ 2.88 md.

[52] ((2 m x 0.50 m x 3.50 m) x 2 walls) + ((2 m x 0.50 m x 2.50 m) x 1 wall) + ((2 m x 0.50 m x 1 m) x 2 front walls) ≈ 11.50 m³.

[53] 11.50 m³ x 0.25md/m³ ≈ 2.88 md.

[54] 11.50 m³ x 1.75 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 22 carriage-loads. (22 carriage-loads / 1.33 trips per day) ≈ 17 od.

[55] 11.50 m³ x 0.40 md/m³ ≈ 4.60 md.

[56] 0.19 md (levelling) + 1.20 md (disposal of rubble) + 0.72 md (quarry stone) + 2.88 md (stone construction) + 2.88 (manufacture mudbrick) + 4.60 md (mudbrick construction) ≈ 12.47 md.

[57] Vallet et al. 1976, pp.255-6.

reduction in stone is negligible and so will be disregarded.[58] Also following Zagora, no secondary supports will be used.[59] On top of the beams were fastened materials, such as earth, reeds and clay, which provided the weather-proofing and allowed for the flat finish.[60] This latter step is considered well within a single man-day.

For the roofing structure, the timber used would have been found nearby. Since the houses reconstructed here are foundation era, it is likely that the timber was reused from the deforestation of the island during the initial establishment. However, since the amount of available timber is unknown, the transport costs will account for a 1 km distance from which the supply was acquired. The timber that spanned the structure would have likely been kept rounded, while the lintels across the doorway was squared. Principal beams, three in number, are expected to have formed the main roof supports. As mentioned, these beams would have been placed a distance into the walls; here this is figured at half the thickness, 0.25 m on each end. With the walls 3.50 m from end to end, the beams will be 3 m in length. To create even spacing covering the entire roof opening, these beams will be at a diameter of 0.35 m and placed 0.49 m apart. The two door lintels, placed side by side, 0.25 m by 0.25 m and 1.50 m in length, need to be squared. Squaring timber requires four cuts lengthwise, each cut at a rate of 0.14 md/m² for a pair of sawyers. In total, 1.29 m³ of timber is needed.[61] Felling the timber at a rate of 2.70 md/m³ comes to 3 md.[62] Transporting the softwood increases the labour costs by 1 od,[63] with squaring the lintels at 1 md.[64] Setting the timber in place would take an additional half md, at a rate of 0.1 md per timber, and the final stage of weather-proofing can be expected within an additional md.[65] In total, the roofing structure adds up to 5 md and a single od.[66]

In this reconstruction, the doorway has been set at 1 m. This, then, is taken as the width of the door, which can be reasonably sized at 0.05 m in thickness and 1.75 m in height. It is likely that timber would be difficult to find 1 m in diameter, therefore the expectation is that the door will be made of 3 pieces of timber 0.33 m wide. This allows a door to be built from a single piece of wood. Taking these dimensions, only half of a timber with the diameter of 0.33 m would be needed as 0.15 m of the material is sufficient for the three planks. In felling and

---

[58] Fagerström 1988, pp.101-2; Morris 1998, p.22.

[59] Cambitoglou & Coulton 1971, p.28.

[60] Cf. Fitzjohn 2013, pp.635-6.

[61] ((0.35 m x 0.35 m x 3 m) x 3 beams) + ((0.25 m x 0.25 m x 1.5 m) x 2 lintels) = 1.29 m³.

[62] 1.29 m³ x 2.70 md/m³ ≈ 3.48 md.

[63] 1.29 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) ≈ 1 od.

[64] 4 (length-wise cuts) x 0.25 m (lintel width) x 1.5 m (lintel length) x 0.14 md/m² x 2 (lintels) ≈ 0.42 md. Squaring and weather-proofing costs are added to the construction costs in the table below.

[65] 5 timbers x 0.10 md/timber ≈ 0.50 md.

[66] 3.48 md (felling) + 0.42 md (squaring) + 0.50 md (construction) + 1 md (weather-proofing) ≈ 5.40 md.

transporting the required amount of timber, less than half a man-day and 1 od are needed.[67] To square and cut these planks, six length-wise cuts are needed, four along the outside, and two within, all at a cost of 0.24 md.[68] Labour costs can be saved by gathering the timber for the doorway and roofing structure at the same time, but this consolidation is not accounted for in the calculations. It is likely that in the foundation period multiple construction projects were ongoing simultaneously, and as such these costs would have been combined in a larger, overall effort.

With the final step complete, these reconstructions lead to base estimates of 27 md and 24 od for an all-stone house (Table 4.1) and 19 md and 24 od for a house largely of mudbrick (Table 4.2). These totals reflect an additional 10 per cent cost for supervision.

Fitzjohn's recent calculations of 100 man-days for House 23,10 at Megara Hyblaia are immediately comparable.[69] First of all, House 23,10 is found to be 4.5 by 4.5 metres in dimension, 1 metre longer on each side than that calculated here, but each wall is only 0.45 m wide, 50 cm shorter. The lower number of days in the base total here comes from the preferred use of rates from contemporary sources as outlined in Chapter 3. Further, he includes an additional step of dressing the stone roughly. As explained above, it is expected that the construction of houses did not require much dressing, and the minimal amount can be included in the construction rate. Further, Fitzjohn does not employ oxen in his account of transportation. He does mention the use of pack animals, but does not include a figure of days. Instead, transport costs are largely factored in the human involvement. Nevertheless, the implications from both cost analyses are quite apparent. While it would not have been impossible for a single man to complete construction of his house in a few months at Syracuse or Megara Hyblaia, it can be expected that multiple workmen were incorporated throughout the process.[70] In fact, the transportation costs may have been the largest obstacle to overcome.

Returning to the base rates, another implication comes from comparing the two housing types, all-stone and mudbrick. At these labour and transport costs, the latter dictated largely by availability of nearby resource, only a week's worth of labour for a single man separates the two. Given that a large workforce was in place completing multiple projects at a time, perhaps this cost difference was minimized. Or if limestone was more readily available than current knowledge leads one to believe, the more efficient choice would have been to

[67] (1.75 m x 0.33 m x 0.33 m) x 0.5 (timbers) = 0.10 m^3; felling: 0.10 m^3 x 2.7 md/m^3 ≈ 0.27 md; transport: 0.10 m^3 x 0.56 tonne/m^3 / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) ≈ 1 od.

[68] 6 (length-wise cuts) x 0.33 m (plank width) x 1.75 m (plank length) x 0.14 md/m^2 x 0.5 (timbers) ≈ 0.24 md.

[69] Fitzjohn 2013, pp.631-4, Table 2.

[70] Fitzjohn 2013, pp.634-5.

forgo the mudbrick alternative. Since archaeological work has not uncovered mudbrick remains, this latter instance may be the case.

Table 4.1: Total labour costs for the construction of an all-stone house at Syracuse

RESOURCE	*ACTION IN MD*		
	Acquisition	**Transport**	**Construction**
STONE:	3.60	21 od	14.38
INITIAL LEVELLING OF SITE:			0.19
DISPOSAL OF RUBBLE:		0.53 + 1 od	
ROOF:	3.48	1 od	1.92
DOOR:	0.27	1 od	0.24
TOTALS:	7.35	0.53	16.73
SUPERVISION: (+10%)	0.74	0.05	1.67
BASE TOTAL:		27.07 + 24 od	
RANGE OF TOTALS:		27.07–76.45	

Table 4.2: Total labour costs for the construction of a mudbrick house at Syracuse

RESOURCE	*ACTION IN MD*		
	Acquisition	**Transport**	**Construction**
STONE:	0.72	4 od	2.88
MUDBRICK	2.88	17 od	4.60
INITIAL LEVELLING OF SITE:			0.19
DISPOSAL OF RUBBLE:		0.53 + 1 od	
ROOF:	3.48	1 od	1.92
DOOR:	0.27	1 od	0.24
TOTALS:	7.35	0.53	9.83
SUPERVISION: (+10%)	0.74	0.05	0.98
BASE TOTAL:		83.02 + 24 od	
RANGE OF TOTALS:		19.48–41.74	

4.8 Syracuse: Temple of Apollo

Built sometime in the first half of the sixth century, the Temple of Apollo was the first temple built entirely of stone in Syracuse (Fig. 6.6). Today, the island of Ortygia is relatively flat. This does not guarantee that that was the case when the Corinthian colonists first landed, but it can be expected, and so no large-scale levelling of the area will be taken into consideration. The stereobate of approximately 58.10 m by 24.50 m does instead have foundation substructures beneath the crepidoma, which continue below the columns. These substructures are also present below the sekos walls and inner colonnades. This depth is estimated to 2.30 m, which will be considered below the state of ground level prior to construction. The substructure below the crepidoma extends 3.50 into the temple, while that below the sekos walls and interior colonnades have been estimated at the same depth, 2 m wide. It will be expected here that substructures were also below the second row of columns on the east end, the front of the pronaos below the two columns, the span of the two interior walls separating the rooms and along the back wall. With these dimensions 2,000 m³ is the estimated total amount of earth to be removed.[71] This same amount can then be considered the quantity of sandstone required for the foundation to ground level. To dig foundations deeper than 1.6 m, the rate 0.15 md/m³ is used. A total of 300 md is estimated to remove the required amount of dirt necessary for the foundations stated.[72] The 2,000 m³ of excavated earth needs to be removed from the construction site or reused in the project. Crawl spaces between the substructures were found to be filled with typical infill of stone and debris, and some stone slabs. To dictate whether or not the excess material will be reused, the amount of crawl space beneath the temple floor must be determined.

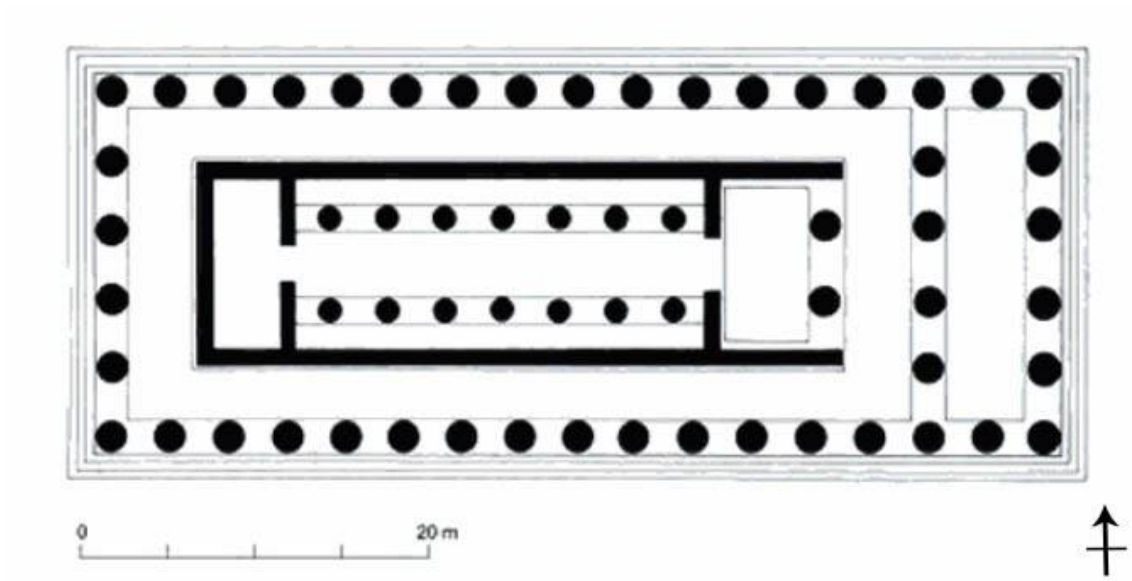

Fig. 4.10: Syracuse. Reconstructed plan of the Temple of Apollo (ST). Mertens 2006, p.108, Fig. 167.

Accounting for the temple floor throughout being 0.50 m in depth, the areas between the crepidoma and sekos substructures are 2.20 m wide by 1.50 m in height, between sekos and inner colonnade supports 0.75 m wide by 1.72 m in height and between the columns 3.60 m by the same height. A four-metre crawl space distance is estimated between the front two rows of columns and on either end between the sekos and colonnades. In total, the crawl space is around 1,030 m³.[73] Dirt excavated from the foundations are, therefore, figured to have been reused for the crawl space debris. The stone slabs will not be accounted for. Redepositing the loose infill is estimated at 0.07 md/m³ equalling 70 md.[74] Since only half of the earth removed

[71] ((2.30 m x 3.50 m x 58.10 m) x 2 temple sides) + ((2.30 m x 3.50 m x 17.50 m) x 2 temple ends) + (2.30 m x 2 m x 17.50 m (second row of columns)) + (2.30 m x 2 m x 36.30 m) x 2 long sekos walls) + (2.30 m x 2 m x 7.60 m) x 4 (interior walls and both ends of sekos)) + (2.30 m x 2 m x 24.60 m) x 2 interior colonnades) ≈ 1,997.78 m³.

[72] 1,997.78 m³ x 0.15 md/m³ ≈ 299.67 md.

[73] ((1.50 m x 2.20 m x 48.6 m) x 2 sides along the sekos) + ((1.50 m x 21 m x 4 m) x 2 between sekos ends and colonnades) + ((1.50 m x 21 m x 4 m (between front two column rows)) + ((1.59 m x 8.60 m x 5.40 m (pronaos)) + ((1.81 m x 0.75 m x 23.40 m) x 2 between cella walls and interior columns) + (1.81 m x 3.60 m x 23.40 m (between interior columns)) + (1.81 m x 8.60 x 2.70 m (adyton)) ≈ 1,030.63 m³.

[74] 1,030.63 m³ x 0.07 md/m³ ≈ 72.14 md.

will be reused, the rest must be taken away. It is not farfetched to expect this to have been reused in other construction projects, perhaps along the coast or at either harbour, 250 m away. This process incorporates the loading and carrying by hand, loading of the cart, transport and then unloading and carrying to final disposal site. This process will require 370 md and 180 od.[75]

Obviously, the infilling would be completed after the crepidoma and substructures are completed. In calculating the amount of material for the steps, each level will be considered separately. The stereobate axis of 58.10 m by 24.50 m will be the starting point, with the step reaching 3.50 m into the temple substructure. The axis of each step will be taken from the archaeological report.[76] Between the first step and the second, there is an approximate 0.35 m difference, between the rest, approximately 0.50 m. Each step is also approximated to 0.50 m in height. With this understanding, the total material for the temple crepidoma is 1,020 m³.[77] The substructures within the crepidoma will be calculated to the measurements stated above, but at a height of 2 m from foundation. This adds 1,740 m³.[78] The rest of the temple floor can be found using the same calculations as the crawl spaces, but to a height of only 0.50 m representing the floor depth, increasing the amount by 330 m³.[79] The floor height differences leading to the pronaos and the sekos will be ignored here as inconsequential to the overall costs. Furthermore, a front staircase was added soon after completion, but not during the original construction, and will also be dismissed here.[80] In total, 5,080 m³ of sandstone is estimated to complete the entire temple platform, foundation and substructures.[81] Quarrying this amount of stone at a rate of 2 md/m³ equates to 10,200 md.[82] Because the closest source for sandstone is 28 km away, the transport costs are expected to be quite high. It would take

[75] 1,997.78 m³ - 1,030.63 m³ ≈ 967.15 m³ excess earth; loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 967.15 m³ x 0.386 md/m³ ≈ 373.32 md; 967.15 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 2,794 carriage-loads. A team of oxen could make 16 trips of 250 m each way in a day. (2,794 carriage-loads / 16 trips per day) ≈ 175 od.

[76] See Appendix 1: S, section E.

[77] Stereobate: ((0.50 m x 3.50 m x 58.10 m) x 2 sides) + (0.50 m x 3.50 m x 17.50 m) x 2 ends) = 264.60 m³; Step 2: ((0.50 m x 3.50 m x 57.40 m) x 2 sides) + (0.50 m x 3.50 m x 16.80 m) x 2 ends) = 259.70 m³; Step 3: ((0.50 m x 3.50 m x 56.30 m) x 2 sides) + (0.50 m x 3.50 m x 15.20 m) x 2 ends) = 250.25 m³; Stylobate: ((0.50 m x 3.50 m x 54.90 m) x 2 sides) + (0.50 m x 3.50 m x 14.50 m) x 2 ends) = 242.90 m³. 264.60 m³ + 259.70 m³ + 250.25 m³ + 242.90 m³ = 1,017.45 m³

[78] ((2 m x 3.50 m x 58.10 m) x 2 temple sides) + ((2 m x 3.50 m x 17.50 m) x 2 temple ends) + (2 m x 2 m x 17.50 m (second row of columns)) + (2 m x 2 m x 36.30 m) x 2 long sekos walls) + (2 m x 2 m x 7.60 m) x 4 (interior walls and both ends of sekos)) + (2 m x 2 m x 24.60 m) x 2 interior colonnades) ≈ 1,737.20 m³.

[79] ((0.50 m x 2.20 m x 48.6 m) x 2 sides along the sekos) + ((0.50 m x 21 m x 4 m) x 2 between sekos ends and colonnades) + ((0.50 m x 21 m x 4 m (between front two column rows)) + ((0.50 m x 8.60 m x 5.40 m (pronaos)) + ((0.50 m x 0.75 m x 23.40 m) x 2 between cella walls and interior columns) + (0.50 m x 3.60 m x 23.40 m (between interior columns)) + (0.50 m x 8.60 x 2.70 m (adyton)) ≈ 327.42 m³.

[80] Mertens 2006, p.108.

[81] 1,997.78 m³ (foundation) + 1,017.45 m³ (crepidoma) + 1,737.20 m³ (substructures) + 327.42 m³ (floor) ≈ 5,079.85 m³.

[82] 5,079.85 m³ x 2 md/m³ ≈ 10,159.70 md.

82,000 od to transport the entire quantity of sandstone to the temple site, based on a direct path, at a gradual incline of 1 per cent.[83] The easiest path at a gradual incline is the best-case scenario for transportation, an unlikely outcome, but this provides the minimum figures with the inherent expectation that the costs were higher. Once delivered, the construction process continues at a rate of 4.0 md/m³ since not all sides of the stone need dressed. Setting the temple platform in place adds 20,300 md.[84]

With the stylobate in place, next to be reconstructed will be the columns in place outside of the sekos. The two columns in the pronaos, and the two interior colonnades will be discussed with the sekos calculations. Seventeen columns were found along the temple sides, four on each end and a second row of four in the east (Fig. 6.6). The front six columns along the east side are 2.01 m in lower diameter and have been estimated at 1.63 m at the top end. To calculate the volume of the capitals, the lower diameter will be taken. This is the simplest way to get highest estimate of material quantity to provide the best labour costs. These six columns to a height of 6.63 m equals 126 m³.[85] The other forty columns outside of the sekos are of the same height, but with a smaller lower diameter (1.85 m), and equate to 712 m³.[86] The capitals will be figured similar to the columns in taking the height and width for maximum volume. To a height of 1.36 m and abacus width of 2.86 m, all forty-six capitals total 512 m³.[87] Up to the architrave, the exterior columns, including capitals, add up to 1,350 m³.[88]

Resting on the capitals, the 'L'-shaped architrave has a height of 2.15 m and depth of 1.82 on its horizontal arm. This same arm is about 0.70 m thick, the vertical arm 0.63 m. The remains of the Temple of Apollo do not provide the extent of the entablature at the corners, and so here we will presume that it stretched to edge of the stylobate. With these measurements, the architrave around the entire temple numbers 323 m³ in stone.[89] The taenia adds 23.59 m³.[90] Above this, the frieze is estimated to raise the entablature height two more metres but only 0.75 m wide, 225 m³ in total.[91] The entablature is expected to have been repeated along the second-row columns, but here the horizontal arm of the architrave will be disregarded. This entablature would have extended the width of the stylobate minus the depths

[83] 5,079.85 m³ x 2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 11,289 carriage-loads. (11,289 carriage-loads / 0.14 trips per day) + 1.7% ≈ 82,007 od.
[84] 5,079.85 m³ x 4 md/m³ ≈ 20,319.40 md.
[85] (π x (1.005 m)² x 6.62 m) x 6 = 126.04 m³.
[86] (π x (0.925 m)² x 6.62 m) x 40 = 711.79 m³.
[87] (1.36 m x 2.86 m x 2.86 m) x 46 = 511.72 m³.
[88] 126.04 m³ (front columns) + 711.79 m³ (other exterior columns) + 511.72 m³ (all capitals) = 1,349.55 m³.
[89] Horizontal arm: ((0.70 m x 1.82 m x 54.90 m) x 2 sides) + ((0.70 m x 1.82 m x 17.86 m) x 2 ends) ≈ 185.40 m³; Vertical arm: ((1.45 m x 0.63 m x 54.90 m) x 2 sides) + ((1.45 m x 0.63 m x 20.24 m) x 2 ends) ≈ 137.28 m³. 185.40 m³ + 137.28 m³ ≈ 322.68 m³.
[90] ((0.275 m x 0.57 m x 54.90 m) x 2 sides) + ((0.275 m x 0.57 m x 20.36 m) x 2 ends) ≈ 23.59 m³.
[91] ((2 m x 0.75 m x 54.90 m) x 2 sides) + ((2 m x 0.75 m x 20 m) x 2 ends) ≈ 224.70 m³.

of the outer entablatures, 20.10 m.[92] The interior entablature then increases the total volume of stone by 61 m³.[93] The entirety of the entablature adds up to 632 m³.[94]

Next, the cornice reaches 1.40 m above the frieze at the highest point, and based on Fig. 4.4, this is approximately 0.70 m from the outer edge. It is at this point that a rafter rests on the cornice and the roof tiles are placed above. Roof timbers and tiles are discussed below. The rest of the cornice, about 0.30 m shorter, is expected to meet the back edge of the frieze, 1.25 m in total width. From this, the horizontal cornice along the roof edge is estimated at 234 m³ of stone.[95]

To determine the total material for the raking cornice, the dimensions of the pediment must be calculated. With the stylobate width given as 21.50 m, the cornice extending 0.50 m on each end and the roof at an 18-degree angle, each roof slope comes to 11.83 m in length and the peak 3.66 m in height.[96] The raking cornice is not expected to have been to the same height as the horizontal cornice, instead only 0.82 m high, and along the slopes the raking cornice extends further than the horizontal cornice, estimated at 0.50 m. Last, approximately 0.75 m of overlapping will be accounted for. Then calculating it in the same manner as the horizontal cornice, the raking cornice along both ends adds 56 m³.[97] Also on each end, the tympanon between the cornices can then correspond to the roof height minus half each cornice height, 2.55 m in total,[98] and the length estimated to the breadth of the central four columns (Fig. 4.3), 13.94 m.[99] Set back from the horizontal cornice extension, corresponding to the frieze width, the tympanon equates to 53 m³.[100] Everything constructed in stone above the entablature adds up to a total of 344 m³.[101]

When discussing the roofing structure of the Temple of Apollo, the timber beams will be placed set into grooves and sockets chiselled in places into the raking cornice. In essence, this would decrease the amount of stone required to be quarried. Logically, however, these would have been taken out of the stone after quarrying, and so would not have lowered the initial labour costs. Indeed, this would only serve to increase the number of man-days. Yet,

---

92 The architrave and frieze widths vary slightly; an average of 0.70 m will be taken. 21.50 m – (0.70 m x 2) ≈ 20.10 m.

93 (2.15 m x 0.63 m x 20.10 m (architrave)) + (0.275 m x 0.57 m x 20.10 m (taenia)) + (2 m x 0.75 m x 20.10 m (frieze)) ≈ 60.53 m³.

94 322.68 m³ (outer architrave) + 23.59 m³ (outer taenia) + 224.70 m³ (outer frieze) + 60.53 m³ (interior entablature) ≈ 631.50 m³.

95 ((1.40 m x 0.70 m x 54.90 m) + (1.10 m x 0.55 m x 54.90 m)) x 2 sides ≈ 174.02 m³; ((1.40 m x 0.70 m x 19 m) + (1.10 m x 0.55 m x 19 m)) x 2 ends ≈ 60.23 m³. 174.02 m³ + 60.23 m³ ≈ 234.25 m³.

96 Roof slope length: 11.25 m / cos(18°) = 11.83 m. Roof height: 11.25 x tan(18°) = 3.66 m.

97 ((0.82 m x 1.20 m x 11.08 m) + (0.52 m x 0.55 m x 11.08 m)) x 4 roof slopes ≈ 56.28 m³.

98 3.66 m – (1.40 m / 2) – (0.82 m / 2) ≈ 2.55 m.

99 (2.01 m (lower column diameters) x 4) + 2.30 m (spacing between centre columns) + (1.80 m (approximate spacing between other front columns) x 2) ≈ 13.94 m.

100 (2.55 m x 0.75 m x 13.94 m) x 2 ends ≈ 53.32 m³.

101 234.25 m³ (horizontal cornice) + 56.28 m³ (raking cornice) + 53.32 m³ (tympanon) ≈ 343.85 m³.

because the total cubic metres of stone to be removed would be negligible within the greater context of labour costs, this facet of the construction process will be ignored.

With the outer columns, capitals, entablature and pediments reconstructed, these volumes will be calculated combined. The stone above the stylobate, outside of the sekos, is estimated at 2,325 m³.[102] Quarrying this much stone at a rate of 2 md/m³ requires 4,600 md.[103] Transport costs will again be high: 37,500 od.[104] This is not as labour intensive as the temple foundation structure, but a high total nonetheless. In setting this amount of sandstone in place, the rate of 8 md/m³ will be used as much of these parts of the temple are meant to be seen from almost every angle, and so the blocks would have been dressed with greater care. This adds to the labour costs by 18,600 md.[105]

Next to be considered is the sekos. The walls are expected to have rose to the same height as the top of the frieze, 12.41 m, as additional support for the cross beams of the roof structure.[106] Two walls of the sekos stretch 37.30 m in length, and with a thickness of 1 m, the back wall is 9.60 m long. Walls separating the three rooms of the sekos are expected to be of the same thickness, and with openings as entrances between rooms, the four extensions have been placed at 3.75 m long each. Material evidence indicates that the first set of doors was not at the front of the pronaos, but instead between there and the cella. Due to the inherent nature of the adyton, a door can confidently be assumed there as well. These doors will be estimated at a height of the interior columns including capitals, 6.03 m. The doorways stretch 2.10 m, and above this a continuation of the stone wall. With these dimensions, the sekos walls total 1,258 m³ of sandstone.[107] The doors themselves are discussed further below. The two columns in the pronaos, are figured at the same size as the external columns supporting an entablature the same dimensions as the second row of front columns, apart from the length. As the sekos rooms are 9.60 m in width, the entablature will reach this distance. These two columns, calculated the same as the outer colonnades, total 36 m³.[108] Both capitals add 22 m³,[109] and above this, the interior entablature equals 29 m³.[110] Turning to the interior columns, much of which has been hypothetically calculated above to ratios based on the exterior colonnades, all

[102] 1,349.55 m³ (columns and capitals) + 631.50 m³ (exterior and interior entablature) + 343.85 m³ (cornice, pediments and tympanon) ≈ 2,324.90 m³.

[103] 2,324.90 m³ x 2 md/m³ ≈ 4,649.80 md.

[104] 2,324.90 m³ x 2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 5,166 carriage-loads. (5,166 carriage-loads / 0.14 trips per day) + 1.7% ≈ 37,527 od.

[105] 2,324.90 m³ x 8 md/m³ ≈ 18,599.20 md.

[106] Outer columns: 7.98 m (column and capital) + 2.15 m (architrave) + 0.275 m (taenia) + 2 m (frieze) ≈ 12.405 m.

[107] ((12.41 m x 1 m x 37.30 m) x 2 long walls) + ((12.41 m x 1 m x 9.60 m) x 1 back wall) + (12.41 m x 1 m x 3.75 m) x 4 doorway extensions) + ((6.38 m x 1 m x 2.10 m) x 2 wall above doorway) ≈ 1,257.87 m³.

[108] $(\pi \times (0.925\ m)^2 \times 6.62\ m) \times 2 = 35.59\ m^3$.

[109] (1.36 m x 2.86 m x 2.86 m) x 2 = 22.25 m³.

[110] (2.15 m x 0.63 m x 9.60 m (architrave)) + (0.275 m x 0.57 m x 9.60 m (taenia)) + (2 m x 0.75 m x 9.60 m (frieze)) ≈ 28.91 m³.

fourteen lower columns drums 1.40 m in lower diameter and 5 m high add up to 108 m³.[111] The capitals are 1.03 m in height and 2.17 m wide totalling 68 m³.[112] The architrave is not 'L'-shaped like that above the outer capitals, instead figured at 1.84 m high by 1.38 wide and extending the length of the cella: 125 m³.[113] Upper column drums placed upon the architrave have been estimated at 1 m lower diameter to a height of 3.59 m, increasing the stone total by 39 m³.[114] Last, the capitals 0.73 m high and 1.55 m wide add 25 m³.[115] Totals, after all this, are 1,709 m³ for the entire sekos.[116] Labour costs for this amount of sandstone equate to 3,400 md quarrying,[117] 27,600 od transport[118] and 13,700 md for construction again at the rate of 8 md/m³.[119] At this point the use of sandstone is now complete. Labour costs will decrease dramatically as working with wood is less labour intensive, although as the source of the timber is expected to be within 1 km, the biggest impact will be seen in the transport costs.

Roofing structures have been discussed fully in the previous chapter. Through the use of timber, the structure spans the entire width and length of the temple, supporting tiles. The primary timbers would have been placed within sockets cut into stone at certain points, but this additional labour has already been discussed as essentially inconsequential to the overall labour costs, and so are disregarded. Using a system of prop-and-lintel to bear the weight of a single ridge beam and purlins, cross beams are essential at all points of support (Fig. 4.11: A). It can reasonably be expected that these cross beams were placed atop each sekos wall, the pronaos columns and the second front row of columns. In addition, the two rows of seven columns would support seven beams as otherwise their inclusion in the construction would be superfluous. Dimensions of the cross beam can be sensibly placed at 0.40 m square, which will be the same as the props. As the 'L'-shaped architrave is expected to have supported the cross beams, the timber will not be placed deeply into the cornice stone, estimated here at 0.20 m, which is 0.55 m shy of the stylobate edge. Therefore, each cross beam will extend the width of the temple minus 1.10 m, 20.40 m in total.[120] It will be figured, further, that each cross beam was comprised of three separate beams roughly 6.80 m each. The volume of timber is largely

---

111 (π x (0.70 m)² x 5 m) x 14 = 107.76 m³.
112 (1.03 m x 2.17 m x 2.17 m) x 14 = 67.90 m³.
113 (1.84 m x 1.38 m x 24.60 m) x 2 colonnades ≈ 124.93 m³.
114 (π x (0.50 m)² x 3.59 m) x 14 = 39.47 m³.
115 (0.73 m x 1.55 m x 1.55 m) x 14 = 24.55 m³.
116 1,257.87 m³ (walls) + 35.59 m³ (pronaos columns) + 22.25 m³ (pronaos capitals) + 28.91 m³ (pronaos entablature) + 107.76 m³ (interior lower columns) + 67.90 m³ (interior lower capitals) + 124.93 m³ (interior architrave) + 39.47 m³ (interior upper columns) + 24.55 m³ (interior upper capitals) ≈ 1,709.23 m³.
117 1,709.23 m³ x 2 md/m³ ≈ 3,418.46 md.
118 1,709.23 m³ x 2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 3,798 carriage-loads. (3,798 carriage-loads / 0.14 trips per day) + 1.7% ≈ 27,590 od.
119 1,709.23 m³ x 8 md/m³ ≈ 13,673.84 md.
120 21.50 m (width of stylobate) – (0.55 m x 2) ≈ 20.40 m.

calculated in total cubic metres, but this detail becomes important in felling and construction costs as the rates are based on timber length and total number of individual timbers.

The ridge beam reaches almost the length of the stylobate, set into the top of the pediments on each end (Fig. 4.11: B). Comparison to known ridge beam sizes in other temples allows the ridge beam here to be sufficiently estimated to 0.50 m square.[121] Placed at an estimated 0.30 m into the stone at each end, 0.45 m short of the edge of the stylobate, the total length of the ridge beam here is figured at 54 m.[122] With the multiple points of support, ten timbers 5.40 m long each will suffice to span the largest gaps. The same can be said for the number of purlins. Each roof slope has been calculated above at 11.83 m, but only 10.88 m needs spanned, subtracting 0.70 m for the bottom cornice edge and half the ridge beam width, 0.25 m.[123] This is the distance of each rafter. A single purlin, 0.40 m square, halfway down each slope provides satisfactory support for the rafters and in turn the tiles (Fig. 4.11: C). Each prop below the ridge beam would rise a distance equal to the height of the pediment and the cornice, minus the height of the ridge beam and cross beam: 4.16 m.[124] For the props below the purlins, the same manner can be used, but at half the dimensions of the pediment: 2.43 m.[125] These props would logically have been cut at an angle on the top ends, but again this factor is minutiae in the overall construction costs. Twelve cross beams,[126] three props for each,[127] a ridge beam[128] and two purlins[129] then provide the primary timbers for the roofing structure, 87 m^3 in total.[130]

Secondary timber, comprised of the rafters, are estimated at 0.30 m square (Fig. 4.4), running 10.88 m up the roof slope, resting halfway on the purlins (Fig. 4.11: D). These rafters are placed equidistant apart, perpendicular to the length of the temple and along both sides of the roof. Upon these rafters are placed the tiles, which the archaeological notes suggest were 0.70 m wide. Placing 0.15 m of each end of a tile on a rafter, the rafters can be spaced 0.40 m apart. To cover the entire roof starting and ending with a rafter, 79 total are needed on each

[121] Hodge 1960, p.46, Table 2.
[122] 54.90 m – (0.45 m x 2) ≈ 54.00 m.
[123] 11.83 m – 0.70 m – 0.25 m ≈ 10.88 m.
[124] 3.66 m (pediment height) + 1.40 m (cornice height) - 0.50 m (ridge beam height) - 0.40 m (cross beam height) = 4.16 m.
[125] A triangle with half the hypotenuse (5.92 m) and half the length (5.63 m) of half the pediment has half the height= 1.83 m. 1.83 m + 1.40 m (cornice height) – 0.40 (purlin height) – 0.40 (cross beam height) = 2.43 m.
[126] (0.40 m x 0.40 m x 20.40 m) x 12 ≈ 39.17 m^3.
[127] Per cross beam: (0.40 m x 0.40 m x 4.16 m) + ((0.40 m x 0.40 m x 2.43 m) x 2) ≈ 1.44 m^3. 1.44 m^3 x 12 (cross beams) ≈ 17.28 m^3.
[128] 0.50 m x 0.50 m x 54 m ≈ 13.50 m^3.
[129] 0.40 m x 0.40 m x 54 m x 2 ≈ 17.28 m^3
[130] 39.17 m^3 + 17.28 m^3 + 13.50 m^3 + 17.28 m^3 ≈ 87.23 m^3.

slope.[131] This creates 155 m³ of secondary timber.[132] For the construction cost, it will be figured that the rafters would have been cut into two 5.44 m lengths each, 316 rafters in total.[133]

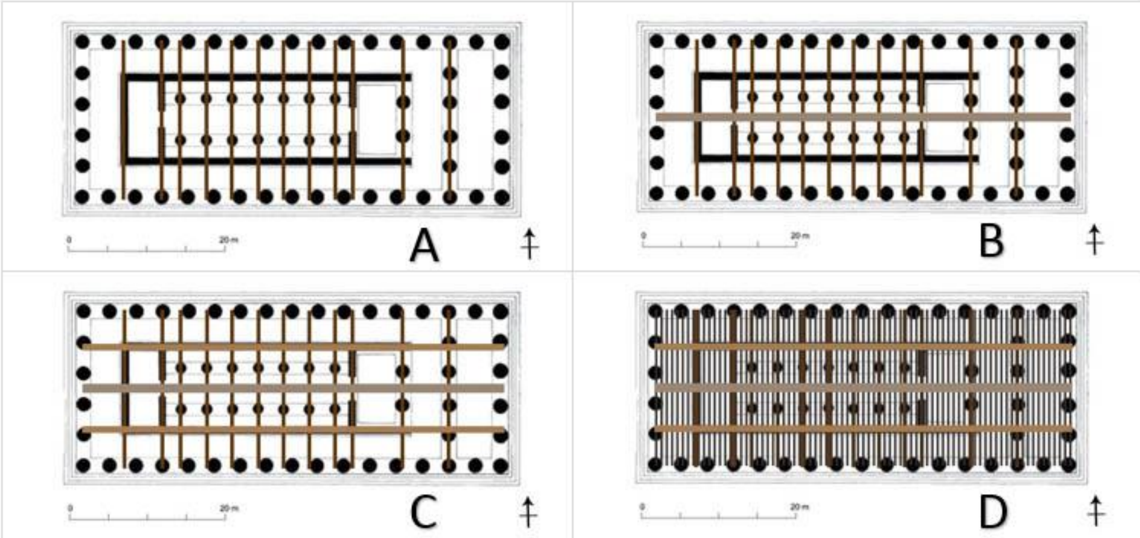

Fig. 4.11: Syracuse. Temple of Apollo (ST). Roof structure indicating (not to scale) cross beams (A), ridge beam (B), purlins (C) and rafters (D). Mertens 2006, p.108, Fig. 167 with additions.

Combined, 242 m³ of timber is needed for the roofing structure according to the estimates outlined here.[134] In the previous chapter, it has been discussed how the labour cost rate of felling wood corresponds to its length. For the cross beams, 6.80 m in length, the rate is 8.2 md/m³; the ridge beam, purlins and rafters are calculated at 5.5 md/m³; the props, 2.7 md/m³. These rates then provide a felling cost of 1,400 md.[135] Transporting the combined volume of timber requires 80 od.[136] Squaring the timber can take place either before or after transport. Cross beams,[137] centre props,[138] purlin props,[139] ridge beam,[140] purlins[141] and rafters[142] all add 410 md to the labour costs.[143] These costs can be calculated to the full length or each individual timber dimensions. This is added to the construction total in the table below. Final timber costs come in placing the beams into the roof structure. It has been estimated in

[131] 54.90 m (stereobate axis length) – (0.50 m x 2) (pediment borders) ≈ 53.90 m. With a rafter on each end: (79 rafters x 0.30 m) + (78 space x 0.40 m) ≈ 54.90 m.
[132] (0.30 m x 0.30 m x 10.88 m) x (79 rafters x 2 slopes) ≈ 154.71 m³.
[133] 79 rafters x 2 pieces x 2 slopes ≈ 316 rafters.
[134] 87.23 m³ (primary) + 154.71 m³ (secondary) ≈ 241.94 m³.
[135] Cross beams: 39.17 m³ x 8.2 md/m³ ≈ 321.19 md; ridge beam: 13.50 m³ x 5.5 md/m³ ≈ 74.25 md; purlins: 17.28 m³ x 5.5 md/m³ ≈ 95.04 md; rafters: 154.71 m³ x 5.5 md/m³ ≈ 850.91 md; props: 17.28 m³ x 2.7 md/m³ ≈ 46.66 md. 321.19 md + 74.25 md + 95.04 md + 850.91 md + 46.66 md ≈ 1,388.05 md.
[136] 241.94 m³ x 0.56 tonne/m² / 0.9 tonne per carriage-load ≈ 151 carriage-loads. (151 carriage-loads / 2 trips per day) ≈ 76 od.
[137] 4 (length-wise cuts) x 0.40 m (width) x 20.40 m (length) x 0.14 md/m^2 x 12 (cross beams) ≈ 54.84 md.
[138] 4 x 0.40 m x 4.16 m x 0.14 md/m^2 x 12 (centre props) ≈ 11.18 md.
[139] 4 x 0.40 m x 2.43 m x 0.14 md/m^2 x 24 (purlin props) ≈ 13.06 md.
[140] 4 x 0.50 m x 54 m x 0.14 md/m^2 x 1 (ridge beam) ≈ 15.12 md.
[141] 4 x 0.40 m x 54 m x 0.14 md/m^2 x 2 (purlins) ≈ 24.19 md.
[142] 4 x 0.30 m x 10.88 m x 0.14 md/m^2 x 158 (rafters) ≈ 288.80 md.
[143] 54.84 md + 11.18 md + 13.06 md + 15.12 md + 24.19 md + 288.80 md ≈ 407.19 md.

the previous chapter at 73 md per beam, purlin, cross beam and prop, individually. Ninety-two of these timbers and 316 rafters, at half a day each, equals 6,870 md.[144]

Not yet accounted for in this reconstruction are the wooden supports placed below the cross beams set upon the horizontal arm of the 'L'-shaped architrave. This is expected under each end of the cross beams, not along the entire architrave. The height of the entablature is estimated here at 4.43 m.[145] Subtracting the horizontal arm of the architrave, 0.70 m, these wooden supports are figured here at 3.73 m in height. To support the cross beams 0.40 m wide, the supports will be calculated at 0.80 m wide. This follows the trend of the temple in overcompensating for the necessary reinforcement. Logically speaking, each brace would be best presumed at 10 square timbers 0.37 m thick each, placed one atop the other.[146] This volume of timber, 28.91 m^3,[147] will be figured to have been cut from two timbers 4 m long, which dictates the felling rate, taking 80 md.[148] Transport costs increase the total by 9 od.[149] Squaring these, then, requires the four length-wise cuts as above, and four additional width-wise cuts to make five pieces per timber, adding 40 md.[150] Setting the supports in place will be considered the same as rafters, one half man-day each timber. Ten timbers beneath both ends of 12 cross beams, 240 timbers total, adds 120 md.[151]

Upon the roof structure, tiles will be placed directly on the rafters. This creates the minimum associated costs. Pantiles are joined together, side by side, along the length of the roof. Moving up the slope, each row will be estimated here overlapping the row below it five centimetres. For each slope, the area to be covered by tiles is equal to the length of the stylobate minus the cornice, 53.90 m, by the length of the rafters, 10.88 m: 586 m^2.[152] To cover this area, 77 columns of 24 pantiles and 76 columns of 24 cover-tiles are needed, or 3,672 tiles total per side.[153] Add to this 108 ridge tiles,[154] for a total of 7,452 tiles to cover the entire roof.[155] Table 3.1 in the previous chapter outlines the labour costs for manufacturing each tile type. For the Temple of Apollo, 342 md are estimated, including quarrying the clay.[156] These

---

144 (36 (cross beams) + 36 (props) + 10 (ridge beams) + 10 (purlins)) x 73 md/primary timber ≈ 6,716 md; 316 (rafters) x 0.5 md/secondary timber ≈ 158 md. 6,716 md + 158 md ≈ 6,874 md.

145 2.15 m (architrave) + 0.275 m (taenia) + 2 m (frieze) ≈ 4.43 m.

146 Mertens 2006, p.170, Fig. 165.

147 (0.37 m x 0.37 m x 0.80 m) x 11 timbers x 24 supports ≈ 28.91 m^3.

148 28.91 m^3 x 2.7 md/m^3 ≈ 78.06 md.

149 28.91 m^3 x 0.56 tonne/m^2 / 0.9 tonne per carriage-load ≈ 18 carriage-loads. (18 carriage-loads / 2 trips per day) ≈ 9 od.

150 8 (cuts) x 0.37 m (width) x 4 m (length) x 0.14 md/m^2 x 24 (timbers) ≈ 39.78 md.

151 (10 timbers x 24 supports) x 0.5 md/timber ≈ 120 md.

152 53.90 m x 10.88 m ≈ 586.43 m^2.

153 (77 x 24 (pantiles)) + (76 x 24 (cover-tiles)) ≈ 3,672 tiles per side.

154 53.90 m / 0.50 m ≈ 107.80 ridge-tiles.

155 (3,672 (pantiles and cover-tiles) x 2 sides) + 108 ridge-tiles ≈ 7,452 tiles.

156 77 columns of 24 pantiles x 2 sides ≈ 3,696 pantiles; 61 md per 1,000 pantiles ≈ 225.46 md per 3,696 pantiles; 76 columns of 24 cover-tiles x 2 sides ≈ 3,648 cover-tiles; 31 md per 1,000 cover-tiles ≈ 113.09

costs are listed under the 'acquisition' column in the table below. It will be expected here that the clay was taken from the source to the construction site where kilns were found nearby.[157] Based on 74 m³ per 1,000 tiles, 551 m³ is needed here at transport cost of 1,400 od.[158] To finish the roof, the tiles are estimated at 0.07 md/m² to set: 82 md.[159]

Separating the cella from the pronaos and adyton, two doorways are accounted for in this reconstruction. Each doorway is estimated at 2.10 m wide by 6.03 m high. Accounting for double hardwood doors at each, four total doors 1.05 m wide, to the same height and figured at 0.07 m thick. In turn, each door will be constructed as two planks 0.53 m wide. Rationally, eight total planks can be cut from a single timber 0.53 m wide and 6.03 m long. This would require 11 cuts: four to square the timber and seven to cut the eight planks at 0.07 m thick, taking 5 md.[160] A single timber of this size is 1.69 m³.[161] Felling and transporting the timber adds 14 md and 1 od.[162] Additional costs piecing the planks together were ignored above in the residential construction, however here the doors are much more complex, and so another full man-day will be included.

After this thorough exercise, the final labour costs amount to 88,900 man-days and 148,900 ox-carriage days. The large number of ox-carriage days is associated with the use of sandstone, the nearest source 28 km away, as opposed to limestone that was found locally. Perhaps the Syracusans felt the limestone should be reserved for other projects, like residential construction. Or the extra costs in gathering a resource a great distance away would represent better the adoration to the god, Apollo, as well as providing more notoriety for those charged with the task of building the temple itself. This is purely speculation, but evidence towards the latter point comes in the inscription on the temple crepidoma interpreted as the name of a donor.[163] There are places where costs can be lowered, for instance in acquiring resources simultaneously and combining transport in carriage-loads less than full. On the other hand, such a complicated endeavour could easily find hindrances through multiple avenues, including labour, oxen or resource shortages. These possibilities have been discussed above and will be addressed further in the last chapter. Through the labour cost estimates, it is easily apparent

md per 3,648 cover-tiles; 31 md per 1,000 ridge-tiles ≈ 3.35 md per 108 ridge-tiles. 225.46 md + 113.09 md + 3.35 md ≈ 341.90 md.

157 Cf. De Angelis 2016 where kilns were found in specially designed areas near sanctuaries. The same will be presumed here.

158 7,452 tiles x 74 m³ / 1,000 tiles ≈ 551.45 m³; 551.45 m³ x 1.75 tonnes/m³ / 0.9 tonne per carriage-load ≈ 1,072 carriage-loads. (1,072 carriage-loads / 0.75 trips per day) ≈ 1,429 od.

159 (586.43 m² x 2 slopes) x 0.07 md/m² ≈ 82.10 md.

160 11 x 0.53 m x 6.03 m x 0.14 md/m² x 1 (timber) ≈ 4.92 md.

161 6.03 m x 0.53 m x 0.53 m ≈ 1.69 m³.

162 Felling: 1.69 m³ x 5.5 md/m³ x 1.5 (hardwood) ≈ 13.94 md; 1.69 m³ x 0.9 tonne/m³ / 0.9 tonne per carriage-load ≈ 2 carriage-loads. (2 carriage-loads / 2 trips per day) ≈ 1 od.

163 Scott 2016, p.138.

that this project required a large workforce and many years to complete. Once the population estimates are calculated below, plausible timelines will be proposed.

Table 4.3: Total labour costs for the construction of the Temple of Apollo at Syracuse

RESOURCE		***ACTION IN MD***	
	Acquisition	**Transport**	**Construction**
FOUNDATION:	3,995.56	32,250 od	7,991.12
INITIAL LEVELLING OF SITE:			299.67
DISPOSAL OF RUBBLE:		373.32 + 175 od	
PLATFORMS:	6,164.14	49,753 od	12,328.28
SEKOS:	3,418.46	27,590 od	13,673.84
OUTER COLUMNS AND ENTABLATURE:	3,962.10	31,979 od	15,848.40
PEDIMENTS:	687.70	5,551 od	2,750.80
ROOF:	1,466.11	85 od	7,440.97
TERRA-COTTA TILES:	341.90	1,429 od	82.10
DOORS:	13.94	1 od	5.92
TOTALS:	20,049.91	373.32	60,421.10
SUPERVISION: (+ 10%)	2,004.99	37.33	6,042.11
BASE TOTAL:		88,928.76 + 148,813 od	
RANGE OF TOTALS:		88,928.76–109,875.08	

4.9 Kamarina: Fortifications

The mid-sixth century fortifications include a double-curtain stone socle (Fig. 4.12) below a mudbrick superstructure, stretching approximately 7 km in distance and only 2.6 metres in width. Although that known about the structure does provide a solid basis from which to reconstruct the entire circuit,[164] there are still gaps in knowledge. Starting with the socle, the reconstruction will account for a height of 2 m with the mudbrick superstructure of the same height. This is based upon the estimated minimum average height of walls in this period at 4 metres,[165] the superstructure was normally composed of mudbrick, and 2 metres makes a solid socle above any attacking force. While the wall may have risen up to 6 metres or more, the extra height may not have provided enough additional protection compared to the costs associated with doubling the materials.

In the construction of the wall at Kamarina, construction costs will be calculated for the quarrying and setting of the limestone foundations, filling in the inner gap between the socle walls and the manufacture and placement of the mudbricks for the fortification's superstructure. As in that above, the earth must first be removed before a single block of stone can be placed. For a solid base, a depth of 1 m will be considered here. At a rate of 0.14 md/m³,

[164] See Appendix 1: KM, section D.
[165] Frederiksen 2011, p.95.

this first step would need 2,500 md to remove 18,200 m³ of earth.[166] This quantity of rubble will be set aside for now and reused for infill between the two wall curtains.

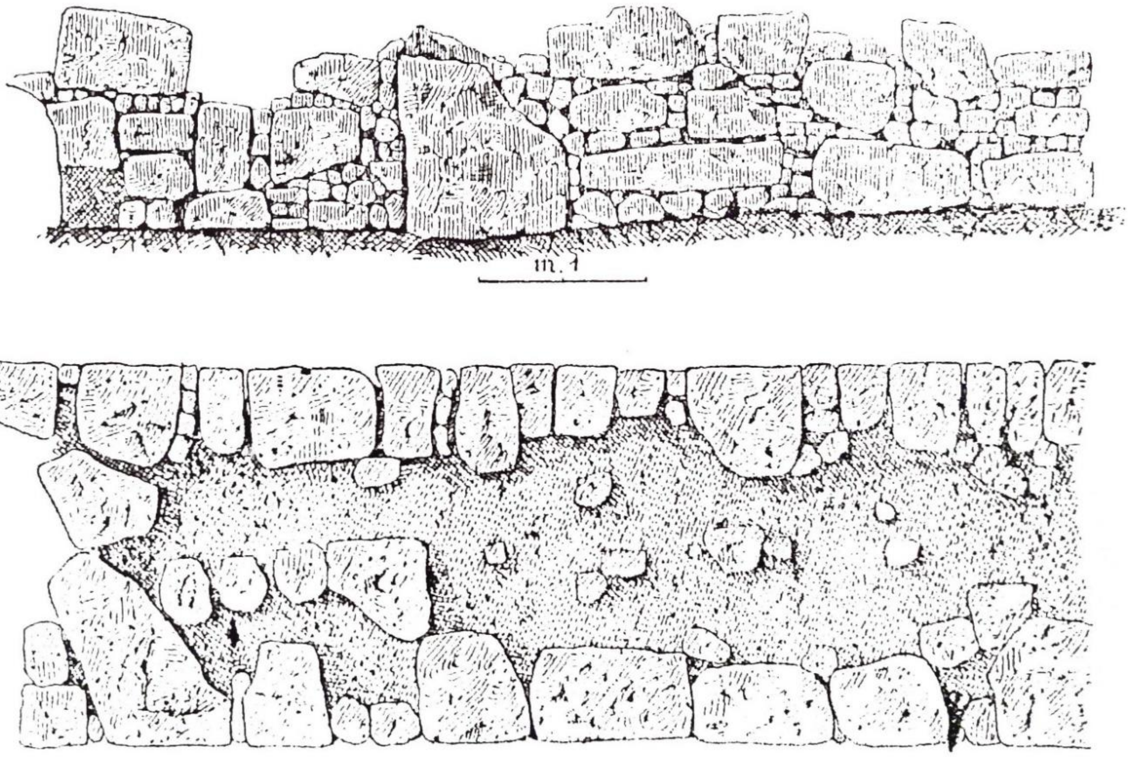

Fig. 4.12: Kamarina. Side and top view of section of eastern wall (KMF). Orsi 1899b, pp.207-8.

For the stone socle, a reasonable approximation of the ratio of limestone blocks to inner fill can be set at 2:1 or roughly 67% limestone to 33% rubble. A double-curtain wall may be built with the outer wall deeper than the interior, however for ease in calculations and to overcome unknowns the two wall faces will be reconstructed to the same depth.[167] Similarly, for structural reasons walls often tapered inward above the foundations, so that the width at the top does not necessarily match that of the socle.[168] This too will be disregarded. At the stated dimensions, 24,388 m³ of stone and 12,012 m³ of rubble is needed.[169] This amount of stone is then quarried, transported and set into place. Since here the stone was gathered locally and not through the traditional quarrying process expected for the other reconstructions below, the rate for quarrying will be dropped to 1 md/m³. This is because some care would still be required for removal from the ground. With this lower rate, the labour costs equal the

[166] (1 m x 2.6 m x 7,000 m) x 0.14 md/m³ ≈ 2,548 md; earth removed: 1 m x 2.6 m x 7,000 m ≈ 18,200 m³.
[167] This is the case at Heloros, see Chapter 5.
[168] Frederiksen 2011, p.57.
[169] Total stone required: (2 m x 2.6 m x 7,000 m) x 66% ≈ 24,388 m³; total rubble required: (2 m x 2.6 m x 7,000 m) x 33% ≈ 12,012 m³.

volume of stone, 24,400 md.[170] Transporting this amount of stone from 0.50 km away adds 8,800 od.[171] In constructing the stone curtain walls, the rate will also be cut in half to 2 md/m³. This is for similar reasons as before: dressing the stone still is needed to provide the proper setting. With this, the cost is 48,780 md.[172] Once the stone is in place, the rubble is then filled back into the socle. This is done in 840 md.[173] The excess rubble, 6,188 m³, then needs disposed of elsewhere.[174] This could have been anywhere and reused for any reason. Here a distance of 250 m will suffice, and no additional cost will be considered due to elevation change. This process requires manual labour of carrying, loading, transport and unloading, and the ox-carriages: 2,400 md and 1,100 od in total cost.[175] The stone socle is now complete, and the mudbrick superstructure will be placed above it.

This reconstruction estimates the mudbrick at the same dimensions as the entire stone socle with rubble infill: 36,400 m³.[176] The earthy materials required to manufacture the mudbricks likely came from the river Hypparis approximately 250 m from the urban centre. At 0.25 md/m³, the labour cost total increases by 36,400 md.[177] Transporting the entirety of the mudbrick adds 4,800 od.[178] Completing the superstructure then requires an additional 14,600 md.[179]

Constructing a wall seven kilometres long is quite an extensive process, at 112,900 md (Table 4.4). Yet, what may be the largest undertaking is supplying enough oxen to support the 14,700 od. In actuality, the wall length may have been less, as the entire span has not been uncovered. The seven-kilometre length is taken from archaeological estimates. What's more, as stated, is that excavations have shown that the fortifications were constructed quickly and without proper quarrying techniques. While this fits perfectly into the time period, immediately before the war with Syracuse, it also suggests that much of the work must have involved the cutting of corners and poor craftsmanship. This has already been somewhat accounted for in the calculations, but quite possibly this figure could significantly decrease even further. On top of this, there cannot be any certainty that the project even came to fruition. The destruction of Kamarina could attest that the fortifications did not work, whatever the reason.

---

[170] 24,388 m³ x 2 md/m³ ≈ 24,388 md.
[171] 24,388 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 70,454 carriage-loads. (70,454 carriage-loads / 8 trips per day) ≈ 8,807 od.
[172] 24,388 m³ x 2 md/m³ ≈ 48,776 md.
[173] 12,012 m³ x 0.07 md/m³ ≈ 841 md.
[174] 18,200 m³ - 12,012 m³ ≈ 6,188 m³.
[175] loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 6,188 m³ x 0.386 md/m³ ≈ 2,389 md; 6,188 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 17,876 carriage-loads. (17,876 carriage-loads / 16 trips per day) ≈ 1,117 od.
[176] 2 m x 2.6 m x 7,000 m ≈ 36,400 m³.
[177] 36,400 m³ x 0.25 md/m³ ≈ 9,100 md.
[178] 36,400 m³ x 1.75 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 70,778 carriage-loads. (70,778 carriage-loads / 16 trips per day) + 7.5% ≈ 4,756 od.
[179] 36,400 m³ x 0.4 md/m³ ≈ 14,560 md.

Table 4.4: Total labour costs for the construction of fortifications at Kamarina

RESOURCE	*ACTION IN MD*		
	Acquisition	**Transport**	**Construction**
STONE:	24,388	8,807 od	48,776
MUDBRICK:	9,100	4,756 od	14,560
LOOSEFILL:	*Gathered during levelling*		841
INITIAL LEVELLING OF SITE:			2,548
DISPOSAL OF RUBBLE:		2,389 + 1,117 od	
TOTALS:	33,488	2,389	66,725
SUPERVISION: (+ 10%)	3,349	239	6,673
BASE TOTAL:	112,863 + 14,680 od		
RANGE OF TOTALS:	112,863–293,084		

4.10 Syracuse and Kamarina Population Modelling

Muggia's population estimate for Syracuse is the most site-specific assessment for south-east Sicily. It includes the settlement sizes both in the Archaic and Classical period, the latter being ignored here.[180] The Archaic extension of the city included the island of Ortygia and the district of Akradina for a total of 120 hectares (Fig. 1.4). Muggia calculates a population of 20,000, taking 166 people per hectare. This latter number will be used here as a maximum estimate for the population in 485 BC. Hansen's method calculates 9,000–12,000 people in the urban area with only 60 hectares inhabited and 150 to 200 people per hectare. Adjusting De Angelis' estimates to strictly follow Hansen gives a range of 3,750–10,000.[181] However, his lower estimate only accounts for the island of Ortygia, and given that by 485 BC the urban area spread to the mainland, this figure can be disregarded. Therefore, these estimates produce a range of 9,000–20,000 inhabitants in Syracuse at the end of the Archaic period. Working backward at a rate of 0.50 per cent annual increase, the initial estimate in 733 BC would have comprised 2,600–5,800 people.[182] These are unrealistically high numbers for the size of the foundation party setting off from Greece, so further scrutiny is necessary.

The island of Ortygia, as it stands today, is approximately 50 ha in size.[183] Based on archaeological evidence largely of later periods, Muggia expects the entire island to have been occupied at the end of the Archaic period, while Hansen only accounts for a habitation area of 20 per cent for the same time period.[184] With the monumental construction taking place on the island, Hansen's estimate is more likely, although Muggia's figure will be taken as an upper limit. The closest comparison for foundation period settlement density is at Megara Hyblaia,

180 Muggia 1997, pp.56-7. Muggia does not provide a rural estimate for the Archaic period.
181 De Angelis 2016, p.143, Table 5. See section 3.8 above.
182 $9{,}000 / (1 + 0.0050)^{248} \approx 2{,}613$. $13{,}944 / (1 + 0.0050)^{248} \approx 5{,}806$.
183 Area measured using Google Maps Area Calculator, Daft Logic 2014b.
184 Muggia 1997, pp.125-6, Fig. 5; Hansen 2006b, p.42, Table 2.1.

where De Angelis estimates 9 people per hectare in the last quarter of the eighth century BC.[185] At this density, using 50 ha as the size gives an initial settlement population of 450; with 20 per cent for habitation, this drops to 90 people.[186]

Establishing the hinterland attached solely to Syracuse reaches c. 300 km².[187] This has been outlined in Fig. 4.13 with the southern and western boundaries abutting the hinterlands of Heloros and Akrai respectively, while the northern extent ends near the northernmost reach of the river Anapos, halfway between Syracuse and Megara Hyblaia. Akrai is c. 35 km west of Syracuse, and the boundary between the two settlements is drawn halfway between them. The river Kakyparis (modern Cassibile) has been designated as a possible southern extent along the coast line towards Heloros and westward to the higher elevated land. Using Muggia's estimate of one site per square kilometre and fifteen inhabitants per settlement for the end of Archaic period,[188] the rural population in the hinterland of Syracuse can be calculated as 6,000. However, the size of the *chora* found here places Syracuse within the group outlined by Hansen expected to have an equally distributed urban and rural population. This means a maximum of 20,000 rural residents from Muggia's urban estimate for 485 BC, equal to De Angelis' adjusted rural upper limit.[189] A range is now set for the rural population in 485 BC of 6,000–20,000 people. Hinterland estimates at this time include both the rural indigenous and Greek populations. They could have participated in construction projects at times when their input was not needed in agriculture.

Fig. 4.13: Syracuse. Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterland attached to Syracuse. De Angelis 2016, p.67, Map 4 with additions.

[185] De Angelis 2003, p.44, Fig. 24.
[186] 9 people per hectare x 50 hectares ≈ 450 people; 9 people per hectare x 10 hectares ≈ 90 people.
[187] This was found using a Google Maps Area Calculator Tool, Daft Logic 2014b.
[188] This is in contrast to the 2.6 sites/km² Muggia estimates for Syracuse in the Classical period. See Table 3.5.
[189] See section 3.8 above.

Through population modelling and an annual growth rate of 0.50 per cent (Chart 4.1), with a foundation party of 90 (LU = Low Urban) and an inflow of 18 immigrants, or 4 families,[190] per year, the population rises to 9,000 members by 485 BC. Beginning with 450 colonists (HU = High Urban) and adding 38 people (9 families) each year reaches 20,000. In the hinterland, 1 rural settlement per 10 square kilometres (LR = Low Rural) increasing by 9 people a year (3 settlements every 5 years[191]) provides the lower rural population estimate of 6,000, while with a double density of initial rural settlements (HR = High Rural) and an additional 35 people (2 settlements every year) raises the total to the upper limit of 20,000. This creates scenarios where Syracuse began with a small foundation party up to 450 members cultivating fields close to the island and an indigenous population upwards of 900 already present in the hinterland. The increase to 9,000–20,000 urban and 6,000–20,000 rural because of a successful settlement growing 1.3 per cent a year through attracting an annual influx of at least 4 families moving into Syracuse and an additional rural site from foundation to 485 BC. These models begin with a small residential area on the island of Ortygia and later expansion of the inhabited area to the mainland. The population estimates from the foundation to the end of the Archaic period are presented in

Table 4.5. Based on these figures it is possible to estimate the size of the maximum local workforce available for the construction of the housing and later the Temple of Apollo.

Table 4.5: Population estimates of Syracuse from foundation to the end of the Archaic period

	FOUNDATION C. 733 BC	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
URBAN	90 – 450	1,980 – 4,580	3,560 – 8,030	5,590 – 12,450	6,810 – 15,120	8,200 – 18,130	9,110 – 20,130
RURAL	450 – 900	1,600 – 4,950	2,570 – 8,340	3,800 – 12,680	4,550 – 15,290	5,390 – 18,250	5,950 – 20,220
TOTAL	540 – 1,350	3,580 – 9,530	6,130 – 16,370	9,390 – 25,130	11,360 – 30,410	13,590 – 36,380	15,060 – 40,350

190 Based on an average family size of 4 members. See section 3.8 above.
191 Based on an average rural settlement size of 15 people. See section 3.8 above.

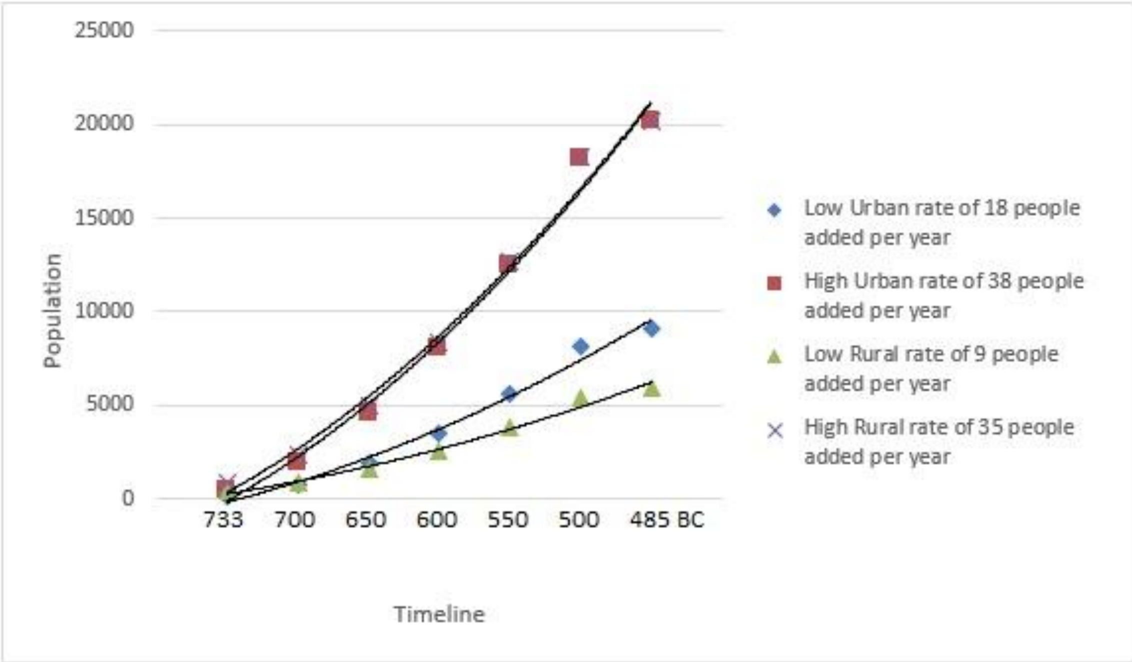

Chart 4.1: Population models of Syracuse from foundation to 485 BC.

Estimating the number of inhabitants of Kamarina proves to be a more daunting task. Above all, the tumultuous history of the site makes it difficult to achieve accurate urban population estimates through evidence after its destruction in 552 BC. The only known Archaic period areas of residential habitation are in the western part of the settlement, near the sea, and a small grouping to the east at the foothills of the Collina di Herakles.[192] Fortifications dating to the mid-sixth century, likely immediately prior to the site's destruction at the hands of the Syracusans, stretch around seven kilometres in total distance and encompass an area of about 150 hectares (Fig. 1.8). It is expected that the extent of the wall was not to enclose the area already built upon, but rather with view towards future expansion. Hansen uses Muggia estimate of 48 per cent inhabited and comes to an estimated population of 10,800–14,400 people.[193] This is taken as the population of the settlement in 552 BC.[194]

At foundation, it is likely that the inhabited land reserved for houses was not much smaller, limited to around 37 hectares.[195] At Hansen's residential density, this estimates a population range of 5,500–7,400 which will be figured as the number of inhabitants in 599 BC.[196] This is much larger than Syracuse at foundation, however a larger colonial size can be accepted if members were gathered from the other settlements, the indigenous populations or

---

[192] Pelagatti et al. 1976, p.124; Martin et al. 1980a, p.514.
[193] Muggia 1997, p.97; Hansen 2006b, p.42, Table 2.1. (150 ha x 48%) x 150 people/hectare ≈ 10,800. (150 ha x 48%) x 200 people/hectare ≈ 14,400.
[194] For comparison, Muggia estimates an urban population of 14,000 for the Timoleon era reconstruction three centuries later.
[195] Martin et al. 1980a, pp.510-4.
[196] 37 ha x 150 people/hectare ≈ 5,500. 37 ha x 200 people/hectare ≈ 7,400.

even Corinth.[197] Further, the necessity to establish a settlement and solidify their possession of the area before the presence of other Greek settlers may have urged Syracuse to place a significant population at the mouth of the river Hypparis.

Equally uncertain in the current study is the population under the influence of Kamarina in its hinterland.[198] This area has been generally defined by the Achates (modern Dirillo) to the north-west, the Herminius (modern Irminio) to the south-east and the highest reaches of the river Heloros (modern Tellaro) near its source in the north-east.[199] Yet, defined by a distance of 15 km, the furthest extent eastward is the modern city of Ragusa. The Achates and Herminius are maintained as logical boundary markers,[200] although influence could have spread for a few kilometres farther. That the ancient Herminius played a role as boundary between Kamarina and Syracuse is more obvious, as a pivotal point leading to the rebellion was the crossing of the Herminius by Kamarina.[201] The outlined *chora* encompasses 650 km², close to previous estimates of 670 km² (Fig. 4.14).[202] Muggia expects this area to be densely populated (4 sites/km²) by the Timoleon period;[203] this is unlikely for the first half of the sixth century BC. With this hinterland size, the rural population estimate will follow Hansen: two-thirds of the overall population figures. At foundation, this is 11,000–14,800, roughly 1–1.5 sites per square kilometre. These density figures will be used as starting points for the rural population.

Fig. 4.14: Kamarina. Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterland attached to Kamarina. De Angelis 2016, p.67, Map 4 with additions.

[197] Pelagatti 1985, p.295; Di Stefano 1993-1994, pp.1373-5.
[198] Cf. Di Stefano 2009.
[199] Muggia 1997, p.97.
[200] See Frisone 2012 on the role of rivers in delimiting boundaries and the emerging identities of the Greek colonies.
[201] Dion. Hal. *Pomp.* 5.4; Domínguez 2006, p.290.
[202] Muggia 1997, p.97; De Angelis 2000a, p.124-6; De Angelis 2000b, p.112-3.
[203] Muggia 1997, pp.97-8; see section 3.8 above.

Modelling the population at Kamarina indicates a much larger immigration of people into the area (Chart 4.2). At the same growth rate, a foundation party of 5,500 (LU) adding 73 people per year, the population rises to 10,800 members by 552 BC. With the high urban estimate (HU) of 7,400 colonists and an influx of 24 families (95 people) per year raises the population to 14,400. On the low end, the rural population begins in 599 BC with 9,800 (LR), increasing by 176 people a year (c. 12 settlements every year) provides an estimate of 21,600. An additional settlement a year (194 people total) raises the high rural estimate (HR) to 28,700. Kamarina was founded with a large population and grew 1.5 per cent annually, almost doubling in size by the time of their destruction. As the urban population doubled, so did the intramural inhabitation area. The rise in total population from 15,300 to 32,400 or 22,000 to 43,100 in half a century indicates a successful settlement. Population estimates are found in Table 4.6 from the date of foundation to the date of its destruction by Syracuse. In the last chapter, implementing rank-size distribution provides an analysis on the demography of Greek Sicily, and the impact Kamarina had within.

Table 4.6: Population estimates of Kamarina from foundation to the 552 BC[204]

	FOUNDATION 599 BC	575 BC	552 BC
URBAN	5,500 – 7,400	8,060 – 10,760	10,810 – 14,370
RURAL	9,750 – 14,630	15,470 – 21,420	21,620 – 28,740
TOTAL	15,250 – 22,030	23,530 – 32,180	32,430 – 43,110

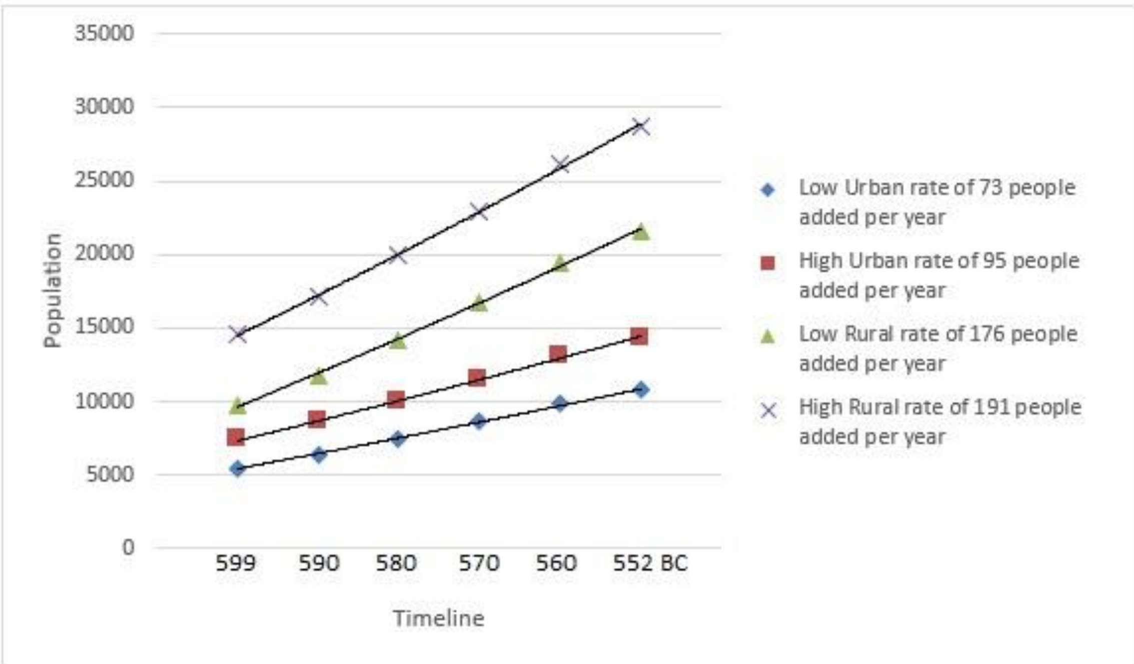

Chart 4.2: Population models of Kamarina from foundation to 552 BC.

[204] It is not implausible that the population of Kamarina in the Archaic period was less than estimated here, however these estimates are supported by the best available evidence and most recent methodologies.

Examination on the available work force for the construction projects outlined here make available initial indications of the effect these had on the local societies. Similar analyses of projects of houses and monumental construction provide comparanda. At Selinous, seven temples were constructed between 550 and 450 BC, with multiple projects ongoing simultaneously at any one time.[205] These temples are estimated to have cost 1,600 talents in total. Selinous was a larger settlement than those founded by Syracuse, up to 10,000 inhabitants, and wealthy benefactors allowed for such an ambitious temple building programme, however some implications can be taken for the present study. Work on temple G lasted around 55 years (525-470), and De Angelis estimates at least 38 men working full-time on this project alone. The smaller temples A and O lasted 30 years (490-460) with at least six full-time labourers for each. De Angelis has calculated the quantity of stone, and associated man-hours, for these temples: at eight hours a day, temple G is estimated to 840,000 man-days, temple A and O to around 77,000 each. Therefore, with a minimal workforce, construction of the temples under consideration here could have taken decades. However, at Syracuse and each of its settlements only one temple was under construction at a time, and so even with a small labour pool less time can be expected, closer to a decade.

In fifth-century Athens, the construction of around 300 shipsheds took half a century and has been estimated by Pakkanen at 1.2 million man-days and 200 talents.[206] This, however, was not such a costly expenditure to Athens when compared to the 500-talent cost to construct the Parthenon and the annual income of 1,000 talents received from the Delian League. During the construction period, the likely annual investment would have not exceeded 4 talents or 100 workmen. In the third quarter of the fourth century BC, 100 new shipsheds would have required 460,000 man-days and a little more than 150 talents. While the income of Athens was much smaller at this time, the projects would have been covered by the annual *eisphora* of 10 talents. The construction of the shipsheds are comparable to monumental projects like city walls and large temples, providing some comparison to those discussed here, but the annual income of Archaic Syracuse cannot be expected to have reached that of Classical Athens.

Fitzjohn's estimates over housing construction in Megara Hyblaia lead to the view that each project took at least a year but more likely much longer.[207] The most simplistic example he discusses is estimated at 115 man-days, and this is only considering the usage of stone. At a minimum of a year to complete, this suggests that a single man had at most a third of his time to devote to work other than the required economic or agricultural duties. A more realistic

[205] De Angelis 2003, pp.166-70.
[206] Pakkanen 2013b, pp.72-3.
[207] Fitzjohn 2013.

expectation would be in the range of 25 to 10 per cent of the year (3 to 1.2 months), especially at the initial stages of settlement foundation.

For comparison, construction of the Baths of Caracalla is firmly dated to a maximum of 6 years (211-216 AD) requiring between 1,900–13,100 workers employed at any one time.[208] This size of a workforce is unfeasible for Syracuse and its settlements, and further the labourers tasked to this project were expected to have been working full-time. The Baths of Caracalla were more complex than the Archaic period temples discussed here: the precinct of the baths is estimated to over 1 million man-days alone. However, this example illustrates the control the various steps in the construction project had over the length of time to completion. For example, the foundations took eight months to complete before the construction of the substructures could begin. This took the majority of the year, and the next step of the project (substructures) did not commence until after the winter season, four months later. In this manner, the temple construction in south-east Sicily could have followed a similar strategy where a portion of the structure was built (e.g. the foundations), and work on the next level did not begin until the following year.

Therefore, the construction projects discussed below are expected to have taken a year to a few years at least for the houses and up to a decade or more for the temples. Timelines for the fortifications were likely more along that of the temples, although Kamarina is an exception. The expectation of the workforce is at 220 days a year for full-time labourers, as discussed in Chapter 3, to only a few months a year for each labourer. These base standards will then be implemented in the analysis of the construction projects in this and the following chapters.

At the time of foundation, an initial group of 90–450 people at Syracuse would have demanded 23–113 houses.[209] In the previous chapter, it has been argued that 22.5 per cent of a population can be reasonably expected to participate in physical labour: 20–100 men. At this time, the responsibilities of establishing a settlement would have likely required the workforce to be divided amongst various tasks. Therefore, at 27–76 md to build an all-stone house, and if these men were only available for 1.2 months (36 days) a year (able to work 720–3,600 md in that time),[210] it would take 1–3 years to build a house for every family in the settlement.[211] This would include housing for the annual immigration of 4–9 families as expected through the population modelling and utilise a crew of 3–16 men constructing houses at any one time. If

[208] DeLaine 1997, p.182.

[209] This is based on families of 4 members, ignoring here the possibility that slaves joined their owners to found settlements. For the size of the group, see section 3.8 above.

[210] At an average of 30 days a month: 36 days x 20 men ≈ 720 md/year; 36 days x 100 men ≈ 3,600 md/year.

[211] Low estimate: (23 houses x 27.07 md) / 720 md/year ≈ 0.86 years; (((0.86 years x 4 families/year) + 23 houses) x 27.07 md) / 720 md/year ≈ 0.99 years. High estimate: (113 houses x 76.45 md) / 3,600 md/year ≈ 2.40 years; (((2.40 years x 9 families/year) + 113 houses) x 76.45 md) / 3,600 md/year ≈ 2.86 years.

each labourer was available for 3 months (90 days) a year (1,800–9,000 md),[212] the timeline decreases to a few months to a year with 10–50 men.[213]

At 19–42 md per house and 36 days a year, building houses largely using mudbrick would slightly shorten the timelines to around 1–2 years, including new families moving in.[214] If the entire workforce was available for 90 days, every family would have had permanent shelter in half a year.[215] These timelines use the same number of labourers as above; however, employing the entire foundation population, building the lower-cost houses and working 90 days, the task could have been completed during the summer.

The workforce would not have worked on each house individually; instead the labour force would have been pooled together for certain aspects of resource gathering, transport and construction. For instance, levelling the foundation of the houses has been estimated at less than a fifth of a man-day, so the start of the projects for simple houses was straight-forward. Transport costs for the roof and doors could be combined into fewer ox-carriage loads requiring less labour than if transported separately. Each door has been estimated at 0.04 md to transport the wood. Then, as an example, the timber for the doors can be moved to the construction site by a single man and a pair of oxen in less than a day. Therefore, it is likely that every family had a house built entirely of stone within a year and quite certainly if mudbrick was used. At foundation, building houses before the winter would have been a priority, so an initial period of concentrated house construction would have been highly likely. Once the founding population was housed in permanent shelter, a small crew of 10–14 men could provide new families the same shelter during the summer months.

The Temple of Apollo can be dated to the first half of the sixth century. The above calculated population estimate range for 600 BC is 6,100–16,300 and for 550 BC 9,400–25,100. The 88,900–109,900 md and 149,000 od estimated to complete the temple amounts to a major overtaking. Further, the oxen and rural labour workforce would have only been available for three months out of the year, July through September.[216] Outside of this time, the labourers would have consisted only of members of the urban centre and specifically employed

---

[212] 90 days x 20 men ≈ 1,800 man-days/year; 90 days x 100 men ≈ 9,000 man-days/year

[213] Low estimate: (23 houses x 27.07 md) / 1,800 md/year ≈ 0.35 years; (((0.35 years x 4 families/year) + 23 houses) x 27.07 md) / 1,800 md/year ≈ 0.37 years. High estimate: (113 houses x 76.45 md) / 9,000 md/year ≈ 0.96 years; (((0.96 years x 9 families/year) + 113 houses) x 76.45 md) / 9,000 md/year ≈ 1.03 years.

[214] Low estimate: (23 houses x 19.48 md) / 720 md/year ≈ 0.62 years; (((0.62 years x 4 families/year) + 23 houses) x 19.48 md) / 720 md/year ≈ 0.69 years. High estimate: (113 houses x 41.74 md) / 3,600 md/year ≈ 1.31 years; (((1.31 years x 9 families/year) + 113 houses) x 41.74 md) / 3,600 md/year ≈ 1.45 years.

[215] Low estimate: (23 houses x 19.48 md) / 1,800 md/year ≈ 0.25 years; (((0.25 year x 4 families/year) + 23 houses) x 19.48 md) / 1,800 md/year ≈ 0.26 years. High estimate: (113 houses x 41.74 md) / 9,000 md/year ≈ 0.52 years; (((0.52 years x 9 families/year) + 113 houses) x 41.74 md) / 9,000 md/year ≈ 0.55 years.

[216] Isager & Skydsgaard 1992, p.104; Salmon 2001, p.200. See section 3.8 above.

craftsmen. In 600 BC, the workforce would have consisted of 800–1,810 urban and 580–1,880 rural workmen potentially contributing 49,700–332,100 md per year.[217] At these rates, construction of the Temple of Apollo would have taken a few months to 2 years to complete, utilizing around 460 labourers during the summer months, dropping to 130 labourers the rest of the year, each working 36 days a year.[218] However, this timeline would require thousands of teams of oxen each year during the agricultural offseason (assuming each ox worked the same number of days as its owner) to transport all the required materials to the temple site.[219] This is unfeasible. Based on the rural population of 580–1,880, the number of rural settlements in the Syracusan hinterland can be estimated as 39–125.[220] If completed closer to 550 BC, the labour pool would have grown to 1,260–2,800 urban and 860–2,850 rural labourers able to work 76,300–508,500 md per year.[221] With this larger workforce the temple could have been finished within 18 months, requiring 550 labourers during the summer and 210 men during the rest of the construction season, working 36 days a year each.[222]

These timelines are unrealistic. Instead, if construction took closer to half a century, as temple G at Selinous, and the workforce worked full-time, 8–10 men and 33 oxen teams could complete construction of the temple in 50 years; a reasonable number in comparison to the 38 men estimated by De Angelis to have completed temple G in 55 years.

In the mid-sixth century, when the Archaic fortifications at Kamarina are dated, the urban population there has been estimated as 10,800–14,400 and 21,600–28,700 in the hinterland. At an estimated 112,900–293,100 md to build the fortifications, it becomes clear that Kamarina needed a large enough workforce with which to accomplish such a feat, presumably with the participation of the indigenous population within their *chora*. With a workforce of 2,430–3,240 urban and 4,860–6,460 rural labourers potentially contributing 262,400–873,000 md per year,[223] the entire fortifications could have been completed in a couple months to a year.[224] In fact, the project could have been completed by a rural workforce of 1,700–3,800 during the summer months. This is quite reasonable, especially given that the

---

[217] 49,680 md/year at 1,380 labourers working 36 days/year; 332,100 md/year at 3,690 labourers working 90 days/year.
[218] 88,929 md / 332,100 md/year ≈ 0.27 years. 109,875 md / 49,680 md/year ≈ 2.21 years.
[219] 148,524 od / 2.21 years / 36 days/year ≈ 1,867 ox-carriages; 148,524 od / 0.27 years / 36 days/year ≈ 15,280 ox-carriages.
[220] At an estimated 15 people per farm, see section 3.8 above.
[221] 76,320 md/year at 2,120 labourers working 36 days/year; 508,500 md/year at 5,650 labourers working 90 days/year.
[222] 88,929 md / 505,800 md/year ≈ 0.18 years. 109,875 md / 76,320 md/year ≈ 1.44 years.
[223] 262,440 md/year at 7,290 labourers working 36 days/year; 873,000 md/year at 9,700 labourers working 90 days/year.
[224] 112,863 md / 873,000 md/year ≈ 0.13 years. 293,084 md / 262,440 md/year ≈ 1.12 years.

workmanship was of low quality.[225] The real hindrance to overcome would have been the transport cost of 14,700 od; however, if completed from July to September, only 160 ox-carriages would have been needed,[226] a realistic possibility in an area of up to an estimated 1,900 farmsteads.[227] But if material was used from the immediate vicinity, perhaps being carried to the site manually, that number could also be reduced. Credibly, the project could have been completed in only a few weeks.

For comparison, Dionysios I's construction of the Epipolae fortifications on the northern flank of Syracuse at the end of the fifth century involved 60,000 people and 6,000 pairs of oxen, and the task was completed in only 20 days.[228] This wall was shorter, six kilometres long, but 'of corresponding height' to Syracusan walls. It required a major undertaking by Dionysios I to rally the great number of workers to accomplish the task, but financial motivation brought great enthusiasm to the labourers, with some even working into the night. Obviously, comparisons between the two building projects cannot be direct, except in the speed at which large-scale construction can be accomplished giving the right motivation. At Kamarina, the desire to demonstrate its independence, command of resources and power, let alone any pressing needs for security, could have been enough to realise such an outcome. Assuming all these factors, achieving such a spectacular accomplishment as building a wall four metres high and seven kilometres long in only a few weeks could easily inspire a city-state. Even if the labour pool was significantly smaller and the process took the better part of a year, no more proof would have been needed that Kamarina could survive and flourish without the watchful eye of Syracuse. Unfortunately, the confidence of the settlement may have verged on arrogance, and the events following their crossing of the Herminius serves as testimony. This is discussed further in the last chapter.

In the next three chapters, application of the methodologies outlined in Chapter 2 will be repeated for Heloros, Akrai and Kasmenai. These are addressed in chronological order by foundation date. This presents an evolution of the Syracusan settlements over time, as well as demonstrating the different aspects in relation to each other. In the last chapter, the results from this and the following chapters will be brought together for a more thorough discussion of the settlements and their place within the entire Syracusan settlement system.

[225] The feasibility of such a project is demonstrated by the construction of the Athenian city wall after the Second Persian war in 479 BC, Thuc. 1.93.1-2; Camp 2001, pp.59-60.
[226] 14,680 od / 90 days ≈ 163 ox-carriages.
[227] Based on an average rural settlement size of 15 people. See section 3.8 above.
[228] Diod. Sic. 14.18.2-8; De Angelis 2016, pp.124-5.

Chapter 5: Heloros

Heloros, the first of the Syracusan settlements, likely laid the ground work for the latter's expansion in the following century. Situated almost half a kilometre north of the mouth of the river Heloros (modern Tellaro), the urban centre sits on a low hill, about 20 metres above sea level, on the coast of the Ionian Sea (Fig. 1.5). Strategically, a settlement here guards the end of the Heloros river valley which leads into the Hyblaian mountains. It also marks the southern stretch of the Helorine road thirty kilometres from Syracuse.[1] With a circumference of c. 1,420 m,[2] the settlement atop the hill could have stretched up to 9 ha in size.[3] Archaeological evidence indicates a foundation around 700 BC constituting at least single, one-roomed housing in the urban centre. Later, in the sixth century, were built a simple, two-roomed Koreion to the north and the fortifications around the urban perimeter. This latter construction project easily comprised the largest undertaking of the three mentioned.

The extent of archaeological knowledge with regard to the houses, Koreion and Archaic wall can be found in the catalogue below (Appendix 1: H, sections D, E and F). This is presented, followed by the econometric calculations, and then a population estimate. Population figures allow for the calculations to be further analysed through expected labour workforce sizes. The methodologies used here have been outlined in Chapter 3 and followed in the previous chapter.

5.1 Heloros: The Archaic Wall

Heloros's Archaic wall has been estimated to a length of c. 1,420 m.[4] Dating of the Archaic walls to the third quarter of the sixth century has been fixed by ceramic remains of Protocorinthian and Corinthian Siciliote vases found under the foundations, while within the wall were uncovered portions of Proto-Attican vases painted brown with reddish streaks.[5] Much of the wall surrounding the hilltop[6] was reused or replaced in the fourth century during the Timoleon reconstruction at the site; however an intact section in the northwest was brought to light by Elio Militello in his 1958-59 excavations (Fig. 5.1; Fig. 5.2; Fig. 5.3: HF).[7] From this a few key aspects of its construction were ascertained: the wall was built with grey limestone ashlar blocks in a pseudo-isodomic technique comprising a double-curtain filled with rubble (Fig. 5.10),

[1] Distance confirmed using Google Maps Distance Calculator Daft Logic 2014a.
[2] Orsi 1966b, p.215.
[3] Hansen 2006b, pp.106-7, Frederiksen 2011, p.147.
[4] Orsi 1966b, p.215.
[5] Militello 1966, pp.313-4.
[6] The natural landscape of Heloros has also been referred to as a plateau, Frederiksen 2011, p.147. However, while the modern channel cut into the hillside south of the site (through the later theatre) and the coastal degradation can paint such a picture, a site visit gives a clearer understanding of how the natural hill formation most likely looked in the Archaic period. Site visit 7th, October 2012.
[7] Militello 1966, pp.310-4.

the thickness of which was 2.80 m.[8] Three courses of the external face were found in the excavations, each averaging a height of 30 centimetres. With the location of the urban centre on the coast near a prominent river, layers of sedimentation would have naturally built up over time. In 1899, Orsi noted at a section of the wall, of a later date, was dug to the natural bedrock below, which was then quarried and reused for the foundation directly on top of where it was found.[9] This was likely a common occurrence of the Archaic fortification process throughout the site, although the majority of the limestone is expected to have been taken from nearby quarries to the north and south of Heloros.

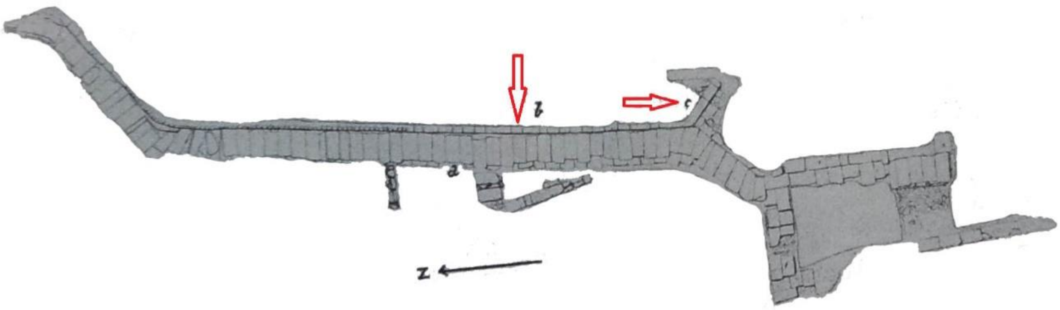

Fig. 5.1: Heloros. North-west stretch of Timoleon fortifications incorporating Archaic period wall (HF) (b, Fig. 5.2) with parapet of Archaic doorway (c, Fig. 5.3). Militello 1966, pp.311-2.

As stated in the previous chapter, Kamarina also built a wall in the second half of the sixth century which consisted of a double curtain wall (Fig. 4.12). There, mudbrick remains have been found suggesting the wall supported a superstructure of the material (Fig. 4.6).[10] Given the similarities in construction technique and wall thickness, it is equally likely that the fortifications at Heloros also included mudbrick atop a stone foundation.[11]

Another point that needs mentioning is the expected length of the Archaic wall. Did it run the entirety of the c. 1,420 m. put forward by Orsi? The only logical reason for building an open-ended length of wall is if a natural barrier negates any need for further fortification, and while there are arguments for purpose-built open wall circuits in the Greek world, this was uncommon if not unlikely.[12] At Heloros, the sea would seem to provide such a natural barrier against land attacks. However, based on a site visit it is apparent that the sea level was not far enough below the settlement to make it impossible for any would be trespasser.[13] It is for this reason that today a modern fence prevents entry from the sea into the archaeological park. Therefore, it can be confidently presumed that a complete wall circuit was most likely necessary

[8] Cf. Frederiksen 2011, p.147.
[9] Orsi 1966b, p.222.
[10] Frederiksen 2011, p.154.
[11] Cf. Frederiksen 2011, pp.86-7.
[12] Frederiksen 2011, pp.53-4.
[13] Further, evidence suggests the sea level of the Mediterranean was higher, Schmiedt 1972, p.311; Rizzo 2003, pp.591-7. Site visit 7th, October 2012.

and in place around Heloros in the Archaic period. Most recent distance calculating places the perimeter about 100 metres short of Orsi's projections. Yet, Orsi's figure is likely to be more trusted given that it was ascertained through fieldwork by hand, and so it will be used here.

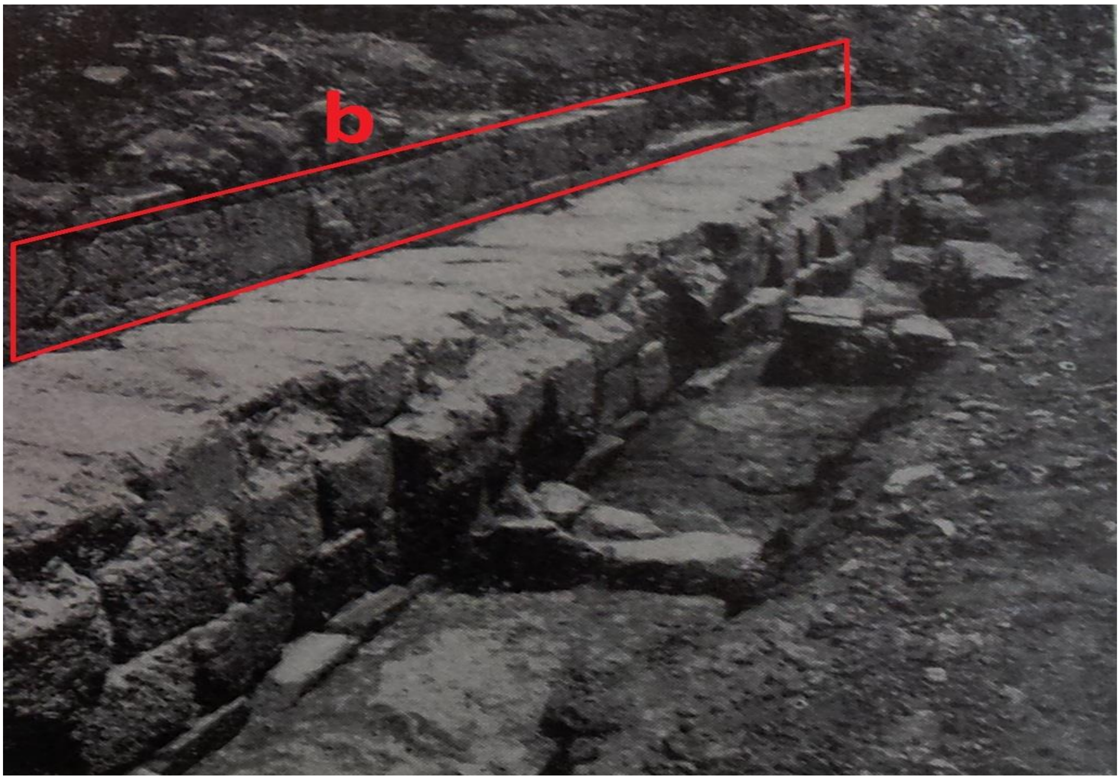

Fig. 5.2: Heloros. Archaic period wall (HF: b), outlined, reused behind later Timoleon reconstruction. Militello 1966, p.314.

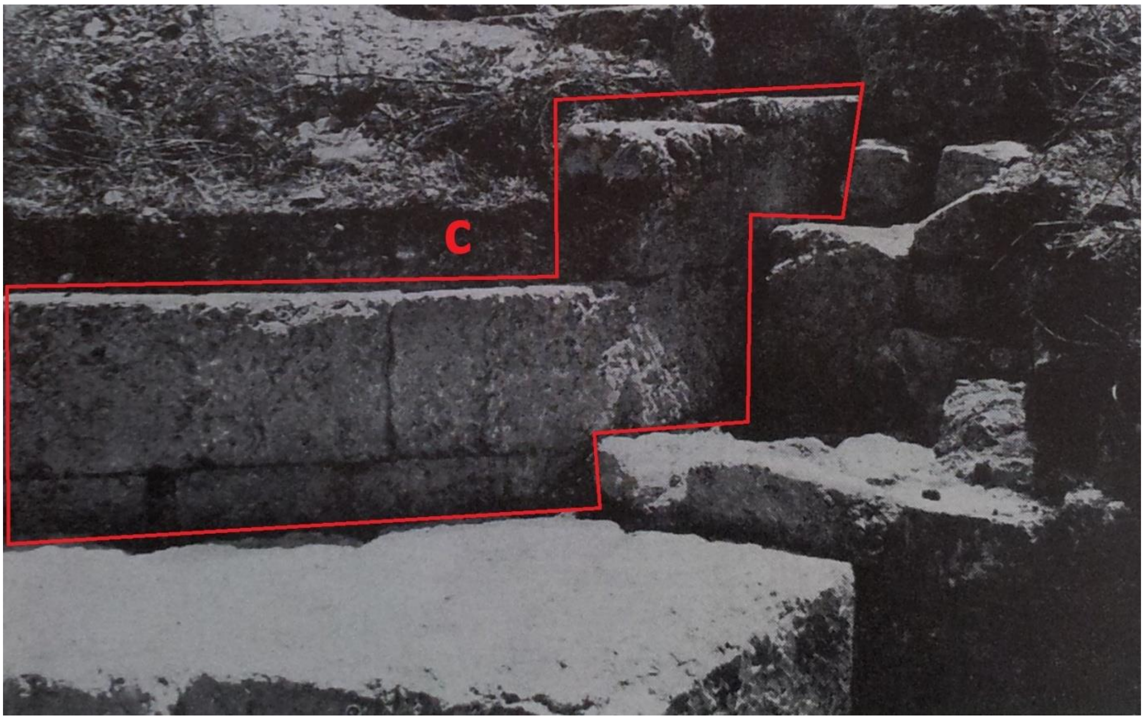

Fig. 5.3: Heloros. Archaic period parapet of western doorway (HF: c), outlined, later closed and reused in Timoleon reconstruction. Militello 1966, pp.311-2.

5.2 Heloros: Archaic Housing

Evidence of the Archaic residential structure at Heloros is, unfortunately, quite scarce.[14] The oldest examples from the time of foundation are small, quadrilinear rooms, measuring 3 to 4 metres a side and built using limestone orthostats as the lowest course of the walls (Fig. 5.5; Fig. 5.6), most likely locally sourced.[15] Any hint of urban planning at Heloros begins with a block defined by the Helorine road and its almost perpendicular axis (Fig. 5.4).[16] This block is around 25 metres wide by 100 metres long, but, as with the Helorine road, these bounds seem to be defined by the natural topography and the easiest passages across it. Short sections of road have also been uncovered which run in a NW-SE direction, but these roads and that previously mentioned cannot be dated earlier than the Hellenistic period.[17] Early houses have been uncovered elsewhere at Heloros, but have been destroyed by later occupation and are only mentioned in passing.[18] Beyond that, the characteristics of Archaic domestic architecture in the urban centre remain unknown.

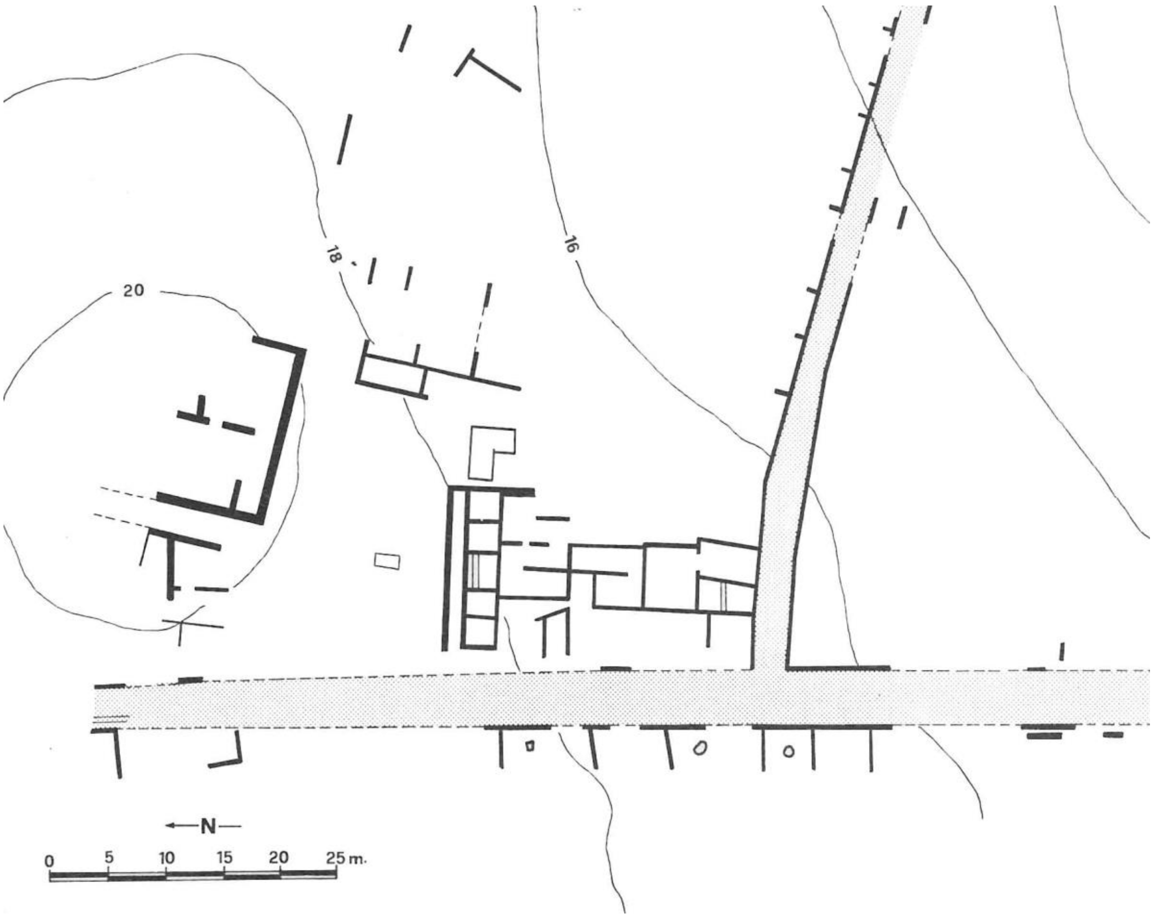

Fig. 5.4: Heloros. Residential centre (HH) east of Helorine road. Martin et al. 1980a, p.550.

[14] Martin et al. 1980a, p.551; Voza 1980-1981, pp.685-6.
[15] Quarrying is still evident today in nearby limestone outcroppings to the north and south of Heloros. Cf. Militello 1966, pp.334-5; Martin et al. 1980a, pp.545, 549.
[16] Voza 1973b, p.118.
[17] Martin et al. 1980a, pp.550-1.
[18] Currò 1966a, p.98; Voza 1972-1973, p.189; Voza 1980-1981, p.688; Voza & Lanza 1994, p.463.

In the previous chapter, comparisons were made between contemporary examples found at Syracuse and Megara Hyblaia.[19] These measured 3.50 m a side to 4.50 m a side, respectively, dimensions close to that found at Heloros. Also evident at Megara Hyblaia and Syracuse is the lack of mudbrick found associated with the residential structures, which indicates that the entire building was likely constructed in stone.[20] The current dearth of Archaic residential archaeology at Heloros prohibits further any definitive reconstruction, and as such the comparisons with Syracuse and Megara Hyblaia compensate for any lacking information. The local limestone outcroppings north and south of Heloros were obviously quarried at some stage, and can be considered the source for the early occupation houses there, although the extraction of stone from the Hyblaian Mountains, as was practiced at Megara Hyblaia,[21] cannot be ruled out. With regard to roofing styles at Heloros, the implications there are simple: there have been no mention of tiles found during excavation of a domestic building, and indeed were not common. Like at Megara Hyblaia and Syracuse, here the roofs will be considered flat, supported by wooden beams, to carry rain water away.

Fig. 5.5: Heloros. Orthostat wall foundations of Archaic house (HH) dated to foundation. Uncovered below later Sanctuary of Demeter, south sector of urban centre. Voza 1980-1981, Tab. 129.

[19] Martin et al. 1980a, p.551, Tab. 65-7; Voza 1980-1981, pp.685-6. See De Angelis 2016, pp.85-8 for an overview of foundation era and Archaic period house structures.
[20] Megara Hyblaia: Gras et al. 2004, p.459. Syracuse: Pelagatti 1982a, p.128. See section 4.2 above.
[21] Gras et al. 2004, p.459.

Fig. 5.6: Heloros. Orthostat wall foundations of Archaic house (HH) dated to foundation. Uncovered below later Sanctuary of Demeter, south sector of urban centre. Voza 1980-1981, Tab. 129.

5.3 Heloros: Koreion

Usually the most studied aspects of an archaeological site are the buildings constructed of grander design and with stronger, longer-lasting materials. Not only because these elements of a past society often gather the most interest, academically and archaeologically, but for the simple reason that they are frequently still visible in the untouched landscape. This is the case at Heloros as well; unfortunately, this evidence is largely from the later Classical and Hellenistic periods and therefore very little is understood of the Archaic period Koreion. Nevertheless, the presence of a Koreion (Fig. 5.7), with its connection to Demeter and Kore, in the Archaic period indicates that from the beginning the agricultural importance of the area, and indeed Sicily, was obvious to the Greeks.[22]

[22] De Angelis 2006, p.33.

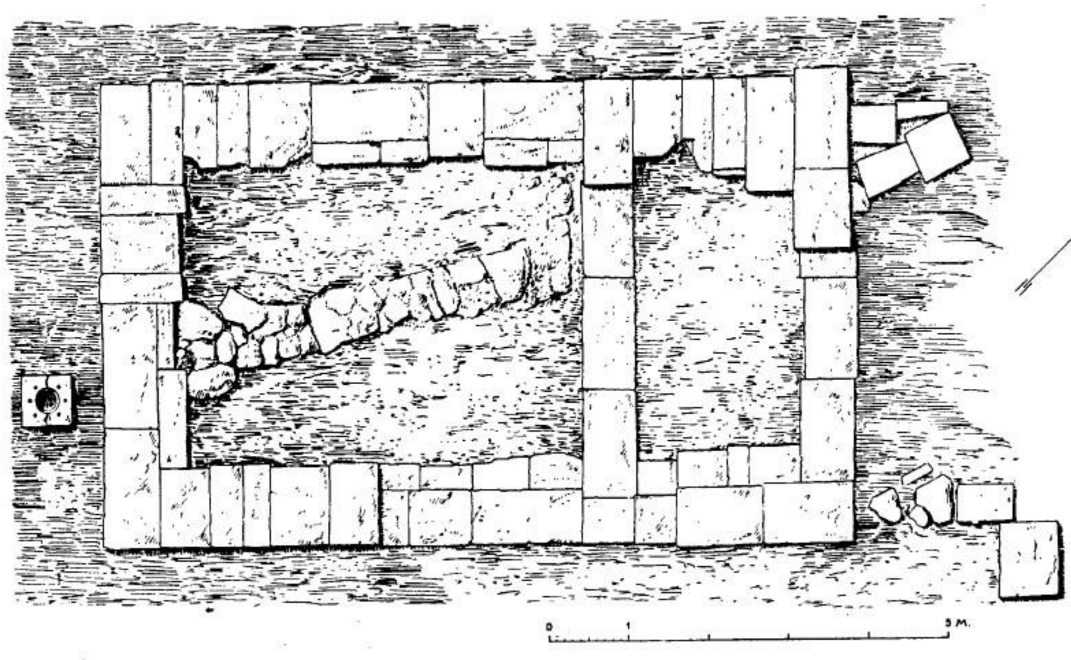

Fig. 5.7: Heloros. Koreion. Currò 1966b, pp. 289-90, Fig. 43.

Outside of the fortifications to the north (Fig. 1.5; Fig. 5.8: HK) the Archaic phase of the Koreion is believed to be a sacellum consisting of two rooms, the walls of which were uncovered and today stand at a height of 2.20 metres.[23] Its identification as a Koreion is considered definitive through the *ex*-voto found still in situ.[24] A related quadrangular building has also been associated with the same period, but that remains all that is known of it, no further information is given and so cannot be factored into the calculations. The Koreion at Heloros was in use between the sixth and fourth centuries, so a construction date in the early sixth century is reasonably expected. As well, written information of the temple does not include any mention of columns or even a peristasis surrounding the building. Structurally, the Archaic Koreion resembles most closely the sixth-century Temple of Athena at Zagora on Andros (Fig. 5.9).[25] There, the temple measures approximately 10.42 m by 7.56 m, with two rooms: the pronaos and cella. The walls are about 0.65 m thick, meaning the interior space stretches over 6 m in width. The external and cella doorways differ at 1.26 m and 1.40 m wide respectively. No evidence is available to suggest a specific roofing structure, which is expected to have been flat. The construction style implemented at the Temple of Athena is the same as that used on the houses at Zagora. In this comparison is established the foundations, including wall and doorway widths and style, and the height of the temple (3 m). Furthermore, the area in which the Temple of Athena was built has provided evidence of cult origins beginning in the

[23] Currò 1966a, p.98.
[24] Martin et al. 1980a, p.547.
[25] Cambitoglou 1971, pp.20-1, 32; Cambitoglou 1988, pp.165-78.

last quarter of the eighth-century, a situation that may be mirrored at Heloros.[26] Acceptable estimations will be made below using the comparisons drawn from the temple at Zagora to overcome the limitations made by the scarcity of Archaic period archaeological material.

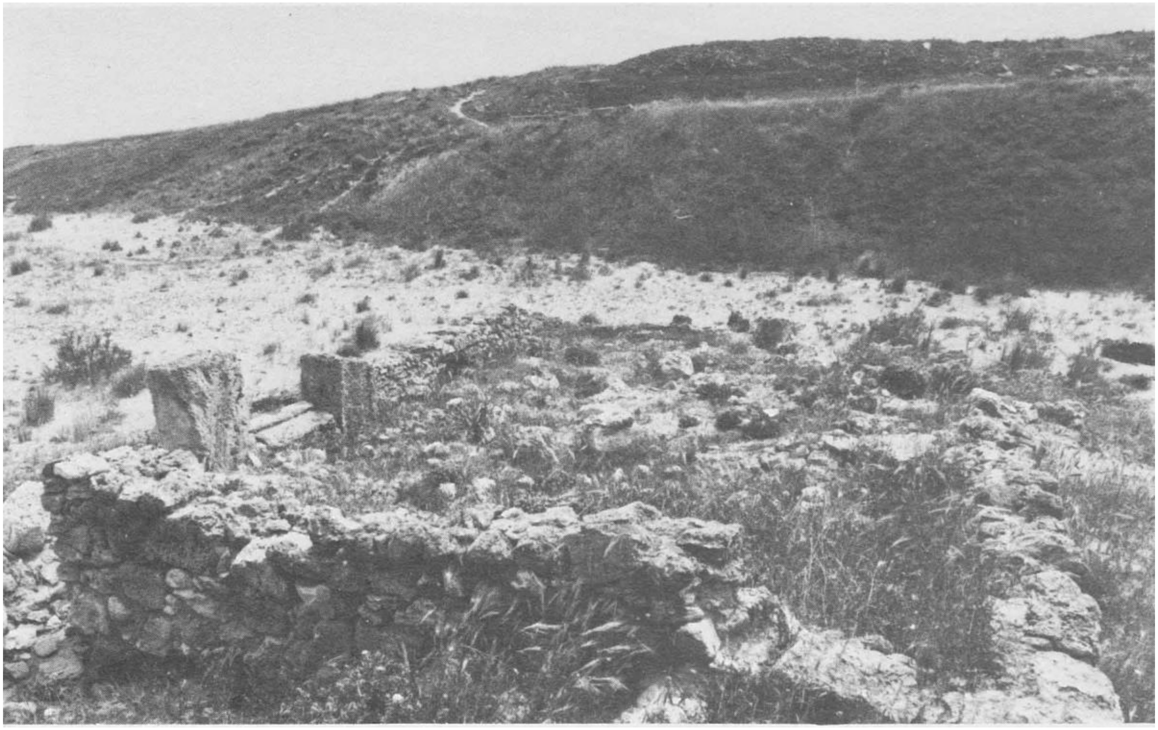

Fig. 5.8: Heloros. View of Koreion (HK) from north. Martin et al. 1980a, p.548, Fig. 88.

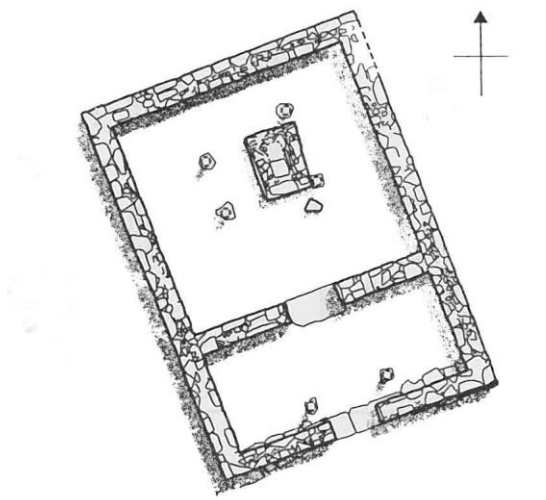

Fig. 5.9: Zagora (Andros). Temple of Athena. Mazarakis Ainian 1997, Fig. 309.

5.4 Architectural Energetics and Econometric Calculations

Using the information given of the archaeological remains from the Archaic period, now will be reconstructed to the best estimates the construction of the mid-sixth century fortification, an eighth-century residence, both in stone and mudbrick, and the first phase of the Koreion which

[26] Mazarakis Ainian 1997, pp.174-5.

is found outside the urban centre, to the north. As stated before, much of the following is presumed from comparisons with other, closely-related Greek city-states, but, most importantly, the calculations used will be the lowest estimates. This is to examine the minimal amount of work needed, while it is expected that the actual amount of resources and man-power employed at Heloros in the Archaic period was greater. The methodology applied here has been detailed in an earlier chapter, including the rates of work in man-days per cubic metre which will be implemented. Local limestone was easily available from nearby quarries, in fact traces of ancient quarrying can still be found in small outcroppings located within 0.5 km either side of Heloros.[27] In transport, the oxen would have to navigate on average an incline of about 10 per cent, increasing the cost by 17.4 per cent. Labour costs are calculated in the accompanying footnotes, seen in the text as rounded figures, while the total numbers are found in the supplementary tables. Costs are calculated in groupings but itemized in greater detail in the tables.

5.5 Heloros: Fortifications

With regard to the late Archaic wall at Heloros, contradictory information is given about the foundation levels in so much that Militello states the external wall is deeper than the internal curtain, which is usually the case, while Frederiksen claims the opposite.[28] Although the primary archaeological report is the accepted source, for the sake of the calculations here the wall curtains will be considered of equal height. This is not due to the uncertainty caused by the two sources, but the actual difference in depth between the two curtains is unknown; furthermore, it cannot be proven that any inequality in the wall foundation was consistent throughout the entire circuit surrounding Heloros.

Although the inherent susceptibility of mudbrick to the effects of time forever lends doubt to exact wall dimensions, it is not expected that the Archaic wall reached a great height.[29] At Heloros only the socle remains, for the most obvious reasons, but also because of the fourth century reconstruction. Again, then, this cannot be fully accounted for in the calculations here.

Archaeological remains of the Archaic wall at Heloros consist of a double-curtain (Fig. 5.10), on average 2.80 metres thick and stretching c. 1,420 metres in total length. It is expected that Heloros built their wall with a mudbrick superstructure on top of the stone socle (Fig. 4.6), as was common practice in the Archaic period throughout the Greek Mediterranean.[30] This stone socle, furthermore, would have needed to have been of a considerable height, not merely

[27] Site visit 7th, October 2012. Cf. Militello 1966, pp.334-5; Martin et al. 1980a, pp.545, 549.
[28] Militello 1966, p.312; Frederiksen 2011, p.147.
[29] Orsi 1966b, p.223.
[30] Frederiksen 2011, p.82.

the 0.9 m that remains visible today. Like at Kamarina, the presumption here is that the stone socle at Heloros was at minimum 2 m in height with a further 2 m mudbrick superstructure placed on top.

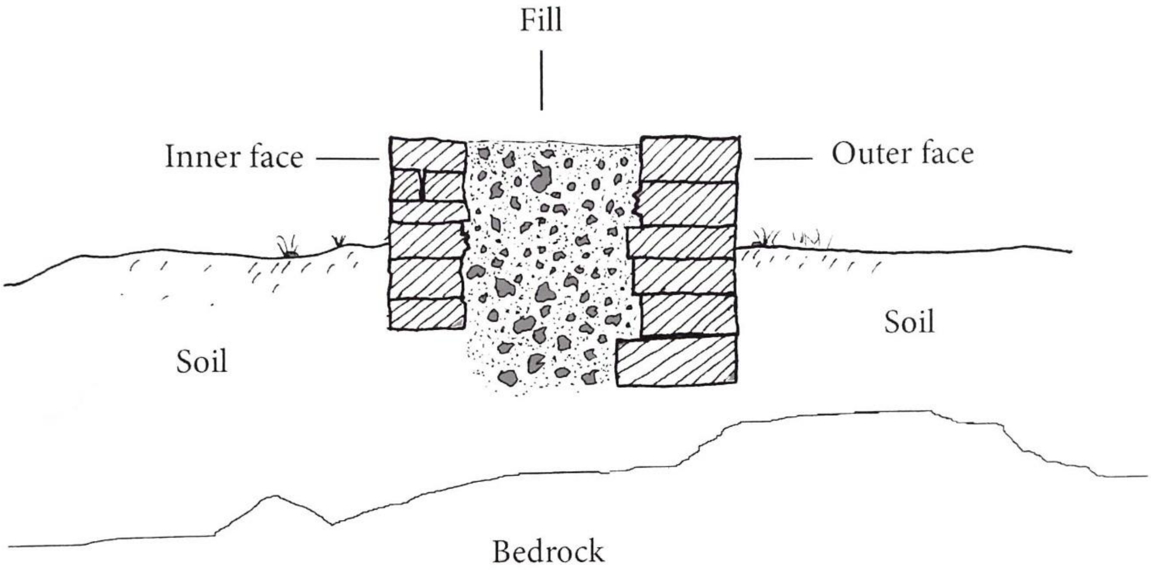

Fig. 5.10: Diagram of double-curtain fortification construction. Frederiksen 2011, p.51, Fig. 3.

Before construction, the line of fortification around the urban centre would have to be cleared and levelled down to the natural limestone bedrock. In 1899, Orsi reached a depth up to two metres in places to the foundation levels of the fortifications.[31] Given that his excavations were also around the later Timolean wall, and it cannot be known for certain the virgin topography of Heloros in the sixth-century, a reasonable expectation is that at least 1 m of soil and bedrock would have been removed in preparations for construction. This process can be figured at 0.14 md/m³ requiring 560 md before any building of the fortifications could commence.[32]

Currently, the average width of the limestone blocks at Heloros is unknown. At Megara Hyblaia, the late Archaic north wall was built with blocks averaging 0.68 m wide. Expecting that the inside and outside limestone blocks were more or less equal in size, the ratio of 2:1 limestone to rubble will be used, as at Kamarina. Then, a 2-m tall socle, 2.8 m wide, spanning the length of 1,420 m is equal to 7,950 m³,[33] two thirds of which is roughly 5,330 m³, representing the amount of limestone needed for a stone socle of that size. Using 2.0 md/m³ for quarrying and 4.0 md/m³ for construction, and adding 5,200 md to transport the materials to the site, the wall curtains would initially necessitate around 32,900 md.[34] Transporting the

[31] Orsi 1966b, p.222.
[32] (1 m x 2.8 m x 1,420 m) x 0.14 md/m³ ≈ 556.64 md.
[33] 2.8 m x 2 m x 1,420 m = 7,952 m³.
[34] Quarrying: 7,952 m³ x 67% x 2 md/m³ ≈ 10,656 md; construction: 7,952 m³ x 67% x 4 md/m³ ≈ 21,311 md. 10,656 md + 21,311 md = 31,967 md.

limestone from the quarries would require a total of 2,300 od.[35] Levelling the foundations prior to this resulted in the removal of 3,976 m³ of earth and rubble, while 2,624 m³ is required for the inner fill between the walls.[36] Back-filling the rubble increases the labour cost by 180 md.[37] However, the 1,352 m³ of excess rubble needs taken away from the site. This process involves the rubble being loaded and carried by hand to the ox-carriage, loaded upon the carriage, transported, and then unloaded and possibly carried further. Expecting a transport distance of at least 250 m, the disposal process adds 520 md and 290 od.[38]

The mudbrick superstructure, also 2 metres in height, would equally be 7,950 m³. Transporting the materials to workshops near the wall would require 2,300 od.[39] Including 0.25 md/m³ to manufacture the bricks and 0.4 md/m³ for construction, the mudbrick superstructure would entail an additional 5,200 md.[40] Allotting for supervision, total construction time for the wall at Heloros 4 m high would entail 42,300 man-days and 4,800 ox-carriage days (Table 5.1). An analysis, including suggested timelines of project duration, is considered at the end of this chapter.

Table 5.1: Total labour costs for the construction of fortifications at Heloros

RESOURCE	***ACTION IN MD***		
	Acquisition	**Transport**	**Construction**
STONE:	10,656	2,259 od	21,311
MUDBRICK:	1,988	2,269 od	3,181
LOOSEFILL:	*Gathered during levelling*		184
INITIAL LEVELLING OF SITE:			557
DISPOSAL OF RUBBLE:		552 + 287 od	
TOTALS:	12,644	552	25,233
SUPERVISION: (+ 10%)	1,264	55	2,523
BASE TOTAL:		42,271 + 4,815 od	
RANGE OF TOTALS:		42,271–64,027	

[35] 7,952 m³ x 67% x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 13,392 carriage-loads. (15,392 carriage-loads / 8 trips per day) + 17.4% ≈ 2,259 od.
[36] 1 m x 2.8 m x 1,420 m = 3,976 m³; 7,952 m³ x 33% ≈ 2,624 m³.
[37] 7,952 m³ x 33% x 0.07 md/m³ ≈ 184 md.
[38] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 1,352 m³ x 0.386 md/m³ ≈ 522 md; 1,352 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 3, 906 carriage-loads. A team of oxen could make 16 trips of 250 m each way in a day. (3,906 carriage-loads / 16 trips per day) + 17.4% ≈ 287 od.
[39] Oxen: 7,952 m³ x 1.75 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 15,462 carriage-loads. (15,462 carriage-loads / 8 trips per day) + 17.4% ≈ 2,269 od. The river Heloros is also about 0.5 km from the urban centre.
[40] Manufacture: 7,952 m³ x 0.25 md/m³ ≈ 1,988 md. Construction: 7,952 m³ x 0.4 md/m³ ≈ 3,181 md. 1,988 md + 3,181 md ≈ 5,169 md.

5.6 Heloros: Houses

From the dearth of residential evidence known from the archaeological record at Heloros, one can only definitively say that the first houses were 3 m to 4 m in length on each side, quadrangular in shape and with limestone orthostats at the bottom of the walls. The lower length will be used here creating a house 3 m by 3 m. Greek houses of this period were predominately constructed of a stone socle with mudbrick above.[41] However at Syracuse and Megara Hyblaia, the two sites of closest comparison, mudbrick remains are unattested. For this reason, here will be considered two alternative construction styles at Heloros: an all-stone residence and one built of mudbrick with stone foundations.

Before construction, Heloros's location on a hill next to the coast would require the site to be levelled. Excavations on the fortifications dug up to 2 m to reach the bottom of the foundations, although a reasonable assumption can be made that at the top of the hill it would have been no more than a depth of 0.25 m. This would require the removal of 1.13 m³ of material adding 0.16 md to the process.[42] Included in these calculations is a gap of 1 m for a doorway that is not taken away. This is discussed further below. The material then needs removed from the construction site which involves additional labour costs. While its reuse cannot be determined for certain, the distance to which it was taken will be measured to the end of the plateau, about 200 m from the centre of the settlement. This process adds 1 md and 1 od.[43]

The orthostat building type is found at Megara Hyblaia in the same time period, and there the width of the walls was often 0.70 m. Yet, some houses were built with only 0.45 m to 0.55 m widths. These figures are near the average for Iron Age wall widths in Greece, however the wall thickness has been found to be related to building materials.[44] All-stone walls ranged from 0.50 m to 0.70 m wide, while mudbrick walls tended to be smaller, from 0.45 m to 0.50 m. Here the presumption is that Heloros followed the building practices at Megara Hyblaia and Syracuse, and, keeping minimum estimations, the all-stone walls of the eighth-century houses will be considered 0.50 m thick (Fig. 5.11). The same will be said for the mudbrick alternative.

The height of the house will be the same as calculated for Syracuse, 2.50 m, as will the doorway width, 1 m. Above the doorway, this includes 0.50 m used for the roofing structure.

---

[41] Gras et al. 2004, p.459; De Angelis 2016, p.84.

[42] ((0.25 m x 0.50 m x 3 m) x 2 walls) + ((0.25 m x 0.50 m x 2 m) x 2 walls) – (0.25 x 0.50 x 1 m (doorway)) ≈ 1.13 m³; 1.13 m³ x 0.14 md/m³ ≈ 0.16 man-days.

[43] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 1.13 m³ x 0.386 md/m³ ≈ 0.44 md; transport: 1.13 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 3 carriage-loads. A team of oxen could make 20 trips of 200 m each way in a day. (3 carriage-loads / 20 trips per day) + 17.4% ≈ 0.17 od. Although less than a fifth of such, it will be considered a single ox-carriage day.

[44] Fagerström 1988, p.119.

Also as above, the total stone required will be figured with the doorway and the area above it void of stone. As such, the house incorporated a total of 11.88 m^3.[45]

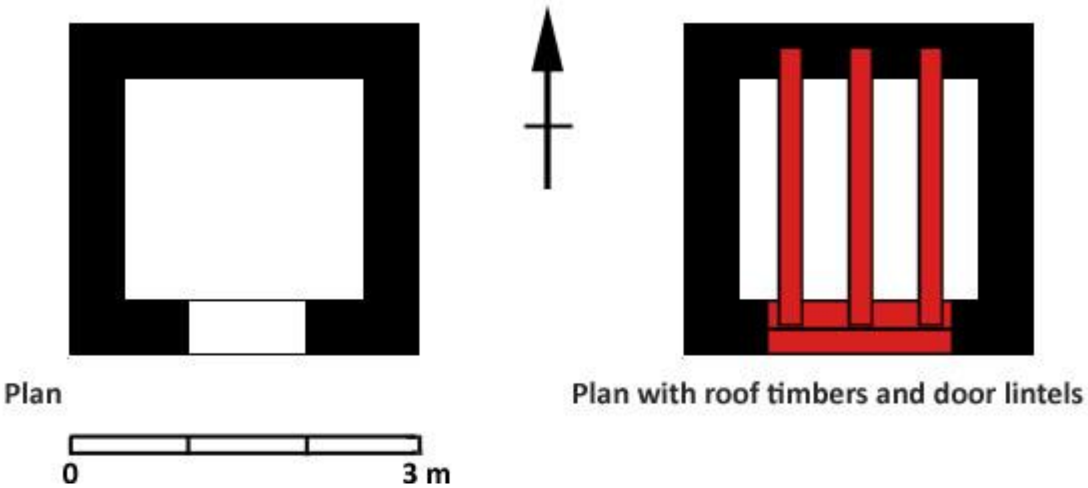

Fig. 5.11: Heloros. House plans (HH) used in the econometric calculations.

Quarrying the limestone would require 3 md,[46] while the transport costs of the material from the nearby quarries would add an additional 5 od.[47] This stage of the process is completed with an additional 12 md for construction.[48]

In a house primarily built in mudbrick, a stone socle would be incorporated, just as in the fortifications. A foundation of 0.50 m proves to be sufficient. This then figures 2 m in height of mudbrick utilised for the 2.5-m-tall wall. Taking away the doorway and area above it, a total of 2.25 m^3 of stone and 9 m^3 of mudbrick would be needed in a 3 m by 3 m house, 0.50 m thick and 2.5 m tall.[49] One md and 1 od would be needed to quarry and transport the stone to the site,[50] while 3 od would be needed to transport the raw material for the production of mudbrick at nearby workshops.[51] The stone foundation adds 2 md,[52] while the mudbrick increases it a further 6 md.[53]

The wooden support beams for the roof would have been sourced locally, and even though the true forestation of the area in the eighth century is unknown, it is reasonable to

---

[45] ((2.50 m x 0.50 m x 3 m) x 2 walls) + ((2.50 m x 0.50 m x 2 m) x 1 wall) + ((2.50 m x 0.50 m x 0.75 m) x 2 front walls) ≈ 11.88 m^3.

[46] 11.88 m^3 x 0.25 md/m^3 ≈ 2.97 md.

[47] 11.88 m^3 x 2.6 tonnes/m^3 / 0.9 tonnes per carriage-load ≈ 34 carriage-loads. (34 carriage-loads / 8 trips per day) + 17.4% ≈ 5 od.

[48] 11.88 m^3 x 1 md/m^3 ≈ 11.88 md.

[49] Stone socle: ((0.50 m x 0.50 m x 3 m) x 2) + ((0.50 m x 0.50 m x 2 m) x 2) – (0.50 m x 0.50 m x 1 m doorway) ≈ 2.25 m^3. Mudbrick: ((2 m x 0.50 m x 3 m) x 2) + ((2 m x 0.50 m x 2 m) x 2) – (2 m x 0.50 m x 1 m) ≈ 9 m^3. From now on, the doorway area will be subtracted from the total.

[50] Quarry: 2.25 m^3 x 0.25 md/m^3 ≈ 0.56 md; transport: 2.25 m^3 x 2.6 tonnes/m^3 / 0.9 tonnes per carriage-load ≈ 7 carriage-loads. (7 carriage-loads / 8 trips per day) + 17.4% ≈ 1 od.

[51] 9 m^3 x 1.75 tonnes/m^3 / 0.9 tonnes per carriage-load ≈ 18 carriage-loads. (18 carriage-loads / 8 trips per day) + 17.4% ≈ 3 od.

[52] 2.25 m^3 x 1 md/m^3 ≈ 2.25 md.

[53] Manufacture: 9 m^3 x 0.25 md ≈ 2.25 md. Construction: 9 m^3 x 0.4 md ≈ 3.60 md. 2.25 md + 3.60 md = 5.85 md.

expect a supply was no more than 0.5 km away. Here, three principal beams will form the main support, and these can be expected at a length of 2.5 m and diameter of 0.2 m, set 0.48 m apart. With the two door lintels at 1.50 m by 0.25 m by 0.25 m, this equates to 0.49 m^3 of wood, and with a nearby source, a two-man team with an ox-carriage could acquire these materials in one day.[54] Squaring the lintels requires four cuts lengthwise along a timber, each cut at a rate of 0.14 md/m^2 for a pair of sawyers, and this process proves to be as labour intensive as felling and transporting the wood.[55] Setting the timber in place would take an additional half md, at a rate of 0.10 md per timber.[56] To finish the roof, weather-proofing can be reasonably achieved with an additional md.

The dimensions of the door are placed at 1 m wide, 0.05 m thick and 1.75 m in height. Three planks of the same thickness, 0.33 m wide and 1.75 m long can be cut from a single timber and assembled together using smaller pieces of wood. This latter cost can be ignored as insignificant. Squaring and cutting the planks from a single timber would necessitate six cuts, but only utilising half the timber, and take 0.24 md.[57] Felling and transporting the wood to the site takes less than half a md and a single od.[58] Thus, including supervision, total base estimates of an eighth century house at Heloros become 33 md and 8 od for an all-stone residence (Table 5.2) and 23 md and 7 od for the mudbrick alternative (Table 5.3).[59]

Quite simply, it can be reasoned that a fair-sized workforce would have been desired. These men and their families could have constituted the colonial party working together to establish the settlement. But it is equally likely that Syracuse sent additional men south to Heloros to aid in the foundation. However, the largest hindrance towards a speedy completion would have been the number of available ox-carriages. If multiple residences were under construction simultaneously, then transporting the materials to the urban centre would have been restricted. Further, at the time of foundation it can be expected that there were scarce numbers of ox-carriages freely available. The wider-reaching social, political and economic implications of this are discussed further in the last chapter.

---

[54] ((0.20 m x 0.20 m x 2.50 m) x 3 beams) + ((0.25 m x 0.25 m x 1.50 m) x 2 lintels) = 0.49 m^3; felling: 0.49 m^3 x 2.70 md/m^3 ≈ 1.32 md; transport: 0.49 m^3 x 0.56 tonne/m^3 / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 8 trips per day) + 17.4% ≈ 1 od.

[55] 4 (length-wise cuts) x 0.25 m (lintel width) x 1.50 m (lintel length) x 0.14 md/m^2 x 2 (lintels) ≈ 0.42 md.

[56] 5 timbers x 0.10 md/timber ≈ 0.50 md.

[57] 6 (length-wise cuts) x 0.33 m (plank width) x 1.75 m (plank length) x 0.14 md/m^2 x 0.5 (timbers) ≈ 0.24 md.

[58] (1.75 m x 0.33 m x 0.33 m) x 0.5 (timbers) = 0.10 m^3; felling: 0.10 m^3 x 2.7 md/m^3 ≈ 0.27 md; transport: 0.10 m^3 x 0.56 tonne/m^3 / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 8 trips per day) + 17.4% ≈ 1 od.

[59] It is also not unreasonable to think that the gathering and transport of wood for the roof and door would have been done together. This consolidation then could eliminate at least an ox-carriage day and possibly 1 day with a two-man team (2 md). This is not included in the calculations.

Table 5.2: Total labour costs for the construction of an all-stone house at Heloros

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	2.97	5 od	11.88
INITIAL LEVELLING OF SITE:			0.16
DISPOSAL OF RUBBLE:		0.44 + 1 od	
ROOF:	1.32	1 od	0.92
DOOR:	0.27	1 od	0.24
TOTALS:	4.56	0.44	13.20
SUPERVISION: (+10%)	0.46	0.04	1.32
BASE TOTAL:		20.02 + 8 od	
RANGE OF TOTALS:		20.02–74.56	

Table 5.3: Total labour costs for the construction of a mudbrick house at Heloros

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	0.56	1 od	2.25
MUDBRICK	2.25	3 od	3.60
INITIAL LEVELLING OF SITE:			0.16
DISPOSAL OF RUBBLE:		0.44 + 1 od	
ROOF:	1.32	1 od	0.92
DOOR:	0.27	1 od	0.24
TOTALS:	4.40	0.44	7.17
SUPERVISION: (+10%)	0.44	0.04	0.72
BASE TOTAL:		13.21 + 7 od	
RANGE OF TOTALS:		13.21–41.52	

5.7 Heloros: Koreion

As stated, the only Archaic period monumental architecture known at Heloros is the Koreion merely 50 metres outside the city walls, north of the urban centre (Fig. 5.8). This phase of the Koreion is believed to be a sacellum consisting of two rooms, the stone walls of which were uncovered and stood at a height of 2.20 metres.[60] The sand dune covering the temple before excavation reached 40 m by 30 m, but the size of the Archaic phase building underneath has not been documented. Dating of the Koreion places its use between the sixth and fourth centuries, suggesting an early sixth century construction.

Close similarities between the Koreion and the Temple of Athena at Zagora allow for the latter building to provide any evidence towards the construction here that is not found in the archaeological reports. The Temple of Athena at Zagora measures approximately 10.42 m x 7.56 m, with the internal lengths of the pronaos and cella 2.80 m and 5.87 m respectively, making the cella over twice as long as the pronaos. Looking at Fig. 1.5, the Koreion appears

[60] Today the building is covered in sand, in part due to its close proximity to the coast, making any observations difficult without proper re-excavation. Site visit; Currò 1966a, p.98.

slightly more elongated, with a smaller pronaos. For this, dimensions are placed at 10.50 m x 7.50 m, with length of the cella interior (6.50 m) over two and a half times the pronaos (2.50 m). These dimensions are based on a 0.50 m wall thickness (Fig. 5.12). Because the Temple of Athena's construction style has been fixed archaeologically to the residential constructions, it will be presupposed that the same relationship was in place at Heloros. Further to this point, the foundations will be levelled down to 0.25 m, and the doorways will be considered 1 m long as both have been calculated for the houses. At the same time, however, the height of the Koreion at Heloros is taken from the temple at Zagora, 3 m, as it is more fitting to monumental architecture, and if anything, the temple rose higher.

Being such a significant building within the society, an all-stone construction of the Koreion cannot be dismissed. However, owing to availability of resources and labour supply, calculations will also be made for a building with a stone socle and mudbrick superstructure. In the latter construction, the stone socle will be estimated at a height of 1 m. With these outlined dimensions, the stone structure of the Koreion, including the doorways, calculates to a total of 57.75 m³,[61] while the mudbrick alternative constitutes 19.25 m³ stone and 38.5 m³ mudbrick.[62]

Levelling the area and transporting resources to the site will be taken from the location of the Koreion on the shore north of the settlement. Reducing the site down to 0.25 m at a rate of 0.14 md/m³ would take a little less than a man-day,[63] while disposing of the rubble at a distance of 200 m adds 2 md and 1 od.[64]

Reconstructing the all-stone example first: quarrying and transporting the stone 0.2 km from the nearest source would require 14 md.[65] A pair of oxen could make approximately 20 trips to the site and back a day, requiring 10 ox-carriage days to transport the material.[66] Once the material has been gathered, the construction process would take 60 more man-days,[67] giving a total manpower of 70 md to complete the walls.

---

[61] ((0.5 m x 3 m x 10.5 m) x 2 walls) + ((0.5 m x 3 m x 6.5 m) x 3 walls) – ((0.5 m x 3 m x 1 m) x 2 doorways) = 57.75 m³.

[62] Stone socle: ((0.5 m x 1 m x 10.5 m) x 2 walls) + ((0.5 m x 1 m x 6.5 m) x 3 walls) – ((0.5 m x 1 m x 1 m) x 2 doorways) = 19.25 m³; mudbrick superstructure: ((0.5 m x 2 m x 10.5 m) x 2 walls) + ((0.5 m x 2 m x 6.5 m) x 3 walls) – ((0.5 m x 2 m x 1 m) x 2 doorways) = 38.5 m³

[63] ((0.5 m x 0.25 m x 10.5 m) x 2 walls) + ((0.5 m x 0.25 m x 6.5 m) x 3 walls) – ((0.5 m x 0.25 m x 1 m) x 2 doorways) = 4.81 m³; 4.81 m³ x 0.14 md/m³ ≈ 0.67 md. The topography near the coast is understandably sandy, but it cannot be known for certain the depth of the bedrock at that time.

[64] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 4.81 m³ x 0.386 md/m³ ≈ 1.86 md; transport: 4.81 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 12 carriage-loads. A team of oxen could make 20 trips of 200 m each way in a day. (12 carriage-loads / 20 trips per day) + 17.4% ≈ 1 od.

[65] Quarrying: 57.75 m³ x 0.25 md/m³ ≈ 14.44 md.

[66] 57.75 m³ x 2.6 tonne/m³ / 0.9 tonnes per carriage-load ≈ 167 carriage-loads. (167 carriage-loads / 20 trips per day) + 17.4% ≈ 10 od.

[67] 57.75 m³ x 1.0 md/m³ ≈ 57.75 md.

Gathering the stone socle for the mudbrick reconstruction accounts for 5 md, transporting 3 od, and 19 md to set in the foundation.[68] To manufacture the mudbricks for the superstructure it would take 10 md, transporting adds 4 od, with 15 md to build the wall.[69]

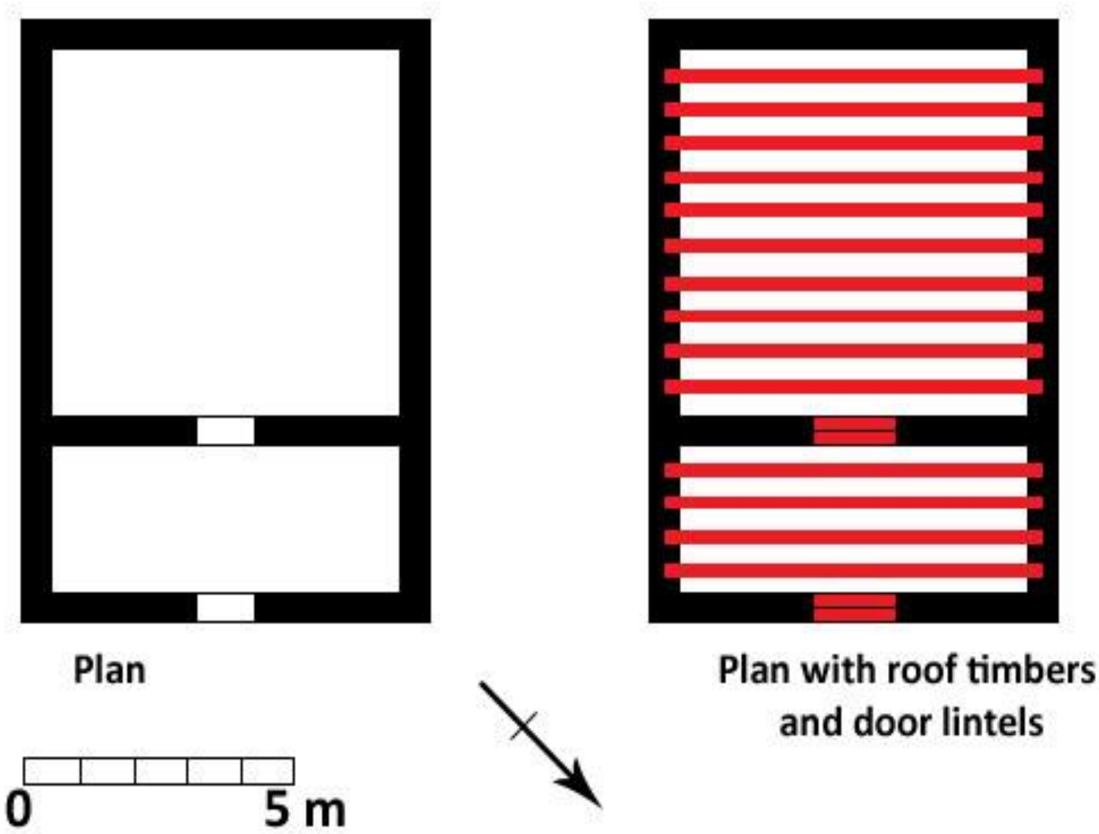

Fig. 5.12: Heloros. Koreion plans (HK) used in the econometric calculations.

Tiles began to emerge in Corinth in the early seventh century, however there is no specific mention of any evidence of the roof material from the Archaic period as it was likely lost in the later Timolean expansion. The Temple of Athena at Zagora is as well figured to have been built with a flat roof, and for these reasons the same will be reconstructed here. This roof construction is essentially the same as that explained above for the residences, with once simple change: the primary beams were not set upon the lintel but instead run the width of the temple. This is due to the fact that the pronaos is wider than it is long, which leads to the presumption that the stronger beams would have been installed spanning the greater distance. The dimensions of the Koreion used here create a cella with a square interior of 6.5 m, and therefore the direction of the beams makes no difference. It is expected that the builders kept the same pattern. Further, it is likely that the timbers were not supported by any poles or

[68] Quarrying: 19.25 m³ x 0.25 md/m³ ≈ 4.81 md; transport: 19.25 m³ x 2.6 tonne/m³ / 0.9 tonnes per carriage-load ≈ 56 carriage-loads. (56 carriage-loads / 20 trips per day) + 17.4% ≈ 3 od; construction: 19.25 m³ x 1.0 md/m³ ≈ 19.25 md.

[69] Manufacture: 38.5 m³ x 0.25 md ≈ 9.63 md; transport: 38.5 m³ x 1.75 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 75 carriage-loads. (75 carriage-loads / 20 trips per day) ≈ 4 od; construction: 38.5 m³ x 0.4 md ≈ 15.4 md.

columns within the interior of the temple.[70] As a main support for the roof, fourteen principal beams with a length of 7 m and diameter of 0.2 m would suffice. In the pronaos, four beams of that size can be evenly spaced 0.34 m apart, while the ten beams in the cella can be a little further apart at 0.41 m (Fig. 5.12). It can be supposed that the timber used for the roof in the temple was squared which would necessitate 11 md of labour.[71] Last, the four lintels, 1.50 m x 0.25 m, can be finished in less than a man-day.[72] Felling and transporting the wood to the construction site adds 2 md and 1 od.[73] To set in place the roofing timbers the same rate is utilised for constructing the house roofs. The reasoning here is twofold: the roof is flat, requiring less overall skill and precision than with a peaked roof, and the timber is not as large as the beams expected for larger monumental architecture. The 18 total pieces of timber then would take 2 md to set into place.[74]

The doors in this reconstruction would be equal to those calculated above for the houses except a metre higher: 1 m by 0.05 m by 2.75 m. Six planks of the same thickness, 0.33 m wide and 2.75 m long can be cut from a single timber to construct both doors. Squaring and cutting the planks requires 9 cuts and takes 1 md.[75] Felling and transporting the wood to the site takes a little over 1 md and 1 od, and could have essentially taken place alongside the timber for the roof.[76]

The Archaic double-roomed sanctuary, therefore, could be feasibly built within a few weeks by a small workforce of fewer than ten (Table 5.4, Table 5.5). Unlike the fortifications, the number of ox-carriage days are relatively small as well, allowing for the minimal crew to work with quite possibly a single pair of oxen. As well, given that the all-stone temple would have added less than a month's work, the people of Heloros may have preferred that version for its aesthetic appeal. The lack of complexity in this temple will become more obvious in comparison with the two temples found at Akrai and Kasmenai. Perhaps the unassuming size of the Koreion was exactly what the small community at Heloros desired, or on the other hand, it was all they could manage with the resources available to them.

---

[70] Unsupported spans of over eleven metres are documented at Selinous (11.70 m) and Agrigento Herakles (11.84 m). See Klein 1998, p.338.

[71] 4 (length-wise cuts) x 0.2 m (timber width) x 7 m (timber length) x 0.14 md/m^2 x 14 (timbers) = 10.98 md

[72] 4 (length-wise cuts) x 0.25 m (lintel width) x 1.5 m (lintel length) x 0.14 md/m^2 x 4 (lintels) ≈ 0.84 md.

[73] (0.7 m x 0.2 m x 0.2 m x 14) + (1.5 m x 0.25 m x 0.25 m x 4) = 0.77 m^3; felling: 0.77 m^3 x 2.7 md/m^3 ≈ 2.08 md; transport: 0.77 m^3 x 0.56 tonne/m^3 / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 8 trips per day) + 17.4% ≈ 1 od.

[74] 18 rafters x 0.1 md/rafter = 1.8 md.

[75] 9 (length-wise cuts) x 0.33 m (plank width) x 2.75 m (plank length) x 0.14 md/m^2 x 1 (timbers) ≈ 1.14 md.

[76] (2.75 m x 0.33 m x 0.33 m) = 0.30 m^3; felling: 0.30 m^3 x 2.7 md/m^3 x 1.5 (hardwood) ≈ 1.22 md; transport: 0.30 m^3 x 0.9 tonne/m^3 / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 8 trips per day) + 17.4% ≈ 1 od.

Table 5.4: Total labour costs for the construction of an all-stone Koreion at Heloros

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	14.44	10 od	57.75
INITIAL LEVELLING OF SITE:			0.67
DISPOSAL OF RUBBLE:		1.86 + 1 od	
ROOF:	2.08	1 od	13.62
DOORS:	1.22	1 od	1.14
TOTALS:	17.74	1.86	73.18
SUPERVISION: (+10%)	1.77	0.19	7.32
BASE TOTAL:		102.06 + 13 od	
RANGE OF TOTALS:		102.06–380.72	

Table 5.5: Total labour costs for the construction of a mudbrick Koreion at Heloros

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	4.81	3 od	19.25
MUDBRICK	9.63	4 od	15.40
INITIAL LEVELLING OF SITE:			0.67
DISPOSAL OF RUBBLE:		1.86 + 1 od	
ROOF:	2.08	1 od	13.62
DOORS:	1.22	1 od	1.14
TOTALS:	17.74	1.86	50.08
SUPERVISION: (+10%)	1.77	0.19	5.01
BASE TOTAL:		98.38 + 10 od	
RANGE OF TOTALS:		76.65–254.64	

5.8 Heloros: Population Modelling

The only population estimate for Heloros is from Hansen, placed at the end of the Archaic period.[77] Due to the small area of the urban centre (9 hectares), Heloros is expected to have an urban population inhabiting around two-thirds of the intramural area; thus 6 hectares. At 150 to 200 people per hectare, by Hansen's estimation Heloros's urban population ranged from 900–1,000 people.[78]

For the population at the time of foundation, Syracuse and Megara Hyblaia provide sufficient comparanda, as connections have already been made with regard to the houses. Modelling already assessed for Syracuse will be used as a basis here.[79] Therefore, at 9 people per hectare and 1.8 ha (20%) to 9 ha (100%) of the urban area inhabited: 16–81 persons.[80]

The hinterland now presented is done so with an agricultural subsistence frame of mind, likely farmed and maintained by a small rural population, whether commuting from the

[77] See section 3.8 above.
[78] 6 hectares x 30 houses x 5 people ≈ 900; 6 hectares x 33 houses x 5 people ≈ 990.
[79] See section 4.10 above.
[80] 9 people per hectare x 1.8 hectares ≈ 16 people; 9 people per hectare x 9 hectares ≈ 81 people.

city-state or inhabiting the farmland. The *chora* of Heloros is defined stretching along the coast from the river Kakyparis (modern Cassibile), westward alongside the mountainous edge, before turning south and terminating along the river Heloros, roughly covering an area ca. 100 km² (Fig. 5.13).[81] This hinterland is based on a western extent 15 km from Heloros, and until better archaeological survey is completed these boundaries are the best available.[82]

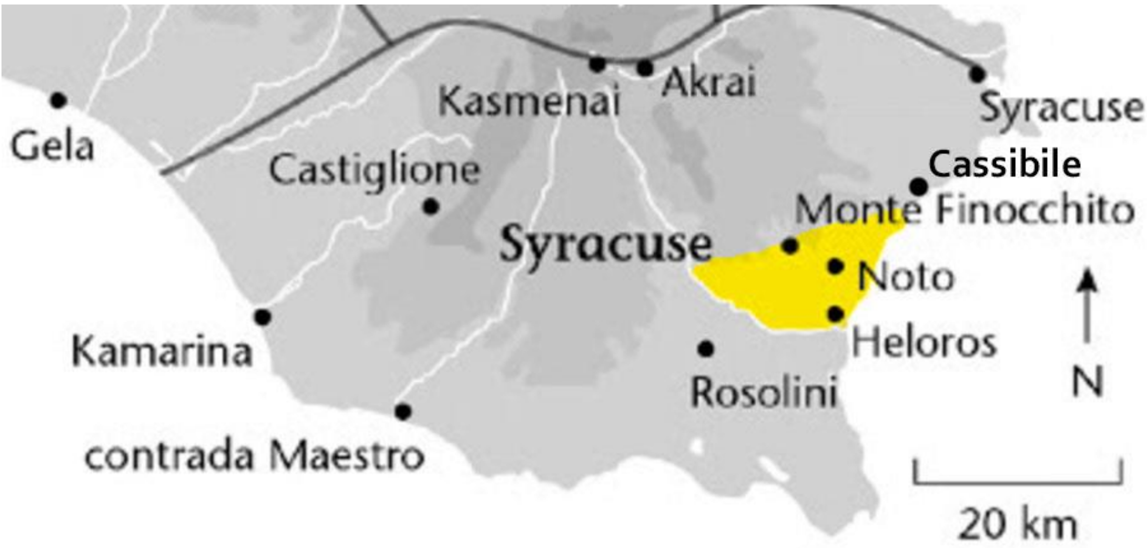

Fig. 5.13: Heloros. Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterland attached to Heloros. De Angelis 2016, p.67, Map 4 with additions.

The coast from Syracuse southwest towards Heloros can be labelled geologically as 'marine terraces'.[83] This stretch narrows to ca. 3 kilometres between the coast and tall plateau between the modern city of Avola and village of Cassibile, where the river Kakyparis (modern Cassibile) empties into the Ionian Sea (Fig. 5.14). This narrowing creates a natural boundary between the immediate hinterlands of Syracuse and Heloros, likely the case to some degree in the Archaic period. Heloros's coastal location lies next to limestone plateaux no more than 300 metres above fertile open farm land and alluvial plains within the valley formed by the river Heloros. The hinterland of Heloros could have theoretically stretched across the south-east corner of Sicily, ending where the Hyblaian Mountains reach the southern coast approximately 40 km to the west/southwest. Yet, more likely the hinterland of Heloros followed closely the river valley possibly terminating at the higher elevations around 15 km to the west (Fig. 5.15). In fact, the river likely formed the southern boundary of the *chora*,[84] as there are no dominant natural landscape features in the south, like the Hyblaian Mountains, to act as a territorial marker.

[81] This was found using a Google Maps Area Calculator Tool, Daft Logic 2014b.
[82] It is not wrong to presume that the population at Heloros travelled south of the river Heloros, and likely settled there. Guzzardi 2001; Bozza 2009, p.258.
[83] Great Britain Naval Intelligence Division 1944, p.392.
[84] Cordano 1986, p.119 suggests that the river Heloros was the southern boundary of the Syracusan territory even before the foundation of Heloros. Cf. De Angelis 2000a, p.116; Lepore 2000, p.63; Frisone 2012.

Fig. 5.14: Heloros. View to the north of urban centre (blue outline) and its territory from the River Heloros (bottom left) to River Kakyparis (top right). Google Earth.

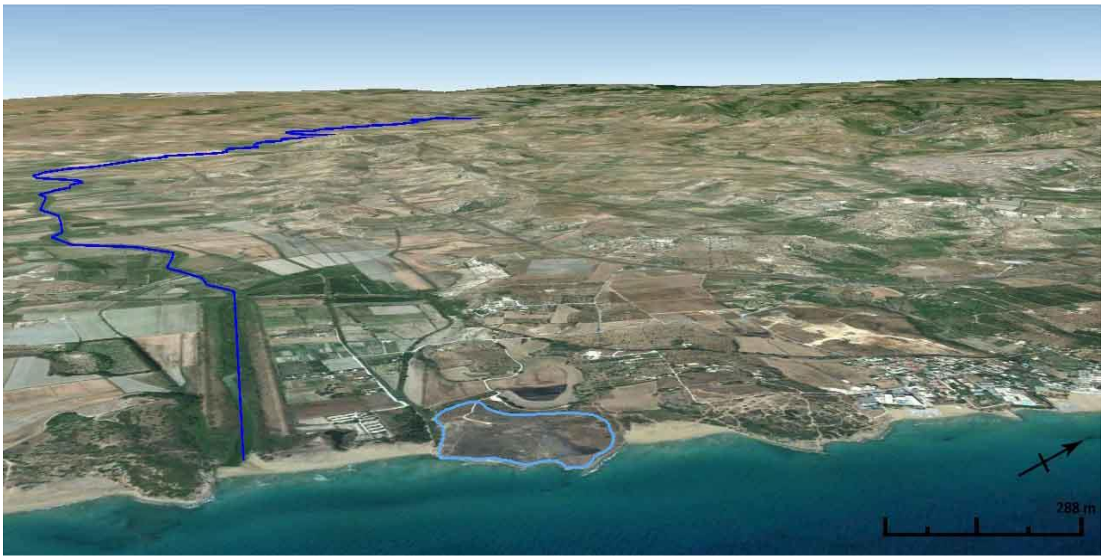

Fig. 5.15: Heloros. View to the north-west of urban centre (blue outline) and its territory with the path of the River Heloros coming from the Hyblaian Mountains. Google Earth.

With this outlined area and Muggia's averages of one site per square kilometre and 15 inhabitants per settlement, a rural population of 1,500 is reached,[85] more than the urban population number calculated for the Classical period. This figure is too large for the foundation period population of Heloros. Hansen estimates that one-third of the total population lived in the hinterland. From his urban figures, this then gives an estimate of a further 450–500 persons, bringing the total population for Heloros to 1,350–1,500.[86] As a useful comparison, the Classical theatre on the southern edge of the urban centre had a capacity of 1,500 persons, lending credibility to this population total.[87] One-third rural to two-third urban ratio seems best for the foundation period as well (8–41 people), capping the population range at 24–122.

[85] 100 km² x 1 site/km² x 15 inhabitants/site ≈ 1,500.

[86] Total population: 2/3rd urban (900) + 1/3rd rural (450) ≈ 1,350.

[87] If the 1,500 capacity of the Classical theatre gives any indication, this population total may not be far from the actual size, albeit on the high side. Fischer-Hansen et al. 2004, p.195.

Starting with the foundation population, various models reach the estimates set forth for the end of the Archaic period (Chart 5.1). In the urban centre, with a starting population at the low end (LU), 16 people, an annual growth rate of 0.5 per cent and an influx of 2 people a year, the population grows to 800 members by 485 BC. Beginning with the higher estimate (HU), 81 people, the same number of immigrants per year reach 1,000 people. In the hinterland, starting with either estimate, 8 (LR) or 41 (HR) people, this growth rate with an increase on average of an individual per year leads to 400–500 rural population by the end of the Archaic period. This suggests that Heloros began modestly and only welcomed a few immigrants a year, or a family every two years, growing on average 1.5 per cent annually. Based on a settlement size of 15 inhabitants, a new rural site appears perhaps once a decade. Population estimates can be found in Table 5.6 from the time of foundation to the end of the Archaic period.

Table 5.6: Population estimates of Heloros from foundation to the end of the Archaic period

	FOUNDATION C. 700 BC	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
URBAN	16 – 81	130 – 220	290 – 390	480 – 620	600 – 750	730 – 900	820 – 1,010
RURAL	8 – 41	70 – 110	140 – 200	240 – 310	300 – 380	360 – 450	410 – 500
TOTAL	24 – 122	200 – 330	430 – 590	720 – 930	900 – 1,130	1,090 – 1,350	1,230 – 1,510

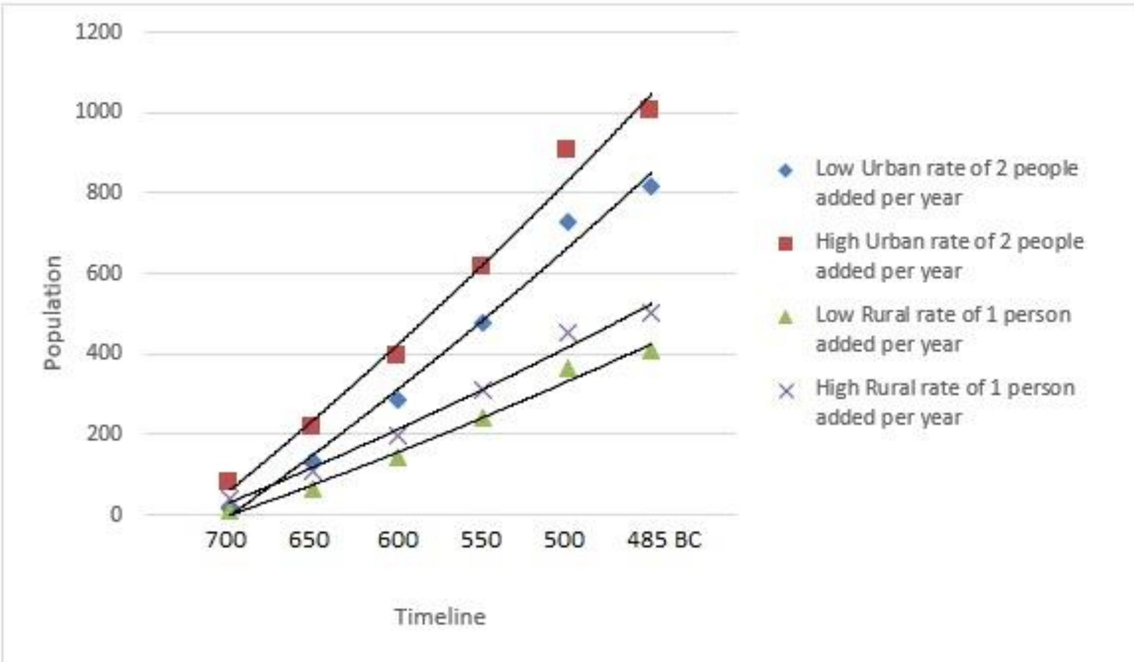

Chart 5.1: Population models of Heloros from foundation to 485 BC.

Snodgrass, in his survey on the origin of the polis, affirms that '[an] isolated community of less than 500 people cannot generate a sharply-differentiated elite; it cannot afford more than a rudimentary degree of craft-specialisation; it cannot muster an army of more than about 100 warriors.'[88] Logically speaking, Heloros, and by extension its metropolis Syracuse, would have wanted an adequately-sized number of inhabitants to allow the city-state to be self-sufficient, and therefore over 500. Yet, population estimates do not support this. Questions over whether or not Heloros contained an elite class or a sizable defensive force pertain to socio-political issues that must be raised in future research. Here, the population estimates are used to calculate workforce numbers at the time of construction for the projects discussed above. This will provide a sense of how the settlement over time was able to devote man-power to construction projects, indicating its ability to be self-sufficient.

Modelling estimates a population of 16–81 residents upon the foundation of Heloros; this accounts for a workforce size of 4–18 labourers and 4–20 houses. This size of labour pool would potentially have been able to complete 140–1,600 md per year.[89] Labour costs for constructing the simple, one-roomed houses at this time have been estimated at 20–75 (all-stone) and 13–42 md (mudbrick). Whether the labourers worked 36 or 90 days a year, and with 1–9 labourers working at any one time, every family at Heloros would have permanent shelter within half a year to a year.[90] With relatively few ox-carriage days per house, a single ox-carriage would be enough. This indicates that upon foundation the population at Heloros was seemingly self-sufficient when it came to residential construction. Furthermore, it is feasible to expect that had housing been a priority, the project could have been completed quickly to ensure the population had shelter prior to winter.

Around 600 BC, the Koreion was constructed at an estimated cost of 130–420 (all-stone) or 100–280 (mudbrick). With an estimated population of 430–590 (290–390 urban, 140–200 rural), the workforce would have accounted for 65–88 urban and 32–45 rural labourers potentially able to work 3,490–12,000 md per year.[91] No matter the use of mudbrick or number of days per year for each labourer, the Koreion would have taken only a couple months to complete.[92] The temple at Heloros is conservative in comparison to the Temple of Apollo at Syracuse,[93] both constructed around the same time, and perhaps the contemporaneity of the

---

[88] Snodgrass 1993, p.39.

[89] In this and subsequent chapters, timelines ranges will consider the lower workforce size at 36 days/year and the higher workforce size at 90 days per year: 144 md/year at 4 labourers working 36 days/year; 1,620 md/year at 18 labourers working 90 days/year.

[90] Stone low estimate: (4 houses x 20.02 md) / 144 md/year ≈ 0.56 years. Stone high estimate: (20 houses x 74.56 md) / 1,620 md/year ≈ 0.92 years. Mudbrick low estimate: (4 houses x 13.21 md) / 144 md/year ≈ 0.37 years. Mudbrick high estimate: (20 houses x 41.52 md) / 1,620 md/year ≈ 0.51 years.

[91] 3,492 md/year at 97 labourers working 36 days/year; 11,970 md/year at 133 labourers working 90 days/year.

[92] Stone low estimate: 102.06 md / 11,970 md/year ≈ 0.01 years. Stone high estimate: 380.72 md / 3,492 md/year ≈ 0.11 years. Mudbrick low estimate: 76.65 / 11,970 md/year ≈ 0.01 years. Mudbrick high estimate: 254.64 / 3,492 md/year ≈ 0.07 years.

[93] See section 4.8 above.

projects limited the number of skilled workmen available to Heloros, or the small size of the settlement did not demand a grandiose place of worship. The population at Heloros had a sufficient number of labourers available to complete the project quickly, with maybe the exception of skilled workmen. More likely the Koreion was given less priority and the construction timeline extended to a year; a small number of full-time workmen (2) could have completed the temple with minimal impact to the settlement's other responsibilities, for instance agriculture.[94]

The fortifications at Heloros are dated to the third quarter of the sixth century BC and have been estimated at a cost of 54,400–78,700 md and 4,700 od, the largest of the three projects discussed in this chapter. Population modelling estimates an average populace of 810–1,030 (540–685 urban, 270–345 rural) providing a workforce of 122–154 urban and 61–78 rural potentially accounting for 6,600–20,900 md per year.[95] At these estimates, the wall would have been completed in 2–10 years.[96] The quicker timeline utilises 77–155 labourers at any one time working 90 days a year, while the latter has a smaller workforce of 20–45 men able to work 36 days a year. These timelines demand 13–26 ox-carriages during the summer months,[97] which is not unfeasible given that the rural population at the time suggests up to 23 farmsteads in the Heloros hinterland.[98] When compared to the rapidity at which the fortifications at Kamarina are expected to have been constructed, this project stresses that Heloros did not have the same man-power available. However, presuming the correct dating to after the rebellion of Kamarina, Heloros did not have immediate need for fortifications, and so a longer project timeline can be expected to allow for minimal disruption to daily activities. For instance, if construction was extended to two decades the project would have required 15 men working full-time and only 3 ox-carriages during the summer months.[99]

A sense of self-sufficiency at Heloros could be argued for based on the available workforce and possible construction timelines even soon after foundation. However, if Snodgrass is correct, then Heloros must be perceived as quite reliant upon outside help, namely Syracuse, for certain aspects such as skilled labourers, resources and defence. The labour estimates of the fortifications justify that point of view; given the events contemporary to the

---

[94] Stone high estimate: 380.72 md / 220 days/year ≈ 2 labourers. At 13 od, a single ox-carriage is more than sufficient.

[95] 6,588 md/year at 183 labourers working 36 days/year; 20,880 md/year at 232 labourers working 90 days/year.

[96] Low estimate: 42,271 md / 20,880 md/year ≈ 2.02 years. High estimate: 64,027 md / 6,588 md/year ≈ 9.72 years.

[97] 4,717 od / 2.02 years / 90 days/year ≈ 26 ox-carriages; 4,717 od / 9.72 years / 36 days/year ≈ 13 ox-carriages.

[98] Based on an average rural settlement size of 15 people. See section 3.8 above.

[99] High estimate: 64,027 md / (20 years x 220 days/year) ≈ 15 labourers; 4,815 od / 20 years / 90 days/year ≈ 3 ox-carriages.

expected construction date, Syracuse may have initiated the project for the sake of securing the settlement. In this case, it can be expected that skilled workmen from the metropolis were readily available to Heloros. Further help would have been necessary if any other civic buildings, presently unknown, were under construction at the same time; however, it would have been possible to postpone their start until the previous project was finished and sufficient workforce was available

Chapter 6: Akrai

The second settlement founded by Syracuse, Akrai, is located 33 kilometres west of Syracuse atop a limestone plateau with three high and difficult slopes to the north, west and south.[1] Access, then, is restricted to the east, although this in itself is not easy. Amongst other waterways, Akrai overlooks the Anapos (modern Anapo) river valley to the north, leading to Syracuse, and the Heloros river valley to the west and south, which empties into the Ionian Sea at Heloros.[2] The settlement is quasi pentagonal, with approximate maximum dimensions of 700 by 750 m (Fig. 1.6). Bernabò Brea estimated the area at 36.50 ha, which would include a section of the present-day city of Palazzolo Acreide, and it is bordered on three sides by the modern Via Martiri di Via Fani which follows the plateau edge. Significant prehistoric evidence has been found dating back to the Upper Palaeolithic period, yet habitation of the area almost ceases by the time the Greeks arrive.[3] Indeed, there is no archaeological evidence of a pre-Greek settlement at Akrai.

The earliest preserved part of Akrai is its urban layout designed at foundation (Fig. 1.6).[4] A little over a century later was built the Temple of Aphrodite,[5] while construction of the wall has been placed towards the end of the Archaic period, but solely on historical probability.[6] The extent of archaeological knowledge of the Archaic period is presented in Appendix 1 (A, sections D, E and F). The section on econometric calculations will be preceded by a general presentation of the relevant material remains. Due to the relative lack of information on Akrai, use of comparative data is important for the analyses. Limestone was readily available at Akrai in the south-east corner of the settlement. The two quarries, known as Intagliata Grande (AQ1) and Intagliatella (AQ2), were used from the first days of settlement, and it can be assumed that the entire volume of stone material was taken from there.[7]

6.1 Akrai: The Archaic Wall

Little remains of the fortifications (Fig. 1.6: AF) placed around the Akrai urban centre. A few traces (Fig. 6.1) have been recovered next to the only two entrances: the Syracusan (East) and Selinuntian gates (West). Blocks were laid out against the natural terrace, arranged three deep and in at least three courses high, allowing for the topography to aid in its support and defence

[1] Distance measured using Google Maps Distance Calculator, Daft Logic, 2014. Great Britain Naval Intelligence Division 1944, p.392, Fig. 65; De Angelis 2003, p.79, Fig. 29.
[2] Bernabò Brea 1956, pp.4-6.
[3] Bernabò Brea 1956, pp.7-16.
[4] Bernabò Brea 1986, p.15.
[5] Bernabò Brea 1986, p.36.
[6] Bernabò Brea 1956, p.22.
[7] Bernabò Brea 1956, p.59.

(Fig. 6.2).[8] Given the scarcity of evidence for the fortifications, much of the data used in the analyses are approximate and based on comparative material.

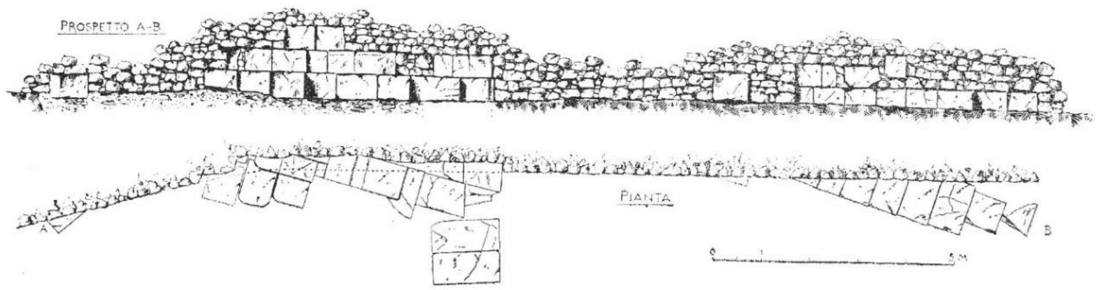

Fig. 6.1: Akrai. Elevation and plan of the fortifications (AF). Bernabò Brea 1956, p.22, Fig. 9.

Following the edge of the plateau, Bernabò Brea concluded that the wall was not continuous and it was supplemented by the natural features of the topography and by modifying the bedrock. The base of the wall was not built at the same elevation throughout, but rather situated at the most vulnerable areas.

Not enough material has been discovered to date the construction of the wall with any precision. Based on historical reasoning Bernabò Brea suggests that it was built in the fourth and third centuries, as part of complex fortifications erected by Dionysios of Syracuse and later in response to Carthaginian sieges.[9] While this hypothesis cannot be dismissed, it is more likely that the decision to fortify the settlement was made already during the Archaic period. The general view now is that Kasmenai was fortified upon foundation, or shortly thereafter in the sixth century.[10] The first wall circuit at Heloros has been dated to the third quarter of the sixth century,[11] and Akrai is likely to have followed suit: Frederiksen's work has demonstrated that fortifications were far more prevalent in the Archaic period than previously thought.[12] Such defensive building programmes in place at the other Syracusan colonies supports this hypothesis, especially given that the project would not have required an entire wall circuit and subsequently less resources. At the time of Bernabò Brea's publication, Monte Casale had not been definitively recognised as the site of Kasmenai, and Militello's excavations of the Archaic wall at Heloros were still a few years away. Had Bernabò Brea known about the dating of these two Syracusan colonies, his reasoning would probably have been different. It is suggested here that walls of Akrai were constructed within the first half of the sixth century. The total workforce assessment presented below will be based on this dating.

[8] Bernabò Brea 1956, pp.21-4.
[9] Bernabò Brea 1956, pp.22-3.
[10] Miller 1995, p.261; Fischer-Hansen 1996, p.354, n.27; Frederiksen 2011, p.155.
[11] Militello 1966, pp.313-4.
[12] Frederiksen 2011, pp.1-3. Cf. Hodos 2010a, p.89.

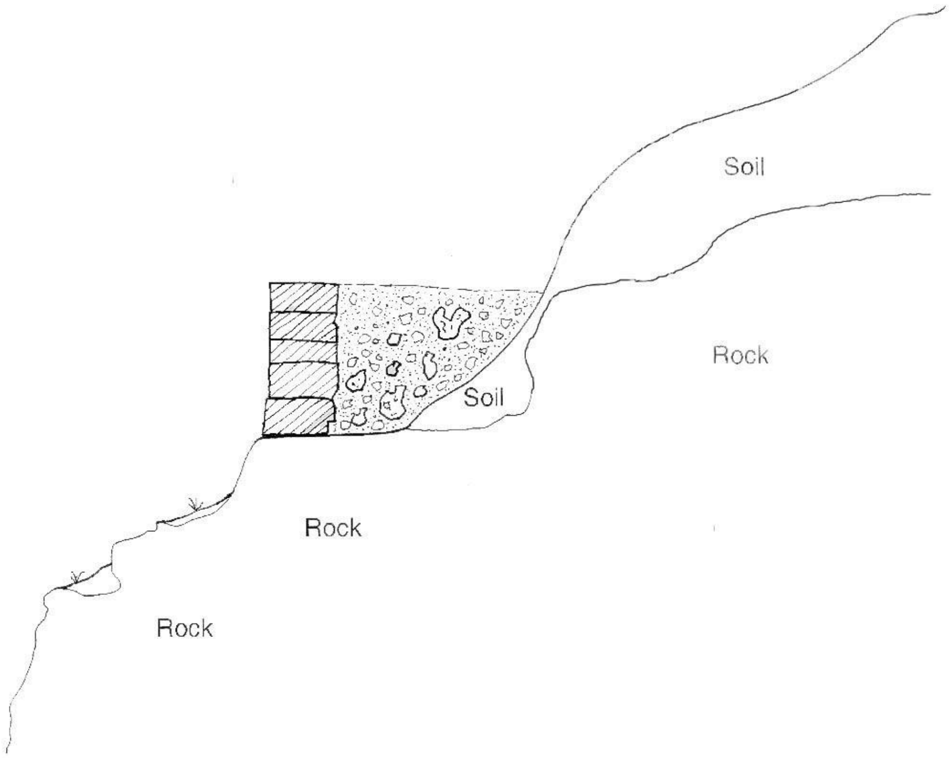

Fig. 6.2: Diagram of terraced wall construction, similar to fortifications at Akrai. Frederiksen 2011, p.52, Fig. 4.

6.2 Akrai: Archaic Housing

As presented in the site catalogue below (Appendix 1: A, section E), the only known evidence of residential planning at Akrai is in the habitation blocks. The stenopoi (3 m wide) are found 27 metres apart ending at the plateia (Fig. 1.6; Fig. 6.3; Fig. 6.4: AH). Beyond this, comparative evidence from other settlements is necessary to reach any conclusions on the residential situation at Akrai. While the urban layout has been associated with the Hellenistic era,[13] excavated evidence does indicate Archaic period inhabitation in the same area.[14] It can be assumed that the layout dates to the foundation of the settlement.

At the time of the foundation of Akrai, in the second quarter of the seventh century, houses had grown from the simple one-room structures as at Heloros to two or more rooms with an associated courtyard.[15] At Megara Hyblaia, on average the houses of this period had two rooms and had a plan area of around 30 square metres.[16] House 22.20 was constructed with three rooms with a total size of 12.75 metres by 4.5 metres around the time of the foundation of Akrai.[17] This is one of the larger houses known of this time at Megara. However, two other houses were renovated in the first half of the seventh century and rooms were

[13] Garozzo 1994, pp.197-8.
[14] Pelagatti 1966a, p.92.
[15] Lang 2005, p.187.
[16] De Angelis 2003, p.23, Fig. 10.
[17] Vallet et al. 1976, pp.272-3; De Angelis 2003, p.23, Fig. 10.

added.[18] This suggests a trend towards larger multi-roomed dwellings around the foundation of Akrai. Therefore, the expectation will be that at Akrai houses were similar, likely of three rooms. To fit the 27-m habitation block, it is estimated that two houses of 12 m by 5 m with a passage of 3 metres in between were constructed at Akrai. The width of the passage is reconstructed on the basis of comparative material from Kasmenai.[19] House 22.20 did not have a demarcated exterior courtyard, and this was also the case at Kasmenai. Further estimated dimensions are based on the house at Heloros: 0.50 m wall width and 2.5 metre total height. This results in a residence at Akrai with three rooms of c. 13.3 m² each, (3.33 m x 4 m); residences at Kasmenai had a similar room size. While at Akrai the rooms are not much larger than at Heloros, the extent of the house itself and the habitation space overall have increased.

Fig. 6.3: Akrai. Central plateia in residential area (AH). Voza 1999, p.132.

[18] De Angelis 2003, p.24, Fig. 11.
[19] See section 7.2 below.

Fig. 6.4: Akrai. Crossroad with plateia horizontal at top and perpendicular stenopos at right. Voza 1999, p.133.

6.3 Akrai: Temple of Aphrodite

The Temple of Aphrodite is located in the south-east corner of Akrai, west of the quarries and south of the Hellenistic theatre (Fig. 1.6: AT). Extensive excavations in 1953 and a subsequent survey provide a wealth of information on the building.[20] The temple, therefore, is the best understood construction at Akrai, though several aspects of the temple need to be reconstructed on the basis of comparative material. Dated to the second half or third quarter of the sixth century, the order of the temple is Sicilian Doric with Ionic influences and follows closely an Akrai foot (A') of 30.4 cm. This is a theorised measurement by Bernabò Brea to have been in standardised use by the Greeks at Akrai. Given this, dimensions can be reconstructed where physical evidence is lacking. Due to the topography of the site, the foundation depth varies six courses (c. 3 m), at the western end, to nearly building directly on the bedrock in the east. The maximum dimensions at the foundation level are as follows: East 19.6 m, West 19.1 m, North 40.5 m, South 40.4 m. The crepidoma has two steps and, measured at the level of the first step, the length and the width of the stereobate are 39.52 m by 18.24 m (Fig. 6.6). It is peripteral in design with stylobate dimensions of 37.68 m by 16.4 m. The structure is hexastyle

[20] Bernabò Brea 1986.

with thirteen columns along the long sides and thirty-four in total. An excavated column fragment provides an upper diameter of 0.98 m. Typically, late sixth-century temples had a lower diameter to upper diameter ratio of c. 1.30,[21] making the column lower diameter 1.22 m (4 A').[22] To fit the principal dimensions at the stylobate level, each column must therefore be placed 1.81 m (6 A') apart and 0.10 m away from the edge of the steps. Bernabò Brea's reconstruction of the temple includes a second row of columns in front of the pronaos: based on the plan they have the same dimensions as the exterior columns. Based on the temple publication it is not known how much evidence for them was discovered during excavations, yet, given the known placement of the sekos, the reconstruction is likely to be correct.

The sekos consisted of a pronaos, an antecella and a cella. Based on the reconstruction and the known dimensions of the stereobate and stylobate, the sizes of the interior spaces can be approximated with sufficient precision, and a hypothetical 30.4-cm Akrai foot is employed in the estimates.[23] The interior width of each room is the same, c. 6.10 m (20 A'), as is the width of the walls, c. 0.90 m (3 A'). The interior lengths of the pronaos, antecella and cella are 2.70 m (9 A'), 4.90 m (16 A') and 12.50 m (41 A') respectively. The pronaos had two smaller columns in antis, also of unknown dimensions. These will be estimated at 0.90 m (3 A'), and if placed 1.20 m (4 A') from each wall, leave 1.90 m (about 6 A') for entering to the interior rooms. The width of the doorways can then be reconstructed at 1.90 m. Bernabò Brea dismisses the possibility of supporting columns inside the two interior rooms.

The Doric order in which the Temple of Aphrodite was built has drawn comparisons with the Syracusan temples of Apollo and Olympian Zeus.[24] They were constructed in the first half of the sixth century, making their influence in the design of the temple at Akrai most probable. The strongest comparisons between the Syracusan temples and that at Akrai are the double colonnades at the front and the back cella wall without an opisthodomos. What Bernabò Brea's report lacks is well-argued suggestions how to reconstruct the Temple of Aphrodite. Comparative elements from the Syracusan temples and other more contemporary structures will be used to fill the gaps. The first most pressing issue surrounding the econometric reconstruction of the Temple of Aphrodite is the height to which it rose. Later sixth-century Sicilian temples typically had a column height of c. 4.5 times the lower diameter;[25]

[21] Woodward 2012, pp.370-81, Appendix 4.2.

[22] 0.98 m x 1.30 ≈ 1.274 m; 0.304 x 4 = 1.216 m. In this instance and below, I prefer to closely follow the Akrai foot.

[23] Measurements have been rounded to the nearest tenth of a metre. While there is danger in basing these figures off an imprecise drawing, this remains the best available evidence known to us. Indeed, these assumptions are not far off others forced to be taken above and below.

[24] Bernabò Brea 1986, p.35.

[25] Dinsmoor 1975, pp.340-3.

here that would be 18 Akrai feet (5.47 m).[26] The typical height of the entablature in comparative structures was c. 2.2 times the lower diameter,[27] and its minimum height at Akrai can be estimated as 2.74 m (9 A').[28] From the latter dimension, the architrave will be considered at half the height (1.37 m or 4.5 A'), and the frieze and cornice each at 0.68 m (2.25 A'). This creates a total height to the pediment of 8.21 m (27 A').

The remaining unknown aspects of the columns and entablature will be largely estimated based on the Temple of Apollo,[29] comparative data and the Akrai foot. In sixth-century Sicilian temples the capital is typically 10 per cent of the total column height,[30] so its height can be approximated as 0.55 m, a little under 2 Akrai feet. The height of the column shaft is, therefore, c. 4.92 m. Archaeological remains do not attest to the width of the capitals, but in later sixth-century architecture the width of the abacus is most often near that of the lower diameter of the columns; 1.22 m will be used here. The pronaos columns will be based on the sekos wall heights, discussed below. Based on Mertens' measurements and drawing presented in Fig. 4.4, the architrave at Syracuse was L-shaped and had a depth near to the diameter of the column. However, in later Sicilian temples this feature was not widely used and the depth of the architrave can be reconstructed as the same as the upper diameter of the column shaft, so 0.98 m in this case. Greek temples tend to be rather conservative structures, so the minimum dimensions can be reconstructed with a relatively high degree of confidence. Any decorative aspects of the temple, such as on the frieze and pediment, will not be included in the calculations.

6.4 Architectural Energetics and Econometric Calculations

Using the information given of the archaeological remains from the Archaic period, estimates are now presented for the construction of the fortification, a residence from the foundation period and the Temple of Aphrodite. Since the archaeological material is limited, much of the following is based on comparisons with other, closely-related Greek city-states. The methodology has been discussed in detail in Chapter 2. The quarries in the south-east corner of Akrai (Fig. 1.6: AQ1, AQ2) likely provided the stone needed to construct all the fortifications, housing and monumental architecture. For this reason, transport costs estimations will vary only slightly between construction projects, and overall they will be shown to be far less than at Heloros and Kasmenai. The difference is largely in the number of ox-carriage days required.

[26] 4.5 x 1.22 m ≈ 5.49 m; 18 x 0.304 m = 5.47 m.
[27] Dinsmoor 1975, pp.340-3. The ratios of lower diameter to entablature height are closer than lower diameter to column height.
[28] 2.2 x 1.22 m ≈ 2.68 m; 9 x 0.304 = 2.74 m.
[29] See section 4.8 above.
[30] Woodward 2012, pp.137-42, Table 5.

While the majority of the fortifications are approximately half a kilometre from the quarries, consistent with the other city-states, the temple is only 50 metres away. This allows a pair of oxen to make 80 trips in a single day. Given that the degree of forestation of the area in the Archaic period is unknown, one kilometre provides a general base from which the timber could have been harvested. In transport from outside the urban centre, the oxen would have had to navigate on average an incline of about 15 per cent, increasing the cost by 25.9 per cent. As before, labour costs are provided in the accompanying footnotes and presented in the text as rounded figures, while the total numbers are itemized in the supplementary tables. Much of the various aspects in the construction processes have been explained in detail in the two previous chapters. Here and at Kasmenai the procedure will be less comprehensive, focusing on the calculations.

6.5 Akrai: Fortifications

Tentatively dated to the second half of the sixth century, the only definitive evidence known about the walls at Akrai is that they were terraced and consisted of three courses of blocks. On the eastern side of the plateau, one stretch of wall has been found up to three courses high, but it can be expected that the project was designed to be higher. Block dimensions were also absent from Bernabò Brea's report, however his illustration of the eastern stretch of wall (Fig. 6.1) will serve as reference to estimating the wall dimensions. Using the quarries in the south-east corner of the urban centre, the farthest edge of the plateau is 700 m away, but much of the northern and western sides are around 500 m away. This is the distance used for transport costs.

From the excavations in the mid-twentieth century, it is apparent that the line of defence did not stretch the entire perimeter of the urban centre.[31] Where the walls were placed depended on the areas more easily accessible from outside the plateau. However, these points cannot be identified with certainty today. A reasonable approximation is that the walls of Akrai circled two-thirds of the settlement. The perimeter of Akrai was approximately 2,600 m,[32] yielding a total wall length of around 1,740 m.[33]

The calculations include the initial levelling of the ground to the bedrock, creating a flat foundation. This includes cutting away the hill behind the wall to allow for three courses of stone to be placed side by side. For the levelling of the foundation, 0.50 m is the estimated depth of removed soil to reach the bedrock. A similar situation can be observed at the east end of the Temple of Aphrodite as will be explained below. Deeper digging was needed for the

[31] Bernabò Brea 1956, pp.21-4.
[32] Based on Google Maps Area Calculator Tool, Daft Logic 2014b.
[33] 2,600 m x 67% ≈ 1,742 m.

other foundation courses of the temple, but the perimeter of the plateau would naturally have had less soil than the top. The estimate of the volume of earth excavated from behind the wall to create a deep enough foundation is arbitrary. This would depend entirely upon the natural formation of the plateau edge at the fortified locations, and this information is now lost. The most probable reconstruction is that the areas where walls were placed had ample enough room (2.25 m) for the standard construction.

The height of the completed walls is unknown, but it is estimated as five courses, creating a wall 2.5 metres high. This can be considered low for a fortification, but given the terraced position, any would-be attacker would have first had to overcome the incline below the wall. For the same reason, a mudbrick superstructure will not be included. Lastly, once completed, the excavated soil would have been used to fill the space behind the wall for added strength. The process would only have required minimal effort and the material from the initial levelling of the foundation or even from digging the foundations of nearby houses could have been used.

In areas around the perimeter of the plateau where a wall was deemed unnecessary, the natural rock face was artificially smoothed and vertically cut to increase its defensive nature.[34] In an attempt to reach a labour cost for this, a few assumptions will need to be made. First of all, each location was likely to have been accessible by at least a single individual without need for any platforms or supports to be built, eliminating any additional work to accomplish the task. Perhaps a ladder was required, but such an item would have been readily available. Next, the labour rate is estimated as the 0.07 man-days per cubic metre used for loose fill. This comes from the fact that the act would have been one of excavating the soil and chipping away the loose rocks to create a vertical edge – there was no need to maintain specific block sizes or smooth lines. The bedrock was probably modified to the same height as the wall, but only 0.25 m into the rock face. The latter figure should provide ample room to eliminate the variations in the natural formation. It will also be figured that this took place on the stretch of the plateau that did not include a wall, therefore 33 per cent of the total perimeter (860 m).[35]

Initial levelling of the areas for the fortifications would have required 300 md.[36] It will be assumed that the material removed for the foundations was reused behind the wall, and so did not need transporting away from the site. This backfilling process then increases the labour cost by 150 md.[37] For the entire wall construction, 9,790 m³ would need to be quarried costing 19,600 md,[38] using around 4,500 od for transport.[39] Completing the construction process

[34] Bernabò Brea 1956, p.23.
[35] 2,600 m x 33% ≈ 858 m.
[36] (2.25 m x 0.5 m x 1,740 m) x 0.14 md/m³ ≈ 274 md.
[37] (2.25 m x 0.5 m x 1,740 m) x 0.07 md/m³ ≈ 137 md.
[38] 2.25 m x 2.5 m x 1,740 m = 9,787.5 m³; Quarrying: 9,787.5 m³ x 2 md/m³ ≈ 19,575 md.

involves an additional 39,200 md.[40] To smooth out the natural rock where walls were not located 40 md would be required.[41] Once this step is completed, presumably the entire perimeter of the plateau was fortified in one way or the other. Supervision at every step adds another 5,900 man-days. In the end, the entire defensive construction process would reach costs of 65,100 man-days and 4,500 ox-carriage days (Table 6.1). In its entirety, fortifying Akrai would have necessitated higher labour costs than at Heloros, as can be expected since the former was four times larger than the latter. However, since there was a quarry on site inside the fortified urban centre, transport costs at Akrai were lower.

Table 6.1: Total labour costs for the construction of fortifications at Akrai

RESOURCE		***ACTION IN MD***	
	Acquisition	**Transport**	**Construction**
STONE:	19,575	4,450 od	39,150
SMOOTHING EDGE:			38
BACKFILL:			137
INITIAL LEVELLING OF SITE:			274
TOTALS:	19,575	0	39,599
SUPERVISION: (+ 10%)	1,958	0	3,960
BASE TOTAL:		65,092 + 4,450 od	
RANGE OF TOTALS:		65,092–80,243	

6.6 Akrai: Houses

The houses at Akrai can be reconstructed as 12 m long by 5 m wide, incorporating three rooms (Fig. 6.5). It is likely that the houses had an open area in front of them, but it would not have added to building costs. Using comparative data from Heloros, the walls are reconstructed as 0.50 m thick and 2.5 m high. Small alleyways 3 m wide presumably separated the houses from each other, while a larger passageway, perhaps up to 4 m likely separated neighbouring groups and allowed access to each courtyard and the stenopoi bordering on each side. While the costs of both all-stone and mudbrick houses were estimated at Heloros, only the former will be calculated here. The assumption is that in the decades before the foundation of Akrai, as Syracuse grew, more resources would have available at Akrai than at Heloros. In fact, stone houses were common from the end of the eighth century at Megara Hyblaia.[42] Further, as there was a quarry within the urban centre, the material was readily available nearby.

A house of these dimensions includes a long back wall of 12 m, four perpendicular walls each 4 m in length and the front wall of 12 m. Levelling the ground before construction likely

---

[39] Transport: 9,787.5 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 28,275 carriage-loads. (28,275 carriage-loads / 8 trips per day) + 25.9% ≈ 4,450 od.
[40] 9,787.5 m³ x 4 md/m³ ≈ 39,150 md.
[41] (0.25 m x 2.5 m x 860 m) x 0.07 md/m³ ≈ 38 md
[42] De Angelis 2003, pp.20-3.

dug only to a short distance given the placement of the settlement on a plateau. Again, the foundations will be lowered to a depth of 0.50 m, removing 10 m³ of earth and taking a man-day.[43] The rubble then would need removed from the site, and although it could have been reused in the backfill placed behind the stone fortifications, here it will be presumed that the rubble was taken out of the urban centre. This construction waste could have been merely dumped off the plateau edge, or even placed in areas along the perimeter more strategically. Either way, to take minimum labour costs, the rubble will be discarded at maximum 0.50 km away, the furthest reach from the centre of the plateau to the edge. Accounting for the carrying, loading, unloading and carriage transport, removing the rubble from the site would entail 4 md and 5 od.[44]

For the walls above ground 50 m³ of stone would have been required.[45] The front wall would have included openings for the entrances, and so their volumes will be subtracted from the total. Given the equal spacing of the walls, the front wall is 3.33 metres in length inside each room. Each doorway at 1 m is close to a third of that length. As above at Heloros, the doorway height will only reach 2 m with a lintel support at the top. Here, the lintel volumes will also be subtracted from the total material costs. For each opening 1.19 m³ can be subtracted from the overall stone calculations,[46] bringing the total down to 46.43 m³. Quarrying this amount of stone would have cost 12 md, transporting it 21 od and an additional 50 md for construction.[47]

At Megara Hyblaia, roof tiles in private houses were not used until the sixth century, but even then the evidence is scarce.[48] The archaeological reports of Akrai do not mention roof tiles, so a flat roof is assumed here.

A three-room house constructed of this size covers 60 m² of space. The principal beams would have been placed across the shorter span of 3.33 m parallel to the length of the house. While the beams could be placed perpendicular to this, neither choice would require support posts within the interior and choosing the shorter span would provide greater support with less timber. These principal timbers, likely kept rounded, would have been placed within and must reach up to an additional 0.25 m into the walls on both ends (Fig. 6.5). Four beams 3.83 m long,

---

43 Long walls: (0.50 m x 0.50 m x 12 m) x 2 = 6 m³; short and interior walls: (0.50 m x 0.50 m x 4 m) x 4 = 4 m³; 6 m³ + 4 m³ = 10 m³. 10 m³ x 0.14 md ≈ 1.4 md.

44 Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 10 m³ x 0.386 md/m³ ≈ 3.86 md; transport: 10 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 29 carriage-loads. A team of oxen could make 8 trips of 500 m each way in a day. (29 carriage-loads / 8 trips per day) + 25.9% ≈ 5 od.

45 Long walls: (0.50 m x 2.5 m x 12 m) x 2 = 30 m³; short and interior walls: (0.50 m x 2.5 m x 4 m) x 4 = 20 m³; 30 m³ + 20 m³ = 50 m³.

46 Doorway: 0.5 m x 2 m x 1 m = 1 m³; lintels: (1.5 m x 0.25 m x 0.25 m) x 2 = 0.19 m³.

47 Quarrying: 46.43 m³ x 0.25 md ≈ 11.61 md; transport: 46.43 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 134 carriage-loads. (134 carriage-loads / 8 trips per day) + 25.9% ≈ 21 od; construction: 46.43 m³ x 1 md/m³ ≈ 46.43 md.

48 Vallet et al. 1976, pp.255-7.

0.2 m in diameter and placed 0.56 apart would support well the roofing structure in each room. Six lintels, 0.25 m x 1.50 m, must be squared taking 1 md.[49] Twelve roofing timbers and six lintels equates to 2.4 m³ adding 1 od, and would cost 2 md to set into place.[50] Add an additional man-day to collect the materials and weather-proof the roof.

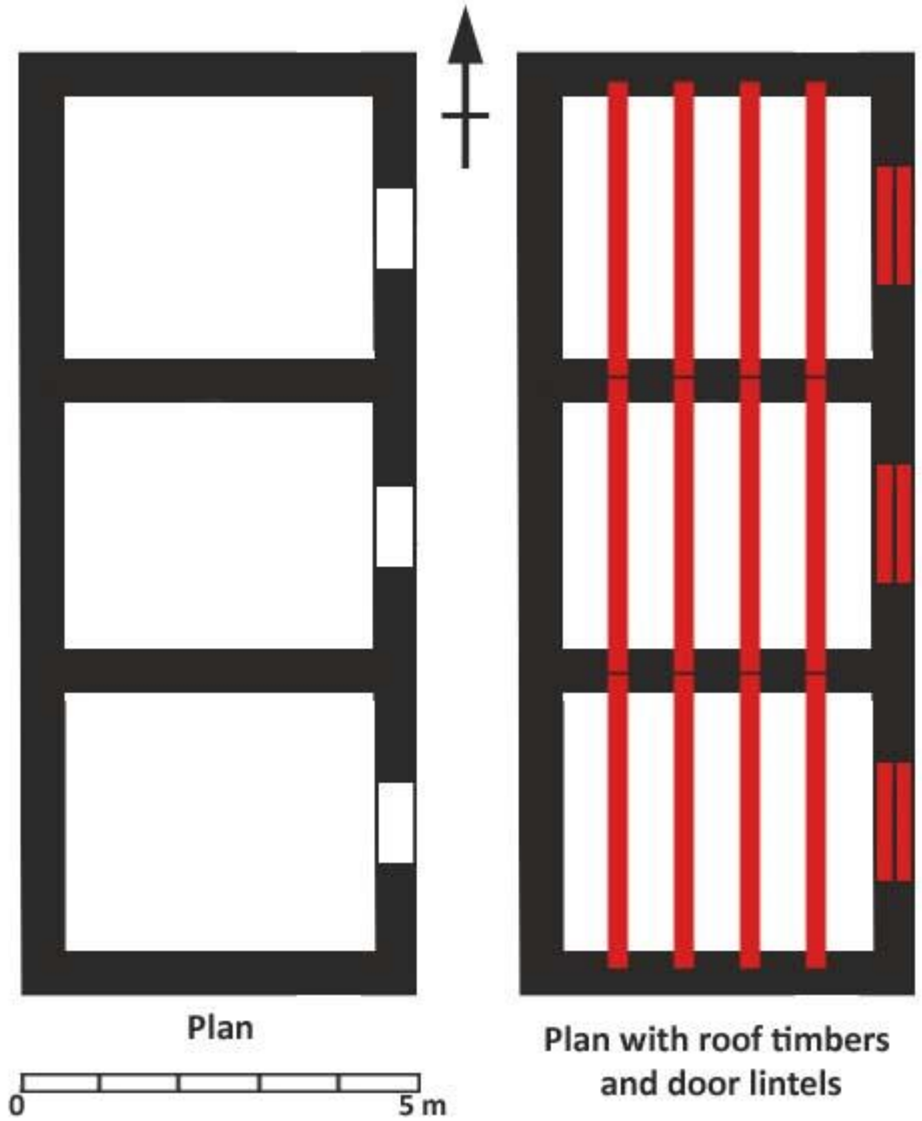

Fig. 6.5: Akrai. House plans (AH) used in the econometric calculations.

Three wooden doors can be reasonably sized to 1 m long, 0.05 m thick and rise 1.75 m high. As above, three planks per door, nine total, cut from one and a half timbers 0.33 m by 1.75 adds 1 md, while the wood costs total 1 md and 1 od.[51] Total cost for the three-roomed residence built in stone adds up to 80 man-days with 30 ox-carriage days (Table 6.2).

[49] 4 (length-wise cuts) x 0.25 m (lintel width) x 1.5 m (lintel length) x 0.14 md/m^2 x 6 (lintels) ≈ 1.26 md.
[50] (3.83 m x 0.2 m x 0.2 m x 12) + (1.5 m x 0.25 m x 0.25 m x 6) = 2.4 m³; felling: 2.4 m³ x 2.7 md/m³ ≈ 6.48 md; transport: 2.4 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 2 carriage-loads. (2 carriage-loads / 4 trips per day) + 25.9% ≈ 1 od; 18 timbers x 0.1 md/timber ≈ 1.8 md.
[51] 6 (length-wise cuts) x 0.33 m (plank width) x 1.75 m (plank length) x 0.14 md/m^2 x 1.5 (timbers) ≈ 0.73 md; (1.75 m x 0.33 m x 0.33 m) x 1.5 (timbers) = 0.29 m³; felling: 0.29 m³ x 2.7 md/m³ ≈ 0.78 md;

Table 6.2: Total labour costs for the construction of an all-stone house at Akrai

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	11.61	21 od	46.43
INITIAL LEVELLING OF SITE:			1.40
DISPOSAL OF RUBBLE:		3.86 + 5 od	
ROOF:	6.48	1 od	4.06
DOORS:	0.78	1 od	0.73
TOTALS:	18.87	3.86	52.62
SUPERVISION: (+ 10%)	1.89	.39	5.26
BASE TOTAL:		82.89 + 28 od	
RANGE OF TOTALS:		82.89–294.48	

6.7 Akrai: Temple of Aphrodite

Likely built in the second half of the sixth century, the placement of the temple was already planned for at foundation of the settlement over a century earlier (Fig. 1.6: AT).[52] The depth of temple foundations varies throughout. The eastern blocks are mostly directly placed on bedrock, while at the opposite end the foundations consist of six courses. With an average height of 0.50 m, this creates a foundation depth of 3 metres. The temple has a double-stepped stereobate (Fig. 6.6) with the lengths of the four sides measuring as follows: East 19.6 m, West 19.1 m, North 40.5 m, South 40.4 m. The maximum size at the first step is 39.52 m by 18.24 m. The width of the two steps has been reconstructed as 92 cm (c. 3 A').[53] Therefore, the stylobate size is c. 37.68 m by 16.40 m.[54]

Due to the unevenness of the bedrock and since over time the temple itself was robbed of its stone in most places, the foundations are estimated at an even slope from 0.50 m at the highest level at the easternmost side of the temple down to 3 m (six courses of 0.50 m) at the opposite end. The volume of earth and bedrock removed is here estimated as an even layer of 0.50 m; 390 m³ in total.[55] The volume of limestone to build the foundations is approximately 1,370 m³.[56] The labour costs for levelling the foundations come to less than 60 md.[57] Disposing of this excess rubble will also require some labour and transport costs of 150 md and 180 od to

---

transport: 0.29 m³ x 0.56 tonne/m² / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 8 trips per day) + 25.9% ≈ 1 od.

[52] Bernabò Brea 1986, p.15.

[53] Bernabò Brea 1986, p.22).

[54] Width: 18.24 m – 1.84 m = 16.40 m; length: 39.52 m – 1.84 m = 37.68.

[55] 0.50 m × 40.45 m × 19.35 m ≈ 391.35 m³.

[56] The first foundation level was removed across the entire temple area, while the remaining foundation is paramount to half a rectangle the size of the temple with a depth of 2.5 m. Using the average dimensions of the whole foundations the volume can be calculated as follows: ((1st level) 0.50 m × 40.45 m × 19.35 m) + ((2.5 m × 40.45 m × 19.35 m) / 2) ≈ 1,369.74 m³.

[57] 391.35 m³ x 0.15 md/m³ ≈ 58.7 md.

an area outside the urban centre.[58] Quarrying the limestone would take 2,750 md;[59] transport 50 od.[60] The most labour intensive aspect of the foundations would be its construction requiring 5,500 md to complete.[61]

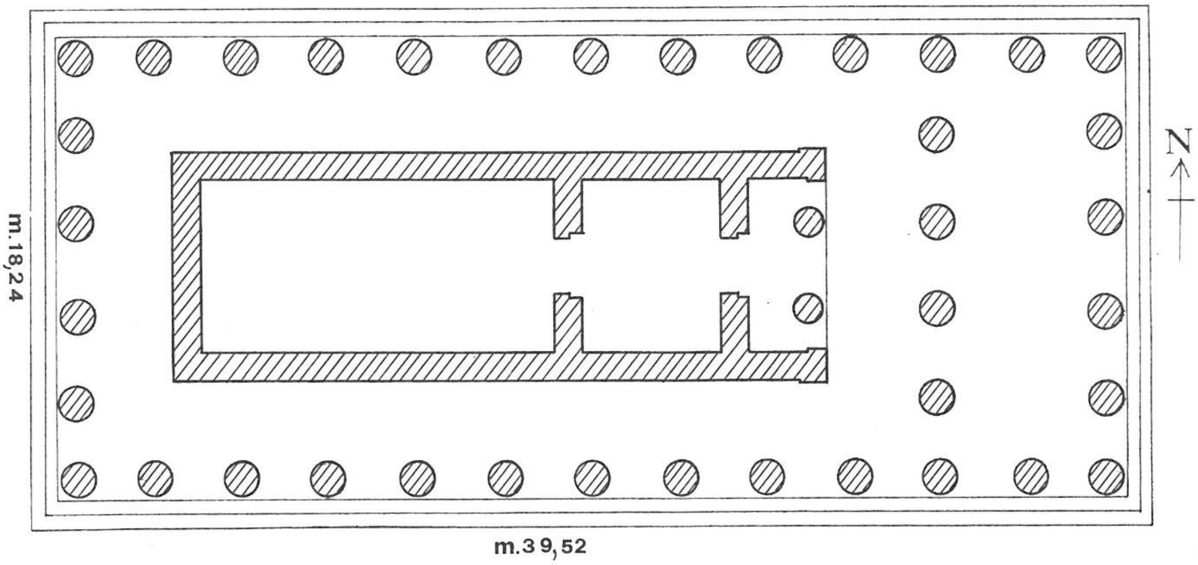

Fig. 6.6: Akrai. Reconstructed plan of the Temple of Aphrodite (AT). Bernabò Brea 1986, p.47.

Once the stereobate is in place, the platforms comprising the two steps and stylobate encompass three more levels of stone. Using the theoretical Akrai foot of 30.4 cm as the height of each step, the first level contains 219.14 m³ of stone, the second level 203.24 m³ and the third 187.86 m³.[62] This 610.24 m³ total of stone equates to 1,200 md of quarrying,[63] 20 od for transport[64] and 2,400 md setting into place.[65]

Upon the stylobate, the sekos faces eastward as expected, opening into the pronaos followed by the antecella and then into the cella. The interior dimensions of the three rooms of the sekos have been estimated above: pronaos 2.70 m by 6.10 m, antecella 4.90 m by 6.10 m and cella 12.50 m by 6.10 m. The wall widths are estimated as 0.90 m, and the width of doorways 1.90 m. Each long wall of the sekos reaches 22.80 m in total length,[66] while in

---

[58] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 391.35 m³ x 0.386 md/m³ ≈ 151.06 md; transport: 391.35 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 1,131 carriage-loads. A team of oxen could make 8 trips of 500 m each way in a day. (1,131 carriage-loads / 8 trips per day) + 25.9% ≈ 178 od.

[59] 1,369.74 m³ x 2 md/m³ ≈ 2,739.48 md.

[60] 1,369.74 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 3,957 carriage-loads. (3,957 carriage-loads / 80 trips per day) ≈ 50 od.

[61] 1,369.74 m³ x 4 md/m³ ≈ 5,478.96 md.

[62] With steps of .92 m, the second level axis is 38.60 m by 17.32 m. 1st level: 39.52 m x 18.24 m x 0.304 m = 219.14 m³; 2nd level: 38.60 m x 17.32 m x 0.304 m = 203.24 m³; 3rd level: 37.68 m x 16.4 m x 0.304 m = 187.86 m³; 219.14 m³ + 203.24 m³ + 187.86 m³ = 610.24 m³.

[63] 610.24 m³ x 2 md/m³ ≈ 1,220.48 md.

[64] 610.24 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 1,763 carriage-loads. (1,763 carriage-loads / 80 trips per day) ≈ 22 od.

[65] 610.24 m³ x 4 md/m³ ≈ 2,440.96 md.

[66] This includes the lengths of the three rooms and the 0.90 m width of each transverse wall.

between these the western wall runs for 6.10 m. The two interior walls extend 2.10 m on either side of the doorways. Based on the column height of 5.47 m, the height of the sekos walls can be estimated as 7.52 m, reaching to the first level of roof supports at the cornice. This includes a column height of 5.47 m and 2.05 m for the architrave and frieze. Further, the doorways will be estimated to the column height with stone above. The two smaller pronaos columns are included in the sekos construction calculations. These have been estimated with a diameter of 0.90 m and height of 5.47 m and the capitals proportional to the smaller size of the columns. The depth of the architrave and frieze carried by these columns, spanning the front of the pronaos, can be presumed to be thinner than the width of the sekos walls, and as such two and a half Akrai feet (0.76 m). Here the stone walls will be calculated only to the height of the cornice, and will stretch in length equal to the opposing, western wall. Including the small columns, this creates 429.83 m³ total of stone required to construct the sekos.[67] Labour costs here equate to about 860 md of quarrying,[68] 16 od for transport[69] and 3,400 md setting into place.[70] Due to the higher precision of joining the blocks, a rate of 8.0 md/m³ will be used at this point as well as for the remaining construction in stone.

Surrounding the sekos are thirty-eight columns (including the four interior columns of the second row in front of the pronaos) supporting the entablature, and leading to the roof. Each column has been estimated at 1.22 m in lower diameter with a shaft height of 4.92 m and a capital height of 0.55 m and abacus width of 1.22 m. All of this totals to 250 m³ of stone.[71] The total height of the entablature, consisting of the architrave, frieze and cornice, is therefore estimated as c. 2.74 m in height, with the architrave height of 1.37 m, and the frieze and cornice each at 0.68 m. The architrave had a depth of c. 0.90 m. This is also the depth of the frieze, while the cornice likely extended outward, away from the sekos, an additional Akrai foot, or 1.20 m in total depth. The length of the entablature was slightly less than the dimensions of the stylobate.[72] With this, the architrave can then be estimated at 130 m³.[73] The volume of stone

---

[67] Long walls: 22.80 m x 0.90 m x 7.52 m x 2 = 308.62 m³; Western wall: 6.10 m x 0.90 m x 7.52 m = 41.29 m³; Interior walls: 2.10 m x 0.90 m x 7.52 m x 4 = 56.85 m³; Eastern pronaos entablature: 6.10 m x 0.76 m x 2.05 m = 8.91 m³; Above doorways: 1.90 m x 0.90 m x 2.05 m x 2 = 7.01 m³; Columns: (π x (0.45 m)² x 4.92 m) x 2 = 6.26 m³; Capitals: (0.90 m x 0.90 m x 0.55 m) x 2 = 0.89 m³. 308.62 m³ + 41.29 m³ + 56.85 m³ + 8.91 m³ + 7.01 m³ + 6.26 m³ + 0.89 m³ = 429.83 m³

[68] 429.83 m³ x 2 md/m³ ≈ 859.66 md.

[69] 429.83 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 1,242 carriage-loads. (1,242 carriage-loads / 80 trips per day) ≈ 16 od.

[70] 429.83 m³ x 8 md/m³ ≈ 3,438.64 md.

[71] Columns: (π x (0.61 m)² x 4.92 m) x 38 = 218.55 m³; Capitals: (1.22 m x 1.22 m x 0.55 m) x 38 = 31.11 m³. 218.55 m³ + 31.11 m³ = 249.66 m³.

[72] The columns are set slightly in from the edge of the stylobate (c. 0.05 m), and the architrave is set c. 0.04 m in from the abacus edge, so 2 × 0.09 m can be subtracted from the stylobate dimensions to obtain the size of the temple at the architrave level (c. 37.50 m by 16.22 m).

[73] Long sides: 37.50 m x 0.90 m x 1.37 m x 2 = 92.48 m³; Ends: 14.42 m x 0.90 m x 1.37 m x 2 = 35.56 m³. As with the walls, the ends are less the width of the long sides. 92.48 m³ + 35.56 m³ = 128.04 m³.

for the frieze was c. 65 m³;[74] the cornice, 84 m³.[75] The four columns in front of the pronaos carried a stone entablature of the same dimensions as the exterior order minus the cornice stone, as a prop-and-lintel support will be placed here. This entablature would have extended the width of the eastern end of the temple, minus the depth of the exterior entablature, where it joined the outer colonnade at each end. This creates 27 m³.[76] In total, the columns and entablature supporting the temple roof requires 550 m³ of stone.[77] Labour costs required to quarry this quantity of stone amount to 1,100 md,[78] with 20 od for transport.[79] At a rate of 8.0 md/m³, 4,400 md complete this phase.[80]

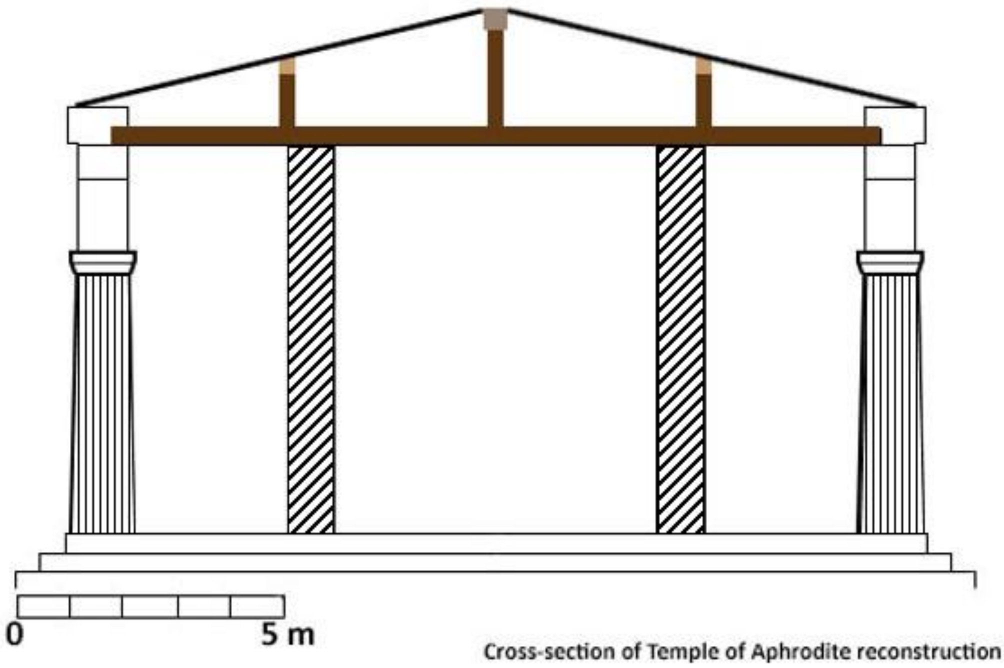

Fig. 6.7: Akrai. Temple of Aphrodite (AT). Roof structure.

The reconstruction of all the elements above the entablature is based on architectural comparanda. Stone pediments would have been constructed at both ends of the temple. The dimensions of the roof can be estimated on the basis of the stylobate dimensions. Based on architectural comparanda, the roof was most likely built of wood above the north and south walls of the sekos (Fig. 6.7).[81] Based on other sixth-century temples, the height of the pediment can be estimated as 1.82 m (6 A'), this generates a total height of the temple at its apex of

[74] Long sides: 37.50 m x 0.90 m x 0.68 m x 2 = 45.90 m³; Ends: 14.42 m x 0.90 m x 0.68 m x 2 = 17.65 m³. 45.90 m³ + 17.65 m³ = 63.55 m³.

[75] Long sides: 37.50 m x 1.20 m x 0.68 m x 2 = 61.2 m³; Ends: 14.42 m x 1.20 m x 0.68 m x 2 = 23.53 m³; At ten points the cross beams are placed within the cornice stone 0.40 m which must be subtracted from the total stone. 61.20 m³ + 23.53 m³ - (0.40 m x 0.30 m x 0.30 m x 10) = 84.37 m³.

[76] 14.42 m x 0.90 m x 2.05 m = 26.61 m³

[77] 249.66 m³ + 128.04 m³ + 63.55 m³ + 84.37 m³ + 26.61 m³ = 552.23 m³.

[78] 552.23 m³ x 2 md/m³ ≈ 1,104.46 md.

[79] 552.23 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 1,595 carriage-loads. (1,595 carriage-loads / 80 trips per day) ≈ 20 od.

[80] 552.23 m³ x 8 md/m³ ≈ 4,417.84 md.

[81] Hodge 1960, p.35.

10.03 m (33 A’) and a roof angle of 12 degrees.[82] The slope of the roof would extend 8.61 m in total on each side of the peak.[83] This is a little over 28 Akrai feet. The height of the raking cornice surrounding the tympanum is here estimated as an additional Akrai foot (0.30 m). The tympanum had a height of c. 8.31 m (27 A’). The distance the raking cornice extends from the vertical face of the pediment is the same as the horizontal cornice on the long sides (cf. Fig. 6.7). The length of the tympanum can be estimated as 13.82 m, a little wider than the breadth of the central four columns. Each end pediment totals 14 m³ of stone.[84] This is calculated with a depth of 0.90 m (3 A’), which matches the depth of the entablature and the cornice overhang, but not the overhang at each end which was included in the cornice calculations above. The two pediments equal 28.16 m³, totalling 56 md quarrying, 1 od for transport and 230 md to set into place.[85]

Timber was the most important material for the roof. The timbers would have slotted into cuttings at certain points in the stone structure, but the amount of additional labour required is quite insignificant and will be ignored. The largest timbers would have been the ridge beams running the length of the temple at its highest point. These were supported by a prop-and-lintel system at many points in the structure. Naturally, it should be expected that each wall provided a point to support the roof, and so the dimensions of the sekos provide the necessary lengths of the timbers. The width of the sekos, 6.10 m, allows for a single timber to span that distance. The cella is the largest space to cover and its length, 12.50 m, requires more than one ridge beam. With no archaeological evidence at Akrai for the timber sizes, architectural comparative material is used in establishing the relevant dimensions. The ridge beam dimensions can reasonably be reconstructed as 0.40 m square[86] and it was supported at both ends and five points in the structure, each north-south wall, halfway along the length of the cella and above the inner entablature. The size of the props and each cross beam can be estimated at 0.30 m square, as will the purlins running parallel to the ridge beam lower down the roof slope, also placed upon the supports. Rafters, placed perpendicular to the primary timbers, were used to support of the roof tiles, and so the tile size defines their positions. The

[82] Dinsmoor 1975, p.87; Mertens 2006, p.109, Fig. 169. Cf. Coulton 1977, p.158.
[83] Given a triangle height of 1.82 m and length of 8.41 m (half the architrave width of the temple and the cornice extensions), the hypotenuse equals 8.61 m: $\sqrt{(1.82\ )^2 + (8.41)^2} = 8.61$.
[84] Each pediment cubic area is half the cubic area of a rectangle with the same dimensions: (16.82 m x 0.90 m x 1.86 m) / 2 = 14.08 m³.
[85] 14.08 m³ x 2 = 28.16 m³; quarry: 28.16 m³ x 2 md/m³ ≈ 56.32 md; transport: 28.16 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 81 carriage-loads. (81 carriage-loads / 80 trips per day) ≈ 1 od; Construction: 28.16 m³ x 8 md/m³ ≈ 225.28 md.
[86] Hodge 1960, p.46, Table 2.

average tile size was 0.70 m x 0.50 m and they are placed directly on the secondary timbers. Thus, 0.10 m square rafters can support a 5-cm overlay of each tile.[87]

Supports for this roof structure are found in the way of cross beams running the width of the temple, placed 0.40 m into the cornice, and props placed vertical from the cross beams to the ridge beam and purlins (Fig. 3.4). Each cross beam, figured to run from a third of the colonnade to that on the opposite side across the width of the sekos (Fig. 6.8: A), would need to run 15.89 m. in total.[88] A single timber could have been placed running this entire span resting on the sekos walls, or split into three pieces, yet either way the distance is the same. Each centre support placed under the ridge beam to the cross beam would measure 1.80 m in length.[89] This is calculated from the total height of the pediment minus the width of the ridge beam, and the difference in height between the cornice stone and the cross beam (Fig. 6.7). Supposing the purlins are placed halfway down the roof slope, the supports for these primary timbers would need to each reach 0.99 metres.[90] This is found in the same manner but with half the dimensions of the pediment. With three props and three cross beams per support, thirty total timbers would be needed in the five prop-and-lintel supports, totalling 8.85 m³ of timber.[91]

Along the top of the temple, the ridge beams are figured to have abutted one another end to end terminating at the stone pediment sockets (Fig. 6.8: B). The same can be expected for the purlins running parallel on each side (Fig. 6.8: C). Therefore, placed into a socket 20 cm deep on each temple end, and supposing grooves were cut through the interior pediment,[92] 39.12 m of total length was required for the ridge beams and each stretch of purlins.[93] This equates to 13.30 m³ of primary timber.[94] At minimum, seven independent ridge beams could have connected the pediments and the supports across the length of the temple. The same can be expected of the purlins on each side, or 14 in all. Rafters, perpendicular to and placed flush with the beams and upon the purlins, would need to run the slope of the roof almost to the

---

87 Cf. Hodge 1960, p.71.

88 Each column sits 0.10 m from the steps with a lower diameter of 1.22 m: 16.4 m (stylobate width) - 0.10 m - (1.22 m / 3) = 15.89 m.

89 1.82 m (pediment height) - 0.40 m (ridge beam height) + 0.68 m (cornice height) - 0.30 m (cross beam height) = 1.80 m.

90 A triangle with half the hypotenuse (4.31 m) and half the length (4.21 m) of half the pediment has half the height = 0.91 m. 0.91 m + 0.68 m (cornice height) – 0.30 (purlin height) – 0.30 (cross beam height) = 0.99 m.

91 (0.30 m x 0.30 m x 15.89 m (length of each cross beam)) + (0.30 m x 0.30 m x 1.80 m (height of each centre prop)) + (0.99 (height of each purlin prop) x 0.30 x 0.30 x 2) x 5 ≈ 8.85 m³.

92 As above, the sockets would not have lowered the initial quarrying costs, and the labour to remove that stone from each block is considered negligible. For these reasons, this aspect of the construction process is disregarded.

93 39.52 m (stereobate axis length) – (0.20 m x 2) (end beam sockets) = 39.12 m.

94 Ridge beams: (0.40 m x 0.40 m x 5.59 m) x 7 = 6.26 m³; Purlins: (0.30 m x 0.30 m x 5.59 m) x 14 = 7.04 m³. 6.26 m³ + 7.04 m³ = 13.30 m³.

edge, 8.41 m, on each side (Fig. 6.8: D). This distance is derived from the expectation of the timbers to have been placed end to end resting on the purlins halfway up the slope, while only extending to within 20 cm of the end of the cornice. The tiles themselves are expected to have reached the cornice edge. Seventy-seven rafters could span 38.30 m, the entire length of the temple less the two Akrai feet pediment border on each end, placed 0.40 m apart.[95] This figure accounts for a single timber stretching the entire slope, totalling 12.95 m³ of secondary timber.[96] The rafters will be cut at half the length, beginning and ending on the centre purlin, which equals 154 on each side or 308 in all.

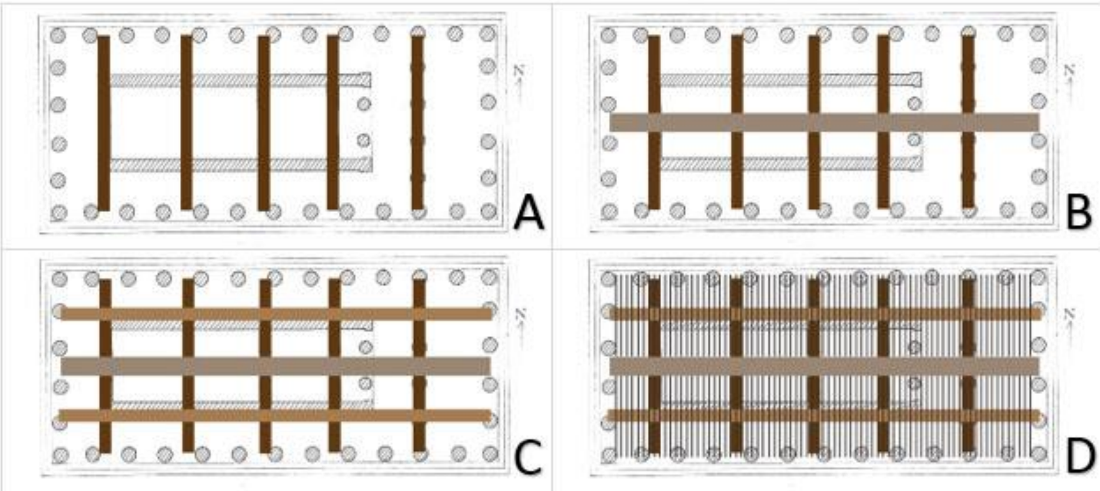

Fig. 6.8: Akrai. Temple of Aphrodite (AT). Roof structure indicating (not to scale) cross beams (A), ridge beam (B), purlins (C) and rafters (D). Bernabò Brea 1986, p.47, Fig. 3 with additions.

In the end, the total timber required from the primary and secondary beams and supports is 35.10 m³.[97] This roof, albeit minimal in design for this case-study, would have amounted to quite an undertaking. Seven ridge beams 5.59 m by 0.40 m and 14 purlins 5.59 m by 0.30 m needed to be squared before they could be placed: 22 md.[98] Squaring the 308 rafters, 0.10 m by 4.97 m, increases the costs by 70 md.[99] To square the supports adds 16 md.[100] Felling the timber adds 150 md,[101] while transporting the timber would take a total of 7 od.[102] Given

---

[95] 39.52 m (stereobate axis length) – (0.61 m x 2) (pediment borders) = 38.30 m; 77 rafters 10 cm in width at 40 cm intervals, with a rafter on each end. (77 rafters x 0.10 m) + (76 space x 0.40 m) = 38.10 m. The 20 cm excess could have easily been accounted for throughout the placement of the rafters.

[96] 77 (rafters) x 2 (roof sides) x (0.10 m x 0.10 m x 8.41 m) = 12.95 m³.

[97] 13.30 m³ (primary) + 12.95 m³ (secondary) + 8.85 m³ (prop-and-lintel supports) ≈ 35.10 m³.

[98] 4 (length-wise cuts) x 0.40 m (beam width) x 5.59 m (beam length) x 0.14 md/m^2 x 7 (beams) ≈ 8.77 md; 4 x 0.30 m x 5.59 m x 0.14 md/m^2 x 14 (purlins) ≈ 13.15 md; 8.77 md + 13.15 md ≈ 21.92 md.

[99] 4 (length-wise cuts) x 0.10 m (rafter width) x 4.21 m (rafter length) x 0.14 md/m^2 x 308 (rafters) ≈ 72.61 md.

[100] Cross beams: 4 (length-wise cuts) x 0.30 m (cross beam width) x 15.89 m (cross beam length) x 0.14 md/m^2 x 5 (cross beams) ≈ 13.35 md; centre props: 4 x 0.30 m x 1.80 m x 0.14 md/m^2 x 5 ≈ 1.51 md; purlin props: 4 x 0.30 m x 0.99 m x 0.14 md/m^2 x 10 ≈ 1.66 md; 13.35 md + 1.51 md + 1.66 md ≈ 16.52 md.

[101] Felling: ridge beams: 6.26 m³ x 5.5 md/m³ ≈ 34.43 md; purlins: 7.04 m³ x 5.5 md/m³ ≈ 38.72 md; rafters: 12.95 m³ x 2.7 md/m³ ≈ 34.97 md; cross beams: (15.89 m x 0.30 m x 0.30 m x 5) x 5.5 md/m³ ≈

the size of the primary timbers, 53 md will be estimated per beam, purlin and the supports, while the secondary timbers will only be calculated at a half man-day per rafter. Seven ridge beams, 14 purlins and 30 support timbers make for 2,400 md of work, while the 308 rafters themselves account for 150 md.[103] At 2,900 md of labour, fitting the timbers of the roofing structure almost matches that of the stone sekos.

The expectation here is that the roof tiles would have been placed directly on the rafters. The overlap of the pantiles is estimated as 4 cm resulting in roughly 77 columns of 13 pantiles with 76 columns of 13 cover-tiles on each side of the roof apex. An additional 79 ridge-tiles then line the top of the roof. In total, 4,136 tiles would have been needed.[104] In Table 2.1 is listed the labour costs for manufacturing the tiles resulting in 185 md for the tiles here, including quarrying the clay.[105] With 74 m³ of clay required per 1,000 tiles, 306.06 m³ would have been needed at Akrai.[106] A transport distance of a kilometre results in 190 od to bring the clay to the construction site.[107] Closely following the beam and rafter lengths, the roof reaches 8.61 m (0.20 m past the rafters) by 39.12 m on each side creating an area of 673.65 m² to be covered in 47 md.[108]

The width of the doorways has been estimated as 1.90 m and 5.47 metres high. Assuming a typical temple entrance with double hardwood doors at each doorway, four total doors with a width of 0.95 m each would have been needed. Each door can be made from two planks about 0.48 m wide by 0.06 m thick and 5.47 m tall. This thickness allows for no waste from the cutting process. It can be reasonably expected that the eight planks making the doors could be taken from one timber over 0.48 m wide and 5.47 m tall using 11 cuts and 4 md.[109]

39.33 md; centre props: (1.80 m x 0.30 m x 0.30 m x 5) x 2.7 md/m³ ≈ 2.19 md; purlin props: (0.99 x 0.30 x 0.30 x 10) x 2.7 md/m³ ≈ 2.41 md; 34.43 md + 38.72 md + 34.97 md + 39.35 md + 2.19 md + 2.41 md ≈ 152.07 md

[102] Transport: 35.10 m³ x 0.56 tonne/m² / 0.9 tonne per carriage-load ≈ 22 carriage-loads. (22 carriage-loads / 4 trips per day) + 25.9% ≈ 7 od.

[103] 7 (ridge beams) x 53 md ≈ 371 md; 14 (purlins) x 53 md ≈ 742 md; 30 (support timber) x 53 md ≈ 1,590 md. 371 md + 742 md + 1,590 md ≈ 2,703 md; 308 (rafters) x 0.5 md ≈ 154 md. 2,703 md + 154 md = 2,857 md.

[104] (77 x 13 pan tiles) + (76 x 13 cover tiles) x 2 sides + 79 ridge tiles ≈ 4,136 tiles.

[105] 77 columns of 13 pantiles x 2 sides ≈ 2,002 pantiles; 61 md per 1,000 pantiles ≈ 122.12 md per 2,002 pantiles; 76 columns of 13 cover-tiles x 2 sides ≈ 1,976 cover-tiles; 31 md per 1,000 cover-tiles ≈ 61.26 md per 1,976 cover-tiles; 31 md per 1,000 ridge-tiles ≈ 2.45 md per 79 ridge-tiles. 122.12 md + 61.26 md + 2.45 md ≈ 185.83 md.

[106] 4,136 tiles x 74 m³/1,000 tiles ≈ 306.06 m³.

[107] Transport: 306.06 m³ x 1.75 tonnes/m³ / 0.9 tonne per carriage-load ≈ 595 carriage-loads. (595 carriage-loads / 4 trips per day) + 25.9% ≈ 187 od.

[108] 8.61 m x 39.12 m x 2 = 673.65 m²; 673.65 m² x 0.07 md/m² ≈ 47.16 md.

[109] 11 (length-wise cuts) x 0.48 m (plank width) x 5.47 m (plank length) x 0.14 md/m² x 1 (timber) ≈ 4.04 md.

These doors then add a total of 14 md and 1 od.[110] These doors are quite complex, and so while the assembly of the planks have been ignored with regard to the residential constructions, an additional cost of making the doors seems reasonable to include a full man-day.

In total, the Temple of Aphrodite has been calculated at 28,100 man-days and 480 ox-carriage days. It becomes immediately apparent that a decent sized labour force would be necessary to complete the project in a sufficient amount of time. Contrary to the norm, however, the nearby quarry allows for a relatively small number of ox-carriages at any given time. Perhaps the lower labour costs from the easy access to stone allowed for a more elaborate temple, as will be seen in comparison to Kasmenai below.

Table 6.3: Total labour costs for the construction of the Temple of Aphrodite at Akrai

RESOURCE		***ACTION IN MD***	
	Acquisition	**Transport**	**Construction**
FOUNDATION:	2,739.48	50 od	5,478.96
INITIAL LEVELLING OF SITE:			58.70
DISPOSAL OF RUBBLE:		151.06 + 178 od	
PLATFORMS:	1,220.48	22 od	2,440.96
SEKOS:	859.66	16 od	3,438.64
COLUMNS AND ENTABLATURE:	1,104.46	20 od	4,417.84
PEDIMENTS:	56.32	1 od	225.28
ROOF:	152.05	7 od	2,968.05
TERRA-COTTA TILES:	185.83	187 od	47.16
DOORS:	10.40	1 od	5.04
TOTALS:	6,328.68	151.06	19,080.63
SUPERVISION: (+ 10%)	632.87	15.11	1,908.07
BASE TOTAL:		28,116.42 + 482 od	
RANGE OF TOTALS:		28,116.42–34,388.94	

6.8 Akrai: Population Modelling

With an estimated area of 36.5 hectares,[111] Bernabò Brea expects that Akrai, even at its height of prosperity, did not house a large population, certainly no higher than the modern city of Palazzolo Acreide (c. 13,000) in the mid-twentieth century.[112]

Starting with Hansen's method, he expects 50 percent of the intramural area to be inhabited, c. 18 hectares. At 150 to 200 people per hectare, this estimates a population of 2,700–3,600 for the end of the Archaic period.

For the foundation period, Megara Hyblaia provides sufficient comparison. There at the same time, has been estimated 45 persons per hectare.[113] At Akrai, this density gives a

[110] 5.47 m x 0.48 m x 0.48 m ≈ 1.26 m³; felling: 1.26 m³ x 5.5 md/m³ x 1.5 (hardwood) ≈ 10.40 md; transport: 1.26 m³ x 0.9 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 25.9% ≈ 1 od; 10.40 md + 4.04 md (cutting planks) ≈ 14.44 md.

[111] Hansen 2006b, pp.106-7 estimates 35 ha, but here the archaeological report will be used.

[112] Bernabò Brea 1956, pp.6, 26.

population of 810 people, if half the intramural area is inhabited. However, at Syracuse and Heloros an initial foundation inhabitation area of 20 per cent of the urban centre has been used.[114] If this is a more likely colonial expectation, then the population falls to 330 people.[115] These figures will be used as a range for the population upon foundation in 664 BC.

Estimating the *chora* attached to the urban centre of Akrai will be largely based on the almost immediate foundation of Kasmenai nearby only twenty years later (Fig. 6.9). Due to the topography, the area in the Heloros river valley below the plateau edge of Akrai was not as easily accessible to Akrai as that directly east. For this reason, one cannot expect inhabitants in the valley, if many, to have been as densely populated, and soon they become a part of Kasmenai. As will be outlined in the next chapter, the rural area of Kasmenai is estimated here to be largely encompassing the hills directly west of Akrai, and as such, given the topography around Akrai, it lends credence to expect that Akrai explicitly controlled the territory east of the urban centre (Fig. 6.10). Akrai is ca. 35 km west of Syracuse. The hinterland attached to Syracuse was estimated reaching 17.5 km where the two hinterlands are expected to meet (Fig. 6.11); this is accounted for here too. With this the area extends to c. 260 km².[116]

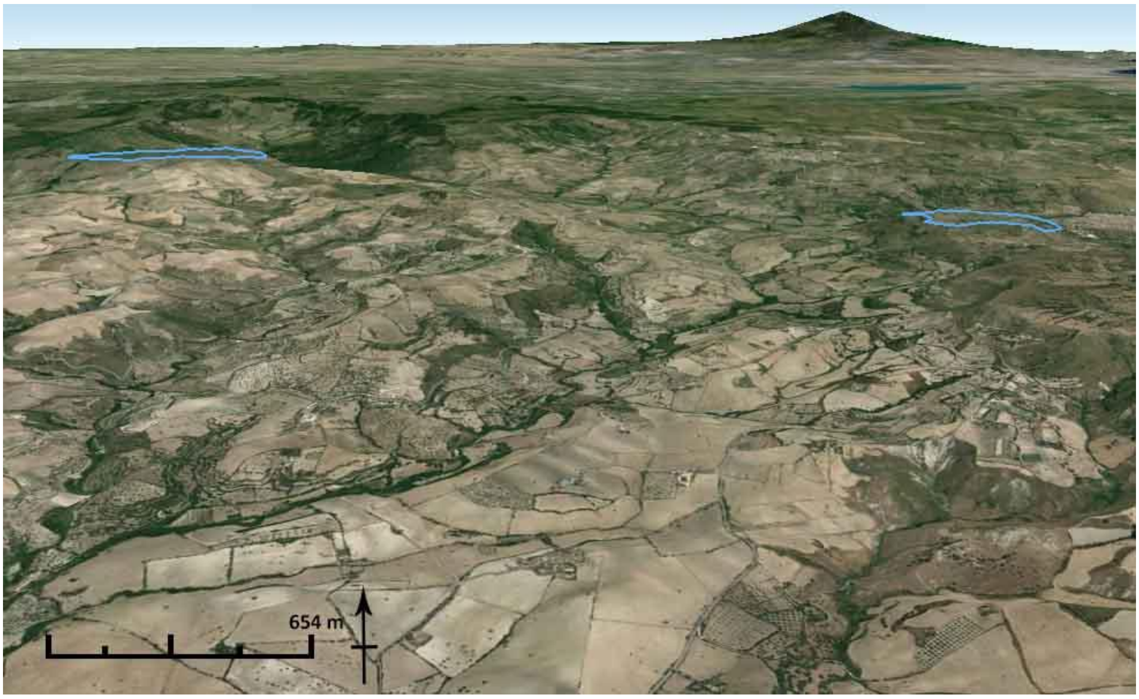

Fig. 6.9: Akrai. Topographical view facing north of Kasmenai (Left) and Akrai (Right). Google Earth.

This stretch of land associated with Akrai is delimited to the north by the river Anapos, as with the territory attached to Syracuse, and follows the plateau edge to the south-east. For the end of the Archaic period, Muggia's estimate of one site per square kilometre and 15 inhabitants per settlement gives a rural population of 3,900. Hansen places a settlement with a

[113] De Angelis 2003, p.44, Fig. 24.
[114] See sections 4.10 and 5.8 above.
[115] 36.5 ha x 20% x 45 people/ha ≈ 329 people.
[116] This was found using Google Maps Area Calculator Tool, Daft Logic 2014b.

territory of this size in the category with an even split of urban and rural populations. Using his urban estimates, the rural population is then 2,700–3,600. Therefore, a range of 2,700–3,900 rural inhabitants is used for those present in the area in 485 BC. In 664 BC, following Hansen, the rural population is c. 330–810 people, accounting for settlement densities near 0.08–0.2 sites per square kilometre. These densities and the total population range of 5,400–7,500 at the end of the period will provide the basis for the population modelling.

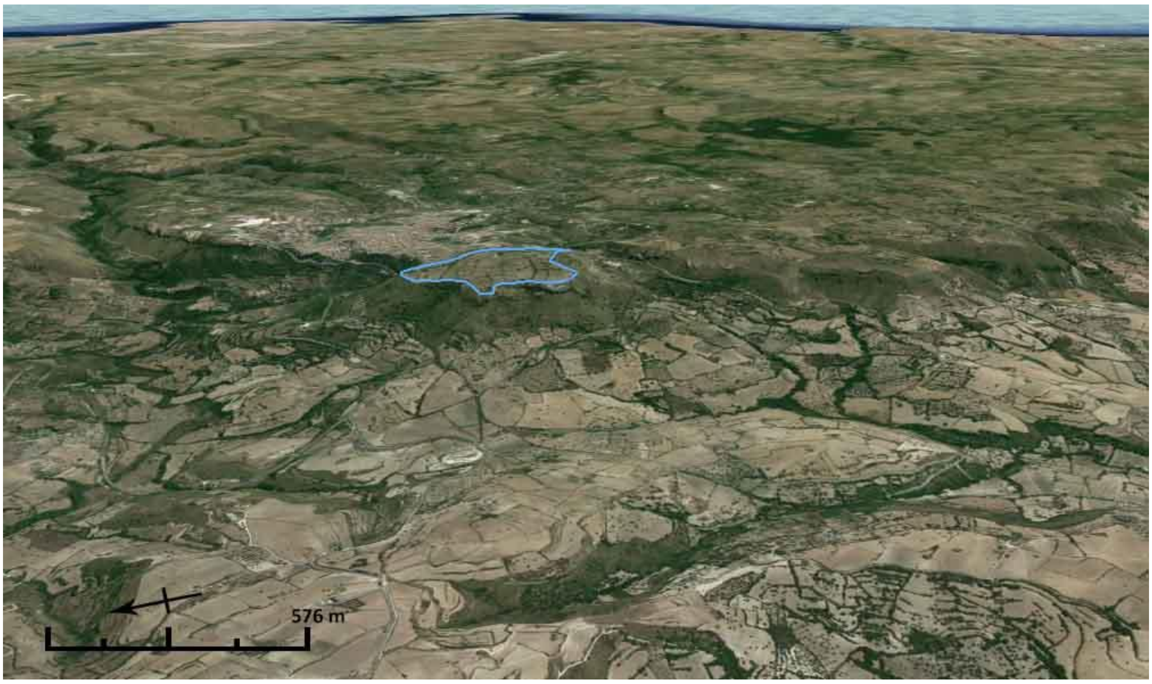

Fig. 6.10: Akrai. Topographical view facing east-south-east towards Ionian Sea. Google Earth.

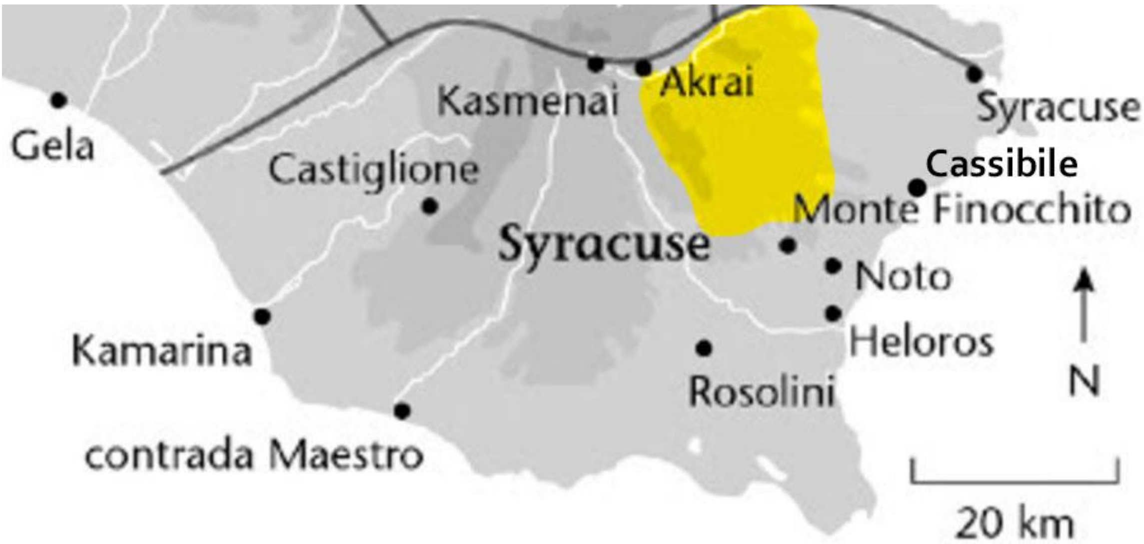

Fig. 6.11: Akrai. Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterland attached to Akrai. De Angelis 2016, p.67, Map 4 with additions.

Following population models, an image of the site through the Archaic period develops (Chart 6.1). A low urban foundation population (LU) of 330 growing at 0.5 percent annually, and adding 6.5 people a year (3 families every 2 years) reaches 2,700 by 485 BC. The higher estimate (HU), 810 people, with 5.5 immigrants per year grows to 3,600. The lower rural (LR) estimate at

0.08 sites per square kilometre, adding 6.5 people a year grows to 2,600, while the higher rural (HR) estimate increases to 3,900 people through an immigration of 7 people per year, roughly a new farmstead every two years. Akrai begins with a larger population than Syracuse had when it was settled, but grows only modestly (average 1 per cent annually) through the centuries. The intramural area and its attached territory dictate the population size and thus the expectations of the site. This is discussed further in Chapter 8. These estimates based on the models are found in Table 6.4 from the time of foundation to the end of the Archaic period.

Table 6.4: Population estimates of Akrai from foundation to the end of the Archaic period

	FOUNDATION 664 BC	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
URBAN	330 – 810	450 – 950	940 – 1,530	1,580 – 2,270	1,960 – 2,720	2,390 – 3,230	2,680 – 3,560
RURAL	310 – 780	430 – 940	920 – 1,600	1,550 – 2,450	1,920 – 2,960	2,350 – 3,540	2,640 – 3,920
TOTAL	640 – 1,590	880 – 1,890	1,860 – 3,130	3,130 – 4,720	3,880 – 5,680	4,740 – 6,770	5,320 – 7,480

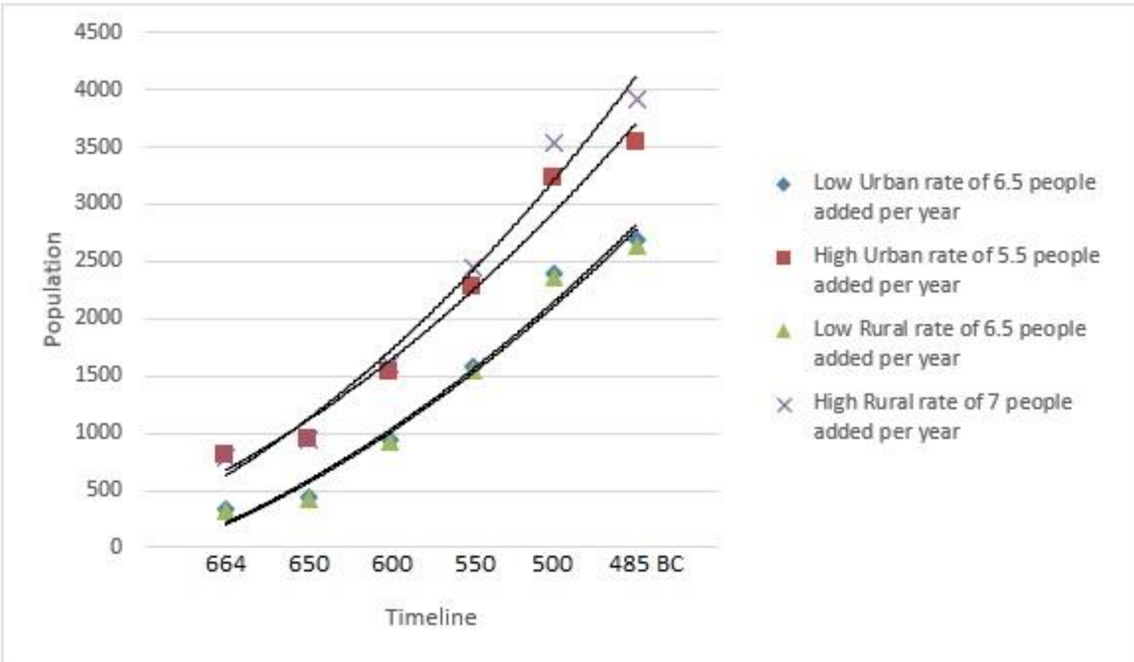

Chart 6.1: Population models of Akrai from foundation to 485 BC.

These population modelling figures estimate 330–810 members in the foundation party, providing a workforce of 74–182 men potentially able to work 2,700–16,400 md per year.[117] A population this size requires 82–203 houses; labour costs for each house have been calculated to 83–290 md. At these estimates, every family would have permanent shelter within

[117] 2,664 md/year at 74 labourers working 36 days/year; 16,380 md/year at 182 labourers working 90 days/year.

1–10 years, including those arriving to the settlement, using a workforce of 12–91 men.[118] The latter, longer timeline is based on the higher construction cost estimate and labourers only able to devote 36 days a year to building houses. It can be expected that permanent shelter would have been a priority to the population that founded the settlement, and for this reason the quicker estimate seems more likely with a lower construction cost estimate and the workforce devoting 3 months (90 days) a year to residential construction. At 28 od per house, these timelines would have required 6–60 ox-carriages.[119] The rural population at foundation is estimated at 310–780, or 21–52 farmsteads.[120] If it can be expected that each farmstead had at least one ox, then the quicker timeline becomes plausible.

By the second half of the sixth century, when the fortifications most likely were constructed, Akrai had had over a century to grow. Taking the population at 525 BC as representative of the settlement size: 3,880–5,680 people (1,960–2,720 urban, 1,920–2,960 rural) estimate a workforce of 873–1,278 labourers (441–612 urban, 432–666 rural) potentially completing 31,400–115,000 md per year.[121] The fortifications at Akrai have been estimated as 65,100–80,200 md and 4,500 od. At these figures, the fortifications could be completed in 7 months;[122] feasibly by the entire urban workforce working 90 days a year with the addition of 237 rural workmen during the summer months. On the other hand, with a smaller population and only 36 days a year to devote to construction, the wall would take upwards of 2.6 years to complete with a workforce of 74–246 men at any one time.[123] These timelines would have demanded 50–90 ox-carriages;[124] not an unreasonable request from the estimated 128–197 farmsteads in the area. With a sufficient workforce, a nearby source of stone and the fact that the fortifications here do not follow fully the plateau edge, the construction project would have been completed fairly quickly in comparison to Heloros. However, the Temple of Aphrodite is dated to around the same time, and if both were under construction simultaneously, then a longer timeline is expected.

The same population and workforce estimates will be used to analyse the timelines for the Temple of Aphrodite. For this project, labour costs have been placed at 28,100–34,400 md.

---

[118] Low estimate: (203 houses x 82.89 md) / 16,380 md/year ≈ 1.03 years; (((1.03 years x 1.38 families/year) + 203 houses) x 82.89 md) / 16,380 md/year ≈ 1.03 years. High estimate: (82 houses x 294.48 md) / 2,664 md/year ≈ 9.06 years; (((9.06 years x 1.63 families/year) + 82 houses) x 294.48 md) / 2,664 md/year ≈ 10.70 years

[119] (203 houses x 28 od/house) / 1.03 years / 90 days/year ≈ 61 ox-carriages; (82 houses x 28 od/house) / 10.70 years / 36 days/year ≈ 6 ox-carriages.

[120] Based on an average rural settlement size of 15 people. See section 3.8 above.

[121] 31,428 md/year at 873 labourers working 36 days/year; 115,020 md/year at 1,278 labourers working 90 days/year.

[122] 65,092 md / 115,020 md/year ≈ 0.57 years.

[123] 80,243 md / 31,428 md/year ≈ 2.55 years.

[124] 4,450 od / 0.57 years / 90 days/year ≈ 87 ox-carriages; 4,450 od / 2.55 years/ 36 days/year ≈ 48 ox-carriages.

Using the full capabilities of the labour pool, the temple can be estimated to a timeline of 3–13 months with 246–972 workmen at any one time.[125] This is a third of the estimates for the fortifications (the 480 od are almost a tenth), due to the temple's placement near the quarries. Given this, it may have been planned that both the temple and the fortifications construction timelines overlapped, as those tasked to material resource collection could provide for both. If this were the case, the workforce would have been divided among the two projects; the fortifications would have been completed within 14 months to 5 years,[126] and the Temple of Aphrodite around 6 months to 2 years.[127] Indeed, once the temple is finished, the remaining workforce could have devoted their time to the fortifications, lowering its timeline.

Comparanda discussed in section 4.10 above suggest that these projects would likely have be scheduled to last many years before completion, with smaller workforce sizes than estimated here. However, these analyses indicate well that the population could have provided much, if not all, of the unskilled labourers needed to complete these construction projects with perceivably little affect to the daily aspects of the community. The nearby source of stone would have provided much of the reduction in labour costs, which can be seen when comparing the projects at Akrai with those in the other settlements discussed. Perhaps this allowed for the community to devote their time to the monumental construction projects simultaneously or within a short time of each other.

[125] Low estimate: 28,116 md / 115,020 md/year ≈ 0.24 years. High estimate: 34,389 md / 31,428 md/year ≈ 1.09 years.
[126] 65,092 md / (115,020 md/year / 2) ≈ 1.13 years; 80,243 md / (31,428 md/year / 2) ≈ 5.11 years.
[127] 28,116 md / (115,020 md/year / 2) ≈ 0.49 years; 34,389 md / (31,428 md/year / 2) ≈ 2.19 years.

Chapter 7: Kasmenai

Kasmenai, the third colonial venture of Syracuse, was placed only 12 km north-west of Akrai.[1] Built in the mid-seventh century on a limestone plateau,[2] now called Monte Casale, 830 m above sea level, the inhabited area extends 1,370 m long by 450 m wide (59.6 ha),[3] edged by steep, almost inaccessible sides. Immediately, the naturally defensive parameters of this establishment become apparent, not only for itself, but also for its role in the safeguard of the nearby rivers. This location is 4 km south of Monte Lauro from which the rivers Anapos (modern Anapo), Herminius (modern Irminio) and Heloros (modern Tellaro) originate, whose mouths are respectively located at Syracuse, Kamarina and Heloros. Further to this, the indigenous presence in the area is well documented both prior to and contemporary with the Greek settlement.[4] Although currently there is little presence of trees in the area, it is expected that when the Greeks settled on Monte Casale, they would have had an ample supply of forests from which to harvest wood for building, likely within a kilometre.[5]

Archaeological evidence and historical probability support the argument that it was likely fortified upon foundation,[6] although there are views towards a sixth-century construction.[7] Also evident from the beginning is the dense series of roads running north-west to south-east, but with no discernible crossing plateiai.[8] Most of the dated material from the urban plan is from the sixth century, including the temple which follows the orientation of the surrounding streets.[9]

A catalogue of the archaeological material related to the Archaic wall and houses, and the Temple of Ares can be found below in Appendix 1 (K, sections D, E and F). An overview of the fortifications, housing and monumental architecture are given before discussing the econometric calculations. These estimates provide the minimum likely figures for the constructions. The argument and conclusions presented here will be further discussed in the last chapter within the context of the entire south-east Sicilian Syracusan territory.

---

[1] Martin et al. 1980a, p.529; confirmed using Google Maps Distance Calculator, Daft Logic 2014a.

[2] Great Britain Naval Intelligence Division 1944, p.392, Fig. 65; De Angelis 2003, p.79, Fig. 29.

[3] Area calculated using Google Maps Area Calculator Tool, Daft Logic 2014b. Cf. Hansen 2006b, p.42; Collura 2012, p.29.

[4] Orsi 1928, p.76; Orsi 1931, p.50; Martin et al. 1980a, p.530.

[5] See section 2.4.4 above.

[6] Frederiksen 2011, p.155.

[7] Miller 1995, p.261; Fischer-Hansen 1996, p.354, n.27.

[8] Collura 2012 has attempted to place a central plateia as well as theorises additional plateiai at other points in the urban layout.

[9] Martin et al. 1980a, p.532; 535.

7.1 Kasmenai: The Archaic Wall

At Kasmenai, the archaeologically attested sections of the wall show that the fortifications followed closely the edge of the plateau (Fig. 1.7: KF).[10] With the plateau of Monte Casale having been measured with a long East-West axis of 1,370 m by 450 m North-South,[11] the total length of the circuit wall can be reconstructed as 3,900 m, almost three times larger than Heloros. The length was traced using the Daft Logic distance calculator in Google Maps, and the wall is reconstructed all around the plateau.[12] Towers have been excavated along the northern edge, but these likely belong to the first half of the fourth century.[13] Therefore, as at Akrai and Heloros, the initial Archaic period construction, at foundation, is expected to have been without towers, and the calculations will reflect this.

With exclusive use of volcanic rock, the north and east sides were built as curtain walls (Fig. 5.10), like at Heloros and Kamarina, and employing a construction technique using roughly worked blocks. The thickness of the wall can be estimated as 3 metres,[14] and this will be taken as consistent throughout. The average size of blocks has been measured as 1.10 m x 0.50 m x 0.50 m.[15] It must be presumed that the remainder of the Archaic circuit was constructed similarly. Two gates have been identified along the western and southern sides. The wall thickness of 3 m is only slightly larger than that found at Heloros (2.80 m) and Kamarina (2.20 to 2.60 m). Given the standard Archaic practice of mudbrick walls on a stone socle and the mudbrick remains found at Kamarina leading to the calculations of a mudbrick superstructure at Heloros, the same technique can be expected at Kasmenai. Yet, because of the wider socle, the superstructure could have been higher.

7.2 Kasmenai: Archaic Housing

Kasmenai and its pre-planned Archaic organization are obvious through the systematic division of the plateau into blocks like at Megara Hyblaia but more along the lines of a *per strigas* plan, yet missing the wide plateiai which would stretch along the length of the site (Fig. 1.7).[16] In these blocks are found four square houses at around 12.5 m a side, approximately 156 m² in overall size, delimiting the block itself to roughly 25 × 25 m (Fig. 1.7; Fig. 7.1: KH). Also exhibiting a trend in Greek housing is the presence of a central courtyard surrounded by the rooms and accessed from the narrow stenopoi via a hallway (Fig. 7.3). The construction materials used at

[10] Martin et al. 1980a, pp.530-1.
[11] Voza 1968-1969, p.359.
[12] Daft Logic 2014a.
[13] Martin et al. 1980a, pp.530-1.
[14] Frederiksen 2011, p.155.
[15] Rizza 1957, p.206.
[16] Voza 1973c, p.128; Martin et al. 1980a, pp.533-5.

Kasmenai are locally sourced, as expected, and consist generally of volcanic stone but with the occasional use of limestone. This type of residential construction is late sixth century housing. However, this change in plan from the simple houses found at Heloros was likely complete by the end of the seventh century, and has been found around that time at colonial sites in Sicily.[17] It is possible that the complex houses were a feature of the second stage of residential construction at Kasmenai and that the building of these permanent dwellings was only started once the initial two generations and the settlement itself had been established. While founded in the seventh century, the prevalence of sixth century evidence uncovered in the housing blocks would seem to indicate that this organizational pattern remained consistent through the Archaic period. Therefore, while small-scale renovations and adaptations can be expected, overall the housing pattern at Kasmenai seems to have remained relatively stable for centuries and that no great need to drastically change the initial plan arose. However, several settlements in Sicily did create a new town plan during the sixth century,[18] so such a change cannot be excluded for Kasmenai.

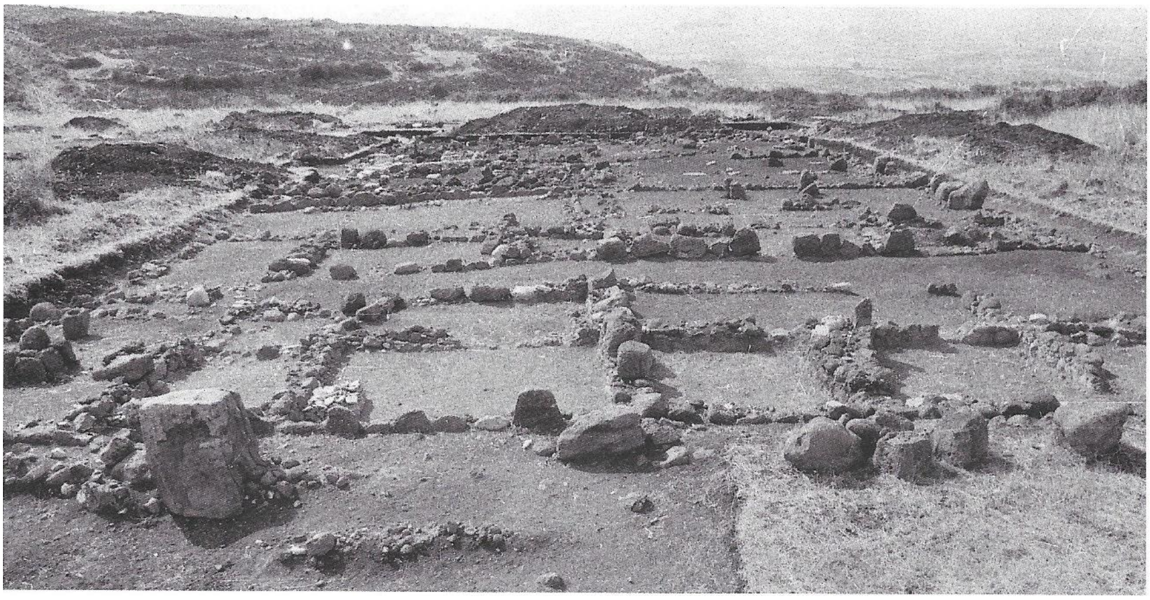

Fig. 7.1: Kasmenai. Housing block (KH), view to the south. Voza 1999, p.142.

7.3 Kasmenai: Temple of Ares

In the north-west corner of Monte Casale, at the highest point of the plateau, sits the only known temple at Kasmenai: the Temple of Ares (Fig. 1.7: KT).[19] Dated to between the foundation and the beginning of the sixth century BC, the first, inner phase of the temple measures c. 25.7 m by 4.5 m, and is aligned to the urban plan (Fig. 7.5). This construction used the same irregular blocks of volcanic stone as is found in the houses and fortifications of the

[17] Morris 1998, pp.33-4.
[18] De Angelis 2016, pp.82-3.
[19] Martin et al. 1980a, p.532; Melfi 2000, pp.39-41.

foundation period. A second, outer phase was added around the mid-sixth century and measures 26.98 m by 7.8 m. This is interpreted here as a temenos wall which does not conform as neatly to the urban plan as the first construction, and also diverges in construction style using fairly regular blocks of white limestone.

Given the relative dearth of information known about the structure, comparanda will be utilised from temples to which comparisons with the Temple of Ares have been made: 'bâtiment h' at Megara Hyblaia and the Megaron of Demeter at Gaggara.[20] The former structure sits just south of the Archaic agora, and was constructed at the end of the seventh century.[21] This temple consists of just two rooms, the cella preceded by a pronaos. A prostyle consisting of three columns has been reconstructed/suggested, but little else is known or hypothesised about it. The entire structure measures 20.30 m by 7.65 m, and the remains of the levels above the foundations are partially preserved. Limestone blocks above, quarried from a nearby extension of the Hyblaian Mountains, are of varying lengths (0.50–1.30 m) but of more regular width (0.60–0.70 m) and height (0.35 m). The limestone blocks of the foundations are larger and they measure 1.30–1.50 m in length, 0.45–0.50 m in width and 0.55 m in height. The pronaos is shallower with blocks similar to the rest but only 0.25 m in height, and it is separated from the cella by two large openings of approximately 1.85 m each. The three interior columns had a diameter of about 0.50 m and they were placed 3.60 m apart from each other and away from the walls. The exterior of the temple is apteral, while there is no evidence of an associated altar or temenos wall. Architecturally speaking, the proportions of the overall plan have been compared to the Doric style prevalent in Central Greece and the Peloponnese, specifically the Temple of Poseidon at Isthmia and the first Temple of Apollo at Corinth. The similarities between the Temple of Ares at Kasmenai and the two temples in Corinthia cannot be coincidental.

At Selinous, the building known as the Megaron of Demeter at Gaggara was built c. 580 BC and was divided into three rooms, a pronaos, a cella and an adyton, measuring in total c. 20.40 m by 9.53 m.[22] The interior of the pronaos is c. 3.20 m by 8.48 m, so the width of the wall blocks can be estimated as c. 0.525 m. The width of the entrance at the bottom of the opening is 2.35 m and its height is 4.14 m, while the entrance to the innermost room was around half that width. The cella is the longest room at 10.76 m, while the adyton has been almost completely lost over time. Given the lengths of the first two rooms and the expectation that block widths were relatively equal throughout, the length of the adyton is c. 4.34 m. This includes the lengths of the pronaos and the cella, and the widths of the front and back walls

[20] Melfi 2000, p.41.
[21] Vallet et al. 1976, pp.227-9.
[22] Koldewey & Puchstein 1899, pp.85-90; Gàbrici 1927, pp.21-73; Dinsmoor 1975, pp.78, 83-4; Grupico 2008, p.341, Table B.6. Selinous.

and the two walls dividing the three spaces. Foundation blocks throughout varied in height from 0.44–0.48 m and were placed down to a depth of c. 1.30 m into the soil. Gàbrici's reconstruction of the Megaron estimates the height of the walls at c. 7.36 m, and with the roof peaking at 2.50 m above the top of the wall; therefore, the total height of the temple can be estimated as 9.86 m. This height, as well as all the figures mentioned above, serve as a comparative base for estimates towards any missing measurements in the reconstruction of the Temple of Ares. Also present at Gaggara is a temenos wall surrounding the temple. This is what the second phase construction at the Temple of Ares is interpreted here as being.

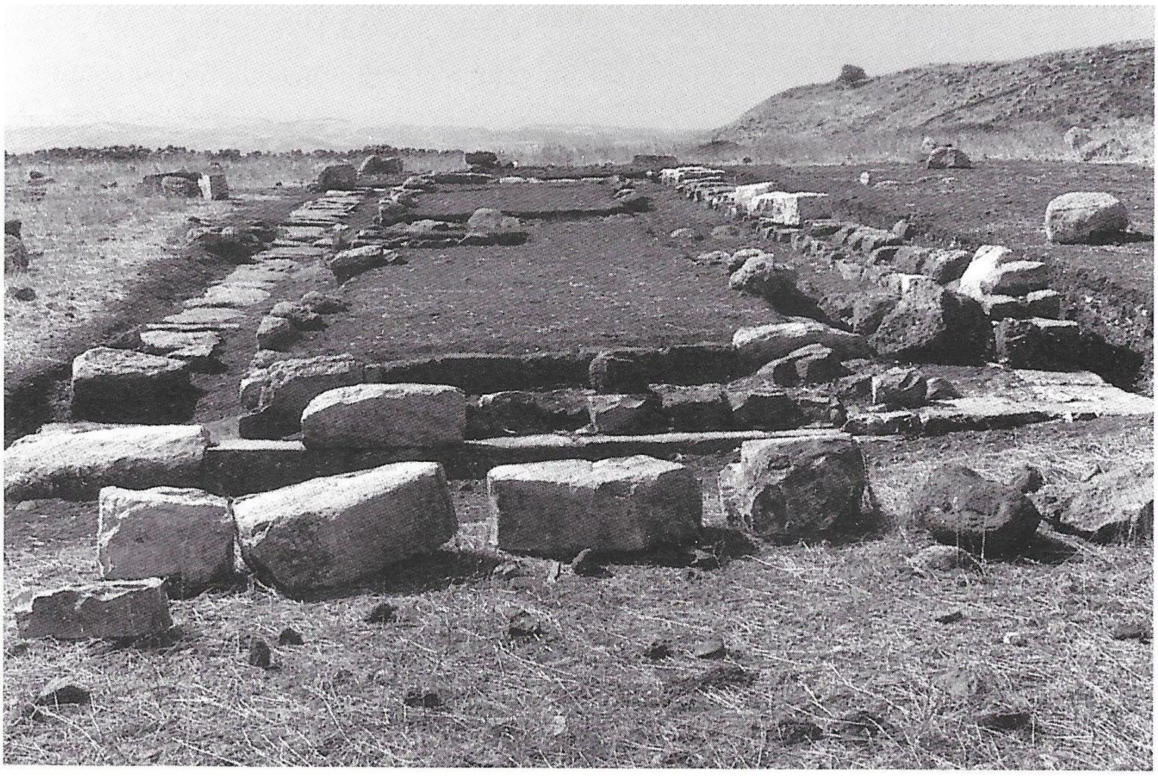

Fig. 7.2: Kasmenai. Temple of Ares (KT), view to the east. Voza 1999, p.142.

7.4 Architectural Energetics and Econometric Calculations

Using the information of the physical remains from the Archaic period, construction costs will now be estimated of the mid-seventh century fortification, a residence of the same period and the slightly later Temple of Ares. The methodology applied here has been detailed in Chapter 3. Volcanic stone was used during construction of the fortifications, houses and the Temple of Ares, which indicates nearby sources, yet the exact locations of the quarries have not been established. A nearby ridge to the north-west is the closest source of volcanic rock which originated from Monte Lauro during its active time in the Miocene period.[23] This sits about 1 km from the centre of plateau, and therefore will be taken as the transport distance for an adequate supply of stone, except for the temple construction, placed in the north-west corner

[23] Schmincke et al. 1997, pp.638-40, Fig. 1.

of the plateau about 0.50 km from the source. In transport, the oxen would have to navigate on average an incline of about 20 per cent, increasing the cost by 34.2 per cent. The accompanying footnotes present the labour cost calculations, while in the text they are rounded figures. Total sums are itemized in the supplementary tables.

7.5 Kasmenai: Fortifications

Archaeological research has provided a wall width of 3 m, and total distance of roughly 3,900 m.[24] Given the large area encompassed by the plateau, it can be expected that Syracuse wished to house a relatively sizable population. Furthermore, given that the site was chosen for its natural topography, with a wall constructed rather soon after the foundation, it becomes quite evident that the fortifications were an important aspect of the settlement. Therefore, a higher wall than previously will be reconstructed, 6 m tall: 2 m in stone socle and the remainder with a mudbrick superstructure. The height of the socle and the total height reflect the very good natural defences of the site. However, the actual construction could have been larger.

Before construction, the line of fortification around the plateau would have to be cleared and levelled down to the natural bedrock. Given the mountainous environment and the construction at the edge of the plateau, reasonable expectations at Kasmenai can be lowered to half a metre, requiring 820 md before any building of the fortifications could commence.[25]

The average dimensions of the measured socle blocks are 1.10 m by 0.50 m by 0.50 m. Given that the Archaic fortifications at Kasmenai have a width of 3 m, a reasonable approximation of the ratio of volcanic stone blocks to inner fill can be set at 1:1 or roughly half volcanic stone and half rubble. The blocks of the exterior face are larger than the interior, but the approximate ratio of the different types of material can be estimated on the basis of Fig. 5.10. With this, a 2-metre-tall socle, 3 m wide, spanning the length of 3,900 m is equal to 23,400 m^3,[26] and half of this is 11,700 m^3. This latter number represents both the volume of stone and fill needed for a socle of that size. The wall curtains would initially necessitate around 70,200 md for quarry and construction.[27] Transporting the volcanic stone from the quarries would require approximately 28,600 trips, equalling a total of 9,600 od.[28]

Adding the 11,700 m^3 of rubble inner fill, requires additional work, yet using the 5,850 m^3 of soil and bedrock removed from the levelling of the foundation would have been

[24] Di Vita 1986, p.387 gives a distance of 3,400 metres for the length of the wall, but, as demonstrated above, this is an underestimate. The expectation is that the entire plateau would have been fortified.

[25] $(3{,}900\ m \times 3\ m \times 0.5\ m) \times 0.14\ md/m^3 \approx 819$ md.

[26] $2\ m \times 3\ m \times 3{,}900\ m = 23{,}400\ m^3$.

[27] Quarrying: $11{,}700\ m^3 \times 2\ md/m^3 \approx 23{,}400$ md; construction: $11{,}700\ m^3 \times 4\ md/m^3 \approx 46{,}800$ md. 23,400 md + 46,800 md ≈ 70,200 md.

[28] $11{,}700\ m^3 \times 2.2\ tonnes/m^3 / 0.9$ tonnes per carriage-load ≈ 28,600 carriage-loads. (28,600 carriage-loads / 4 trips per day) + 34.2% ≈ 9,595 od.

convenient. Assuming it was set aside and then refilled back in, this would save transport costs. Therefore, only an additional 5,850 m³ would need brought from the quarry at an expense of 4,800 od.[29] It will be presumed that this supplementary rubble was excess from the quarrying process was available at no additional quarry cost. Back-filling the rubble increases the labour cost by 820 md.[30] The work load equals roughly 100,000 md and 13,900 od in total to complete the limestone socle.[31]

The mudbrick superstructure, 4 m in height, would be 46,800 m³.[32] The entire process to gather, transport, manufacture and construct the mudbrick superstructure would entail 30,400 md and 61,100 od.[33] Total construction time (Table 5.1) for the 6-metre-high wall at Kasmenai would demand 113,500 md and 75,500 od.

Table 7.1: Total labour costs for the construction of fortifications at Kasmenai

RESOURCE	*ACTION IN MD*		
	Acquisition	**Transport**	**Construction**
STONE:	24,300	9,595 od	46,800
MUDBRICK:	11,700	61,061 od	18,720
LOOSE FILL:	*Gathered during quarrying*	4,798 od	819
INITIAL LEVELLING OF SITE:			819
TOTALS:	36,000	0	67,158
SUPERVISION: (+ 10%)	3,600	0	6,716
BASE TOTAL:	113,474 + 75,454 od		
RANGE OF TOTALS:	113,474–208,947		

7.6 Kasmenai: Houses

The pre-planned urban landscape can be seen best through the largely regular layout of residential space. These quadrangular housing complexes became apparent through the complete excavations in a block uncovered east of the Temple of Ares. Groups of four multi-roomed houses are accessed through courtyards led into either from the stenopoi or irregular passages c. 3.1–3.5 wide connecting the stenopoi. Each group covers an area of c. 25 m by 25 m (625 m²), and is separated from adjacent houses by a half-meter-wide ambitus or a wall. A typical house plan has been published by Collura (Fig. 7.3) and will be used as starting guidelines for the calculations.

[29] Quarrying: 5,850 m³ x 2 md/m³ ≈ 23,400 md; transport: 5,850 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 14,300 carriage-loads. (14,300 carriage-loads / 4 trips per day) + 34.2% ≈ 4,798 od.
[30] 11,700 m³ x 0.07 md/m³ ≈ 819 md.
[31] 89,505 md + 9,653 md + 819 md = 99,977 md; 4,648 od + 9,295 od = 13,943 od.
[32] 3,900 m x 3 m x 4 m = 46,800 m³.
[33] Manufacture: 46,800 m³ x 0.25 md/m³ ≈ 11,700 man-days; transport: 46,800 m³ x 1.75 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 91,000 carriage-loads. (91,000 carriage-loads / 2 trips per day) + 34.2% ≈ 61,061 od; construction: 46,800 m³ x 0.4 md/m³ ≈ 18,720 man-days. 11,700 md + 18,720 md ≈ 30,420 man-days.

The size of a single house can be estimated as 12.5 m by 12.5 m. It is likely that the walls of these houses were built fully in stone, as was common at Megara Hyblaia and Syracuse, and what was calculated for those at Akrai. A foundation width of 0.50 m will be adopted for the walls, and again a 2.5 m height for the walls will be presumed. In the plan based on Collura (Fig. 7.3), the rooms have slightly varying dimensions. However, for the sake of general calculations a more simplistic plan is considered (Fig. 7.4). The eastern and western walls extend the full width of the house or 12.5 m; the northern and southern walls only 11.5 m. This latter length is also used for the two north-south interior walls. Placing these interior walls evenly within the domestic space creates separations of 3.5 m,[34] and this would be the length of any wall dividing the area into rooms. In Fig. 7.4 there are five of these dividing walls. Therefore, using these latter figures as a common basis for building style, a typical house incorporated a total of 110.63 m³ of stone.[35]

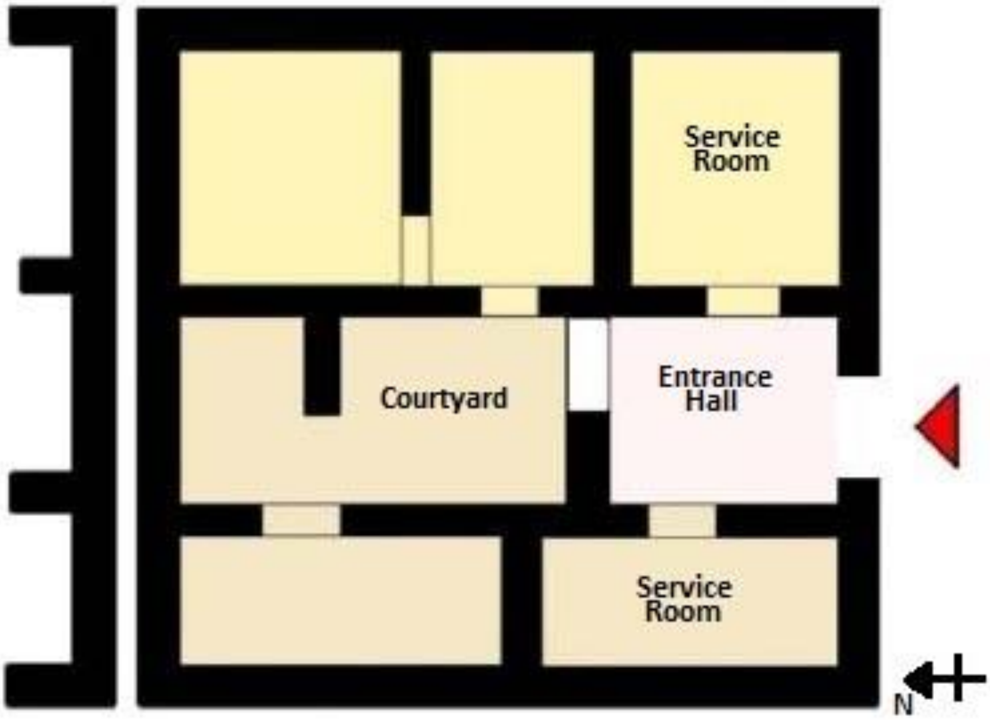

Fig. 7.3: Kasmenai. Typical house plan (KH). Collura 2012, p.10.

Calculations thus far do not take into account doorways between the rooms. To access the eight separate spaces, as in Fig. 7.4, eight doorways would have been necessary, including the one into the courtyard and the entrance hall from outside the residence. As above, each doorway is figured roughly one third the length of the wall in which it was placed. Estimating a

[34] Starting with the house width of 12.5 m minus the 0.50 m widths of the two exterior and two interior walls: (12.5 m – (4 × 0.50 m)) / 3 = 3.5 m.

[35] Before subtracting doorways: Exterior walls: (2 x 12.5 m) + (2 x 11.5 m) = 48 m. Interior walls: (2 x 11.5 m) + (5 x 3.5 m) = 40.5 m. (48 m + 40.5 m) x 2.5 m height x 0.5 m width = 110.63 m³

doorway width of 1 m, this subtracts 7 m³ of material,[36] bringing the total volume of required volcanic stone to roughly 103.63 m³.[37]

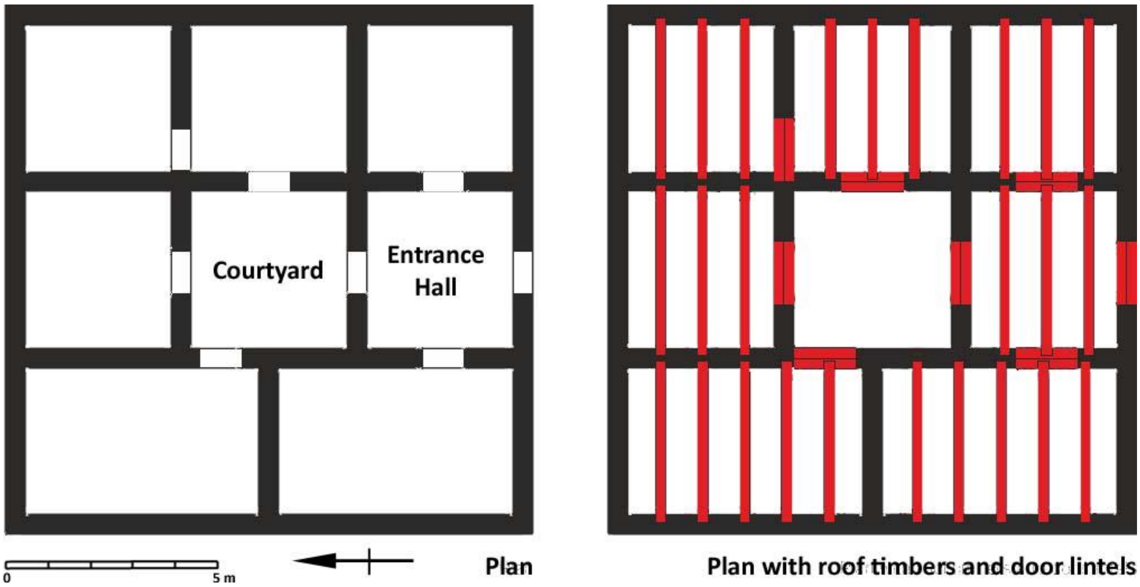

Fig. 7.4: Kasmenai. House plans (KH) used in the econometric calculations.

Levelling the foundations to a depth of 0.25 m would require 10.19 m³ of material to be removed in a little more than one man-day.[38] Taking the rubble at most 250 m from the site to the area below the plateau would require an additional 4 md and 2 od.[39] Building the walls would require 26 md gathering,[40] 85 od transporting[41] and 100 md for construction.[42]

The archaeological reports of Kasmenai do not mention roof tiles, as has been the pattern up to the mid-seventh century in south-east Sicily. The earliest houses can then be assumed to have been constructed with a flat roof, or possibly with a slight incline to prevent water from accumulating. This slope would have been higher at the end with the door declining away to the opposite end. Building the flat roof slightly sloping or perfectly flat makes little difference to the calculations, so as before a flat roof is assumed here.

The wood for the roof would have been sourced locally, and even though the degree of forestation in the area in the seventh century is unknown, it is reasonable to expect a supply was no more than a kilometre away. In simplifying the rooms to equal dimensions, the

---

[36] 1 m x 2 m x 0.5 m = 1 m³; 7 doorways x 1 m³ = 7 m³.
[37] 110.63 m³ - 7 m³ = 103.63 m³.
[38] Exterior walls: (2 x 12.5 m) + (2 x 11.5 m) = 48 m. Interior walls: (2 x 11.5 m) + (5 x 3.5 m) = 40.5 m. (48 m + 40.5 m – 7 m doorways) x 0.25 m height x 0.5 m width = 10.19 m³; 10.19 m³ x 0.14 md (levelling) ≈ 1.43 md.
[39] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 10.19 m³ x 0.386 md/m³ ≈ 3.93 md; transport: 10.19 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 24 carriage-loads. (25 carriage-loads / 16 trips per day) + 34.2% ≈ 2 od.
[40] 103.63 m³ x 0.25 md ≈ 25.91 md.
[41] 103.63 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 253 carriage-loads. (253 carriage-loads / 4 trips per day) + 34.2% ≈ 85 od
[42] 103.63 m³ x 1 md/m³ ≈ 103.63 md.

courtyard would have encompassed an open area of 12.25 m²,[43] and while it quite likely had an awning, it would not have been roofed. Therefore, 144 m² of the house top would have been covered by a roof.[44] The timbers would have been of equal size, and in fact the beams would have likely remained rounded. Using Fig. 7.4 as a guide, laying beams running in an east-west direction placed within the northern and southern walls, staggered in between the interior walls, would have allowed for 25 principal beams to form the main support for the roof. These can be reasonably sized at a length of 4 m by a diameter of 0.30 m (9 m³ of total timber),[45] and placed 0.65 m apart. Supporting posts would not have been necessary as the beams set in an east/west direction would have been placed within the walls and easily spanned the 3.5 m width of each room. The door lintels of 0.25 m diameter and 1.5 m length would need to be squared to fit into the walls, extend beyond the length of the doorway and allow for two placed above each entrance. Squaring the sixteen lintels would take a total of 3 md.[46] The beams and lintels equate to 10.5 m³ of wood,[47] and with a nearby source at most 1 km away adds 30 md and 2 od.[48] Additionally, whatever preferred materials used to finish the roof (earth, reeds, and/or clay) could be gathered from nearby during the wood gathering. Laying the roof is estimated at 0.1 md per timber, equal to 4 md,[49] with 2 md expected to finish the roof with the organic material.

The dimensions of the 8 wooden doors are 1.0 m wide, 0.05 m thick and 2.0 m in height. Using three planks 0.33 m by 0.05 m per door, a total of twenty-four planks will be required. Per timber of 0.33 m in diameter, six planks can be produced involving nine cuts.[50] For all eight doors, four timbers are needed costing 3 md of labour.[51] This amount of timber, 0.87 m³,[52] equals 2 md and 1 od for felling and transport.[53] Including supervision, this then gives a total estimation (Table 7.2) of 200 md and 90 od to construct an all-stone house at the founding of Kasmenai in the mid-seventh century. The social, political and economic implications of this are discussed further below.

[43] 3.5 m x 3.5 m = 12.25 m².
[44] (12.5 m² x 12.5 m²) – 12.25 m² = 144 m².
[45] 4 m x 0.30 m x 0.30 m x 25 = 9 m³.
[46] 4 cuts x 1.5 m x 0.25 m x 0.14 md/m² x 16 lintels ≈ 3.36 md.
[47] 9 m² + (1.5 m x 0.25 m x 0.25 m x 16) = 10.5 m³.
[48] Felling: 10.5 m³ x 2.7 md/m³ ≈ 28.35 md; transport: 10.5 m² x 0.56 tonnes/m³ / 0.9 tonne per carriage-load ≈ 7 carriage-loads. (7 carriage-loads / 4 trips per day) + 34.2% ≈ 2 od.
[49] (25 beams + 16 lintels) x 0.1 md/timber ≈ 4.1 md.
[50] Four initial cuts to square the timber + five cuts to create six planks = 9 cuts.
[51] 9 cuts x 2 m x 0.33 m x 0.14 md/m² x 4 (timbers) ≈ 3.33 md.
[52] 4 (timber) x 2 m x 0.33 m x 0.33 m = 0.87 m³.
[53] Felling: 0.87 m³ x 2.7 md/m³ ≈ 2.35 md; transport: 0.87 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 34.2% ≈ 1 od.

Table 7.2: Total labour costs for the construction of an all-stone house at Kasmenai

RESOURCE		*ACTION IN MD*	
	Acquisition	**Transport**	**Construction**
STONE:	25.91	85 od	103.63
INITIAL LEVELLING OF SITE:			1.43
DISPOSAL OF RUBBLE:		3.93 + 2 od	
ROOF:	28.35	2 od	9.46
DOORS:	2.35	1 od	3.33
TOTALS:	56.61	3.93	117.85
SUPERVISION: (+ 10%)	5.66	0.39	11.79
BASE TOTAL:		196.23 + 90 od	
RANGE OF TOTALS:		196.23–695.57	

7.7 Kasmenai: Temple of Ares

The first phase of the temple was constructed early in the history of Kasmenai using the same volcanic stone as is found in the foundation period housing and fortifications. This structure (Fig. 7.2) measured c. 25.7 m by 4.5 m, and is quite elongated in comparison to 'bâtiment h' at Megara Hyblaia (20.30 m by 7.65 m) and the Megaron of Demeter at Gaggara (c. 20.40 m by 9.53 m). Given the excavated plan of the temple (Fig. 7.5), partial remains of interior walls indicate three separate rooms, a pronaos, cella and adyton, as is found at Gaggara. At Megara Hyblaia and Gaggara, the widths of the blocks were between 0.50–0.70 m. Here, block width will be calculated at 0.50 m, keeping in line with the figures used for the fortifications and houses, and allowing for the least amount of material needed overall. With that, the two interior and two end walls of the temple will each measure 3.5 m in length. Also evident through the temple plan, at least one foundation layer was placed below the structure and any ingresses. Based on the reconstruction of the wall height of the Megaron of Demeter (7.36 m), a lower estimate of 7 m will be used for the height of the walls of the Temple of Ares. Doorways at the compared sites ranged from 1.65 m to 2.35 m, but with the narrow layout of the temple here, the entrances are estimated as 1.5 metres each. The height of the entrance to the pronaos at Gaggera has been reconstructed as 4.14 m; this will be reduced to 4 m here. The roof of the temple will be addressed separately after the construction of the structure.

These foundations will again be dug to half a metre involving the extraction of 16.35 m³ of rock and soil,[54] and require 2 md in total.[55] Removing the rubble adds 6 md and 3 od.[56] At the

---

[54] Long walls: (25.7 m x 0.5 m x 0.5 m) x 2 = 12.85 m³; interior and end walls: (3.5 m x 0.5 m x 0.5 m) x 4 = 3.5 m³. 12.85 m³ + 3.5 m³ = 16.35 m³. This figure can then be used as the amount of lava stone required to place a single foundation level.

[55] 16.35 m³ x 0.14 md/m³ ≈ 2.29 md.

[56] Loading and carrying + loading the cart + unloading and carrying: 0.163 md/m³ + 0.06 md/m³ + 0.163 md/m³ = 0.386 md/m³; 16.35 m³ x 0.386 md/m³ ≈ 6.31 md; transport: 16.35 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 40 carriage-loads. (40 carriage-loads / 16 trips per day) + 34.2% ≈ 3 od.

dimensions given, the first phase of the temple incorporates 236.25 m³ of volcanic stone.[57] Quarrying this amount of volcanic stone would take 470 md,[58] and need 100 od to transport the material from 0.5 km away.[59] The first phase structure would be constructed in 950 md.[60]

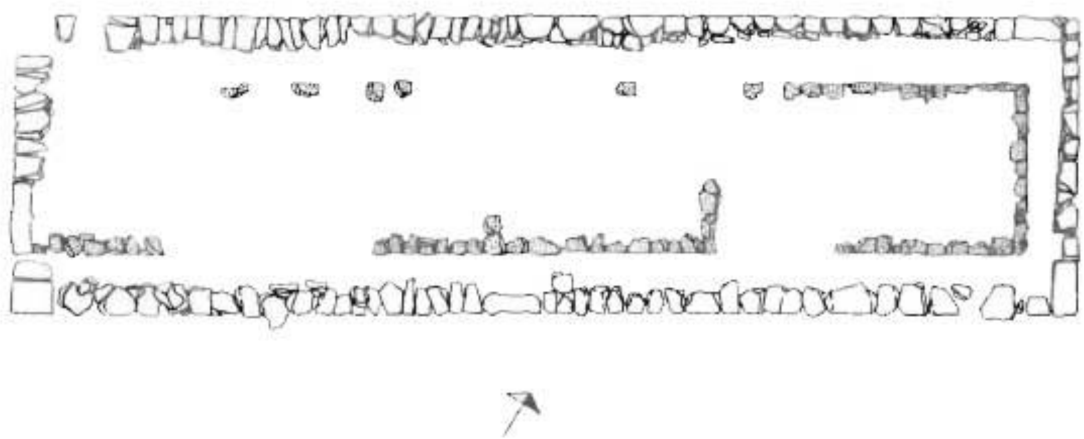

Fig. 7.5: Kasmenai. Excavated plan of Temple of Ares (KT): inner (dark) first phase and outer (light) second phase. Melfi 2000, Fig. 2.

The temenos wall was added about a century later using fairly regular blocks of white limestone. This second, outer phase of construction does not align as well with the urban plan already in place. It measures 26.98 by 7.8 m, and, bearing in mind the excavated plan (Fig. 7.5), with blocks on average around twice the size of those used previously. Based upon a block width of a metre, the end walls here can be figured at 5.8 m long. A temenos wall is not as high as the temple; by comparison that at Gaggera rises to 3 m in height. Only a single entranceway at the front will be accounted for. Up to this period, the construction projects used exclusively volcanic stone which was likely sourced locally, around a half kilometre away. Publications of Kasmenai have not provided a location for the source of white limestone, but the Hyblaian/Ragusa plateau consists of carbonates, so a source for the limestone must have been in the immediate vicinity of the temple.[61] For this reason, it can be expected that this resource was within a kilometre from the settlement. The second phase of the construction consists, therefore, only of the addition of a temenos wall surrounding the existing temple.

[57] Foundation: 16.35 m³; long walls: (25.7 m x 0.5 m x 7 m) x 2 = 179.9 m³; interior and end walls: (3.5 m x 0.5 m x 7 m) x 4 = 49 m³; doorways: (1.5 m x 0.5 m x 4 m) x 3 = 9 m³; 16.35 m³ + 179.90 m³ + 49 m³ - 9 m³ = 236.25 m³
[58] 236.25 m³ x 2 md/m³ ≈ 472.50 md.
[59] 236.25 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 578 carriage-loads. (578 carriage-loads / 8 trips per day) + 34.2% ≈ 97 od.
[60] 236.25 m³ x 4 md/m³ ≈ 945 md.
[61] Great Britain Naval Intelligence Division 1944, p.392; De Angelis 2003, p.79.

Digging a foundation for the temenos down to a half metre requires extracting 32.78 m³ of bedrock and soil,[62] requiring 5 md of labour,[63] and then taken away from the construction site at a cost of 13 md and 7 od.[64] In total, this phase of the temple incorporates 224.96 m³ of limestone[65] which necessitates 450 md for quarrying[66] and 220 od for transport from a source 1 km away.[67] Construction of the temenos is then completed with an additional 900 md.[68]

A ridged roof will once again be accounted for using prop-and-lintel support; however, because of the narrow width of the Temple of Ares, purlins will be excluded. Rafters on either slope will suffice in supporting the tiles.[69] This means that the interior and end walls would have been built higher than the long walls, sloping to the highest point at the centre. The peak of these walls will be reasonably placed at a height 0.50 metres above the rest. This places the highest point of the temple at 7.5 m above the ground at centre, sloping to 7 m on both ends. Geison blocks are unverified at Kasmenai, however an extra 0.20 m of stone will be included projecting outward along the tops of the highest blocks along the perimeter walls. Based on this construction, the roof would sit at an angle of 13 degrees[70] with an incline 2.5 m long (including the cornice stone edge) on each side of the peak.[71] Each pediment atop the two interior walls and two end walls would incorporate an additional 0.28 m³ of stone; 1.12 m³ in total.[72] Accounting for the edge of the cornice blocks 2.34 m³ of stone should be added to the calculations above.[73] This 3.46 m³ total adds 7 md[74] of quarrying time, 2 od for transport[75] and 14 md for construction[76] to the first phase calculations.

---

[62] Long walls: (26.98 m x 1 m x 0.5 m) x 2 = 26.98 m³; end walls: (5.8 m x 1 m x 0.5 m) x 2 = 5.8 m³; 26.98 m³ + 5.8 m³ = 32.78 m³. This figure can then be used as the amount of lava stone required to place a single foundation level.

[63] 32.78 m³ x 0.14 md/m³ ≈ 4.59 md.

[64] Loading and carrying + loading the cart + unloading and carrying: 32.78 m³ x 0.386 md/m³ ≈ 12.65 md; transport: 32.78 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 80 carriage-loads. (80 carriage-loads / 16 trips per day) + 34.2% ≈ 7 od.

[65] Long walls: (26.98 m x 1 m x 3 m) x 2 = 161.88 m³; end walls: (5.8 m x 1 m x 3 m) x 2 = 34.8 m³; doorway: 1.5 m x 1 m x 3 m = 4.5 m³; foundation: 32.78 m³. 161.88 m³ + 34.8 m³ - 4.5 m³ + 32.78 m³ = 224.96 m³

[66] 224.96 m³ x 2 md/m³ ≈ 449.92 md.

[67] 224.96 m³ x 2.6 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 650 carriage-loads. (650 carriage-loads / 4 trips per day) + 34.2% ≈ 218 od.

[68] 224.96 m³ x 4 md/m³ ≈ 899.84 md.

[69] Purlins are not as crucial to a roofing structure as the ridge beam, and can be omitted when the rafters are able to span the distance from side cornice to ridge, Hodge 1960, p.45.

[70] Cf. Coulton 1977, p.158.

[71] Given a triangle height of 0.5 m and length of 2.25 m (half the width of the temple), the hypotenuse equals 2.31 m: $\sqrt{((2.25)^2 + (0.5)^2)} \approx 2.31$. The angle can be calculated using the height and length: $\tan^{-1}\left(\frac{0.5}{2.25}\right) \approx 12.53°$.

[72] Each pediment cubic area is half the cubic area of a rectangle with the same dimensions: (2.25 m x 0.5 m x 0.5 m) / 2 = 0.28 m³.

[73] Long walls: (25.7 m x 0.2 m x 0.2 m) x 2 = 2.06 m³; end walls: (3.5 m x 0.2 m x 0.2 m) x 2 = 0.28 m³. 2.06 m³ + 0.28 m³ = 2.34 m³

[74] 3.46 m³ x 2 md ≈ 6.92 md.

Using the excavated plan as a guide once again, the cella appears to be the smallest interior space (estimated at 5.20 m) with the eastern pronaos the second longest (estimated at 7.60 m), and the western adyton the largest. The adyton is approximately 46 per cent of the length of the entire temple or 10.90 m.[77] The most likely reconstruction is that cross beams would have spanned the width of the temple with props supporting the ridge beams running the length of the building (Fig. 7.6). These primary timbers would have been principally fixed by notches within the blocks of the interior walls. The ridge beams at Gaggara were more than 0.40 m in height and width.[78] For the long adyton length at Kasmenai, three beams 0.30 m in diameter together spanning the length of the room is reasonable when supported by two props and cross beams. The same dimensions for the supports will be assumed. The dimensions of the rafters, running from the walls to the ridge beam would have been smaller: 0.10 m by 0.10 m will be utilized here. The secondary timbers, including the rafters, would have been sized and spaced according to the roof tile dimensions.

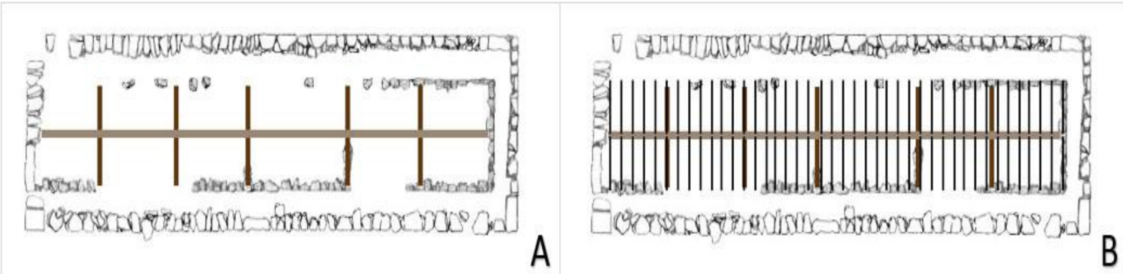

Fig. 7.6: Kasmenai. Temple of Ares (KT). Roofing structure indicating cross beams and ridge beam (A) and rafters (B). Melfi 2000, Fig. 2 with additions.

More than likely the timbers were placed within sockets of the interior and end walls recessed around 0.15 m. Therefore, the primary timbers did not stretch the entire length of the temple, instead 1.1 m short.[79] One ridge beam each in the cella and pronaos and three beams in the adyton gives a total of five ridge beams required in total. These primary timbers total to 2.22 m³ of wood.[80] It would take 11 md and 1 od to gather and transport the wood[81] and 4 md to square the timbers.[82]

---

[75] 3.46 m³ x 2.2 tonnes/m³ / 0.9 tonnes per carriage-load ≈ 9 carriage-loads. (9 carriage-loads / 8 trips per day) + 34.2% ≈ 2 od.

[76] 3.46 m³ x 4 md/m³ ≈ 13.84 md.

[77] Klein 1998, pp.338-9.

[78] Hodge 1960, p.53, Table 3.

[79] The 15 cm recesses would have left 35 cm of solid stone on each end wall block and 20 cm within each interior wall block. Then the primary timbers would only need to reach 24.6 metres in total length.

[80] Ridge beams: (cella: 5.50 m x 0.30 m x 0.30 m = 0.50 m³) + (pronaos: 7.90 m x 0.30 m x 0.30 m = 0.71 m³) + (adyton: 3.73 m x 0.30 m x 0.30 m x 3 beams = 1.01 m³) = 2.22 m³.

[81] Felling: (cella: 0.50 m³ x 5.5 md/m³ ≈ 2.75 md) + (pronaos: 0.71 m³ x 8.2 md/m³ ≈ 5.82 md) + (adyton: 1.01 m³ x 2.7 md/m³ ≈ 2.73 md) ≈ 11.30 md; transport: 2.22 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 34.2% ≈ 1 od.

[82] (Cella: 4 cuts x 5.50 m x 0.30 m x 0.14 md/m² ≈ 0.92 md) + (pronaos: 4 cuts x 7.90 m x 0.30 m x 0.14 md/m² ≈ 1.33 md) + (adyton: 4 cuts x 3.73 m x 0.30 m x 0.14 md/m² x 3 beams ≈ 1.88 md) ≈ 4.13 md.

Cross beams running the width of the temple would be necessary for some extra support. At minimum, it can be figured that two of these were placed inside the adyton, one in the pronaos and one over each interior wall, five in total. These beams will be estimated at the same dimensions as the ridge beam, 0.30 m by 0.30 m, and fit into sockets c. 0.20 m within the stones along the long walls. This places the length of the cross beams at 3.90 m. The props running from the cross beams and walls up to the ridge beam, also expected of similar proportions, would need to be 1 m long, given the lintels are placed not at the top of the walls, but a single block, 0.50 m, below. This adds 2.21 m³ of wood which can be felled and transported in 6 md and 1 od,[83] and squared in 4 md.[84]

The rafters will run perpendicular to the ridge beam, and the 0.50 m tiles will be placed upon them as well as the tops of the exterior walls creating a continual line of tiles stretching the entire length of the temple. For the Temple of Ares, this can be accomplished using eighty-four rafters (forty-two on each side of the ridge beam) 0.10 m wide, placed 0.40 m apart, with each tile resting 0.05 m on a rafter. These rafters stretch from the ridge beam to the long walls, stopping before the extension of the cornice, 2.16 m in total. Felling and transporting the rafter timber would take 5 md and 1 od.[85] Squaring 84 rafters 2.16 m by 0.10 m adds 10 md in total.[86] Since here the tiles will be placed upon the rafters without any other secondary timbers, rafters of this size are sufficient for holding a tiled roof.[87] If battens or sheathing was used, then larger rafters would have been necessary.

Lastly among the roofing timbers are the door lintels. Above three doorways would have been placed six timbers equal in width to those placed in the residences above but 2.5 m in length. The lintels equate to 0.94 m³ of wood,[88] and with a nearby source at most 1 km away adds 3 md and 1 od.[89] Squaring each lintel would take a total of 2 md.[90]

The cost of placing each ridge beam, cross beam and prop can be estimated as 35 md, while door lintels will be figured at the same rate as rafters. Installing the wooden roofing support system would then take 570 md.[91]

---

[83] Cross beams: (3.90 m x 0.30 m x 0.30 m) x 5 = 1.76 m³; props: (1 m x 0.30 m x 0.30 m) x 5 = 0.45 m³. 1.76 m³ + 0.45 m³ = 2.21 m³; felling: 2.21 m³ x 2.7 md/m³ ≈ 5.97 md; transport: 2.21 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 34.2% ≈ 1 od.

[84] (Cross beams: 4 cuts x 3.90 m x 0.30 m x 0.14 md/m² x 5 (beams) ≈ 3.28 md) + (props: 4 cuts x 1 m x 0.30 m x 0.14 md/m² x 5 (props) ≈ 0.84 md) ≈ 4.12 md.

[85] Felling: 2.16 m x 0.10 m x 0.10 m x 84 rafters x 2.7 md/m³ ≈ 4.90 md; transport: (2.16 m x 0.10 m x 0.10 m x 84 rafters) x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 34.2% ≈ 1 od.

[86] 4 cuts x 2.16 m x 0.10 m x 0.14 md/m² x 84 (rafters) ≈ 10.16 md.

[87] Cf. Hodge 1960, p.71.

[88] 2.5 m x 0.25 m x 0.25 m x 6 = 0.94 m³.

[89] Felling: 0.94 m³ x 2.7 md/m³ ≈ 2.54 md; transport: 0.94 m³ x 0.56 tonne/m³ / 0.9 tonne per carriage-load ≈ 1 carriage-load. (1 carriage-load / 4 trips per day) + 34.2% ≈ 1 od.

[90] 4 cuts x 2.50 m x 0.25 m x 0.14 md/m² x 6 lintels ≈ 2.1 md.

[91] (5 ridge beams + 5 cross beams + 5 props x 35 md) + (6 door lintels + 84 rafters x 0.5 md) ≈ 570 md.

An effort to cover the entire roof with tiles, from end to end and peak to each cornice edge, would require fifty-one complete columns of eight pan tiles, fifty columns of eight cover tiles and thirty-seven ridge tiles, 845 total. This accounts for the higher tiles covering roughly 0.10 m of those lower. Above (Table 2.1) is listed the labour costs for manufacturing tiles leading to 38 md for the tiles here, including quarrying the clay.[92] It will be expected here that the clay was taken from the source to the construction site where kilns were found nearby, and with 74 m^3 of clay required per 1,000 tiles, the 62.53 m^3 needed here are transported from a kilometre away in 40 od.[93] The roof running 2.16 m by 25.7 m on each side of the roof slope creates 111.02 square metres of area to cover with tiles in 8 md.[94]

Above, the doorways have been figured at 1.5 m wide and 4 m high. The thickness of the temple doors is estimated at 0.10 m. Each door can be built with five planks of 0.50 width, similar to those for houses. With a seasoned timber 0.50 m by 4 m, eight cuts create five planks of 0.10 thickness, enough for a single door. In 7 md, enough planks can be cut for all three doors.[95] This amount of timber, 3 m^3,[96] equates to 12 md and 1 od for felling and transport.[97]

Completing the Temple of Ares has been estimated at 3,800 man-days and 370 ox-carriage days (Table 7.3). This includes both the inner temple and outer temenos as were finished by the late sixth-century. Completed in the initial days of foundation, the first phase would have entailed around 2,300 md and 150 od, including supervision. The bulk of this would have been in the stone constructions, and it is not unreasonable to think that more labourers were recruited during this stage. The second phase then took upwards of 1,500 md and, due to the change to white limestone and the expectation that the source for this stone was further away, a majority (225) of ox-carriage days. Since this took place a century later, it is feasible to expect that this stage of construction went more quickly with an increased workforce and more skilled labour. These aspects will now be addressed after the population assessments.

---

[92] 51 columns of 8 pan tiles = 408 pan tiles; 61 md per 1,000 pan tiles = 24.89 md per 408 pan tiles; 50 columns of 8 cover tiles = 400 cover tiles; 31 md per 1,000 cover tiles = 12.4 md per 400 cover tiles; 31 md per 1,000 ridge tiles = 1.15 md per 37 ridge tiles. 24.89 md + 12.4 md + 1.15 md = 38.44 md.

[93] 62.53 m^3 x 1.75 tonnes/m^3 / 0.9 tonne per carriage-load ≈ 122 carriage-loads. (122 carriage-loads / 4 trips per day) + 34.2% ≈ 41 od.

[94] 2.16 m x 25.7 m x 2 = 111.02 m^2; 111.02 m^2 x 0.07 md/m^2 ≈ 7.77 md.

[95] 8 cuts x 4 m x 0.50 m x 0.14 md/m^2 x 3 (timbers) ≈ 6.72 md.

[96] 4 m x 0.50 m x 0.50 m x 3 (timbers) = 3 m^3.

[97] Felling: 3 m^3 x 2.7 md/m^2 x 1.5 (hardwood) ≈ 12.15 md; transport: 3 m^3 x 0.9 tonne/m^3 / 0.9 tonne per carriage-load ≈ 3 carriage-loads. (3 carriage-loads / 4 trips per day) + 34.2% ≈ 1 od.

Table 7.3: Total labour costs for the construction of the Temple of Ares at Kasmenai

RESOURCE	*ACTION IN MD*		
	Acquisition	**Transport**	**Construction**
STONE (1ST PHASE):	479.14	97 od	954.26
INITIAL LEVELLING OF SITE (1ST PHASE):			2.29
DISPOSAL OF RUBBLE:		6.31 + 3 od	
STONE (2ND PHASE):	449.92	218 od	899.84
INITIAL LEVELLING OF SITE (2ND PHASE):			4.59
DISPOSAL OF RUBBLE:		12.65 + 7 od	
ROOF:	24.71	4 od	590.51
TERRA-COTTA TILES:	38.44	41 od	7.77
DOORS:	12.15	1 od	6.72
TOTALS:	1,004.36	18.96	2,465.98
SUPERVISION: (+ 10%)	100.44	1.90	246.60
BASE TOTAL:	3,838.24 + 371 od		
RANGE OF TOTALS:	1st phase: 2,334.54–2,877.90 + 146 od 2nd phase: 1,503.70–1,851.73 + 225 od Total: 3,838.24–4,729.63		

7.8 Kasmenai: Population Modelling

Kasmenai has fortunately been studied well enough to provide some figures that can be used as a basis for estimates. Di Vita arrived at his estimate based on the urban layout giving at least 42 groups of insula, 672 total blocks, with 4 houses per block.[98] Considering the very large area, he concludes that there were 1,882 residences, housing 4 individuals each, providing a population of 7,528 in the sixth century, the most active period of the settlement.

Hansen provides for Kasmenai a total intramural space of 60 ha, with at least 75 per cent of it inhabited (45 hectares), for a population range of 6,800–9,000.[99] This estimate is for the end of the Archaic period. On the other hand, Collura suggests that the settlement covered roughly two-thirds of the plateau (40 ha) by the second half of the sixth century BC, estimating 7,000–8,000 members of the community, likely based on Di Vita's figure.[100] At 40 hectares, the population can be estimated, following Hansen, to 6,000–8,000. Therefore, in 485 BC there are estimated 6,000–9,000 members of the community.

For the foundation period, Collura suggests only the north-western corner of the plateau was settled due to the placement of the Temple of Ares. Taking 20 per cent, estimated for Syracuse and Heloros, as the occupied area, and expecting the same inhabitation area (75%), the population in 644 BC is estimated to a range of 1,400–1,800.

[98] Di Vita 1986, p.387.
[99] Hansen 2006b, p.42.
[100] Collura 2012, p.29.

With regard to the rural population attached to the Kasmenai urban centre, the mountainous terrain to the north, changing in the south to undulating hills, does not provide great opportunity for a far-reaching *chora* (Fig. 7.7). With the fertile hinterlands of Syracuse and Heloros more than capable of sustaining the agricultural needs of the other Syracusan colonies, one possibility may be that the area around Monte Casale was kept for the transhumance migration of sheep,[101] or any other herd animal for that matter, during the summer months and then left unattended during the winter when the shepherds led their flocks towards the coastal plains. De Angelis suggests wool may have been the most commonly used fibre, making a large shepherd community at Kasmenai valuable.[102] For comparison, centuries later Varro migrated his flocks seasonally from Reate in the mountains near Rome south-east to Apulia 400 km away.[103] Kasmenai and Heloros are a mere 36 km away, and such a pattern would have been mutually beneficial for both the shepherds from the mountains and their counterparts near the sea.[104]

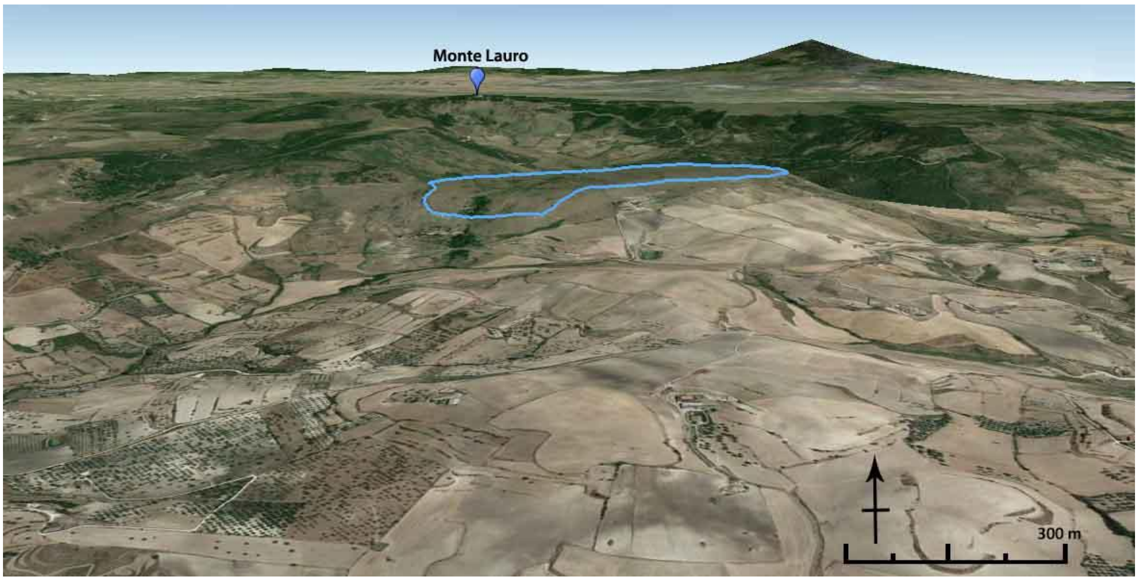

Fig. 7.7: Kasmenai. Topographical view facing north of urban centre (blue outline) and surrounding area, including the peak of Monte Lauro. Google Earth.

The hinterlands estimated in the previous chapters are based on landscape studies suggesting rural populations would live within a three-hour walking distance, which equates to 15 km or an average of 5 km/h walking speed.[105] This rate is based on relatively flat landscapes, not seen in the Hyblaian Mountains. Given that any pastoral population would include older members and at times include herding their livestock to the market, the terrain can reasonably be seen to reduce walking speed by up to two-thirds of the average. Taking this into account, it

[101] Collura 2012, p.2. Zooarchaeological evidence suggests that the Greeks brought with them sheep and cattle to their colonies in Italy, Gaastra 2014. The same may be true with Greek Sicilian colonies.
[102] De Angelis 2016, p.255.
[103] Varro 2.2.9. Cf. White 1970, p.306; Forbes 1995, p.330; Garnsey 1998, p.173.
[104] De Angelis 2016, p.238.
[105] See section 3.8 above.

is estimated that the hinterland of Kasmenai reached only a maximum of 6 km from the urban plateau (Fig. 7.8). The furthest reach of this would likely only be in effect to the south of Monte Casale as Monte Lauro and its ridges to the north provide a hindrance to daily commutes. Further complicating this is the close proximity of Kasmenai to Akrai, which sits at the corner atop a ridge overlooking the Anapos and Heloros river valleys. If Akrai's hinterland was to extend to the west into the valley, then the two *chorai* would overlap. Instead, as proposed in the previous chapter, the area under control of Akrai remained in the Anapos river valley and the plains that flowed east towards the sea and Heloros to the south-east. Therefore, the ridge of Akrai forms the eastern extent of the territory of Kasmenai. This expected hinterland of Kasmenai then encompasses roughly 75 km².

Fig. 7.8: Kasmenai. Syracuse. Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterland attached to Kasmenai. De Angelis 2016, p.67, Map 4 with additions.

Muggia's estimate of one site per square kilometre and 15 inhabitants per settlement is obviously too high for the present study. It would not be unreasonable to expect an average as low as 0.08 (as at Akrai) or 0.1 sites per square kilometre, giving a rural population of 90–113.[106] Alternately, pasture occupied only half of the year could support up to 23 sheep per hectare.[107] In the estimated hinterland of Kasmenai, that accounts for up to 172,500 sheep.[108] Varro provides a figure of one shepherd to 80–100 sheep, which, per the latter figure, gives a total of 1,700–2,200 shepherds at maximum exploitation.[109] It can be expected that not only the man of the household, but his son could be tasked to care for the sheep; if so, 1,700–2,200 shepherds accounts for 850–1,100 households. Those with pasture closest to the settlement could have kept residence within the walls. In fact, the small *chora* estimated here, with the furthest point

[106] 75 km² x 0.1 site/km² x 15 inhabitants/site ≈ 112.5

[107] Belanger 1974, p.168 states up to 15 ewes per acre, which equals 23 per hectare if the land is only used 6 months of the year.

[108] 75 km² = 7,500 hectares. 7,500 x 23 = 172,500 sheep.

[109] Varro 2.10.11. Cf. Scheidel 2005, p.69.

only 6 km from the urban centre, would have allowed the entire pastoral population to be housed within the urban centre. Therefore, the rural population estimate is likely less than one-third the total population, which Hansen expects for a hinterland of this size, or even non-existent. However, for the purposes here the minimal rural population range will be accepted at the time of foundation.

On the low end of the urban range (LU), 1,350 colonists growing 0.5 per cent and 12.5 persons (3 families) a year, reaches 6,000 by the end of the Archaic period. The higher foundation estimate (HU) of 1,800 with an influx of 21 people (5 families) per year grows to 9,100. The expectation is that the hinterland was largely unoccupied; the rural population modelling then follows strictly a growth rate of 0.5 per cent becoming 200–240 by the end of the period. With these population ranges, modelling shows an overall growth rate, with immigration, of 1 per cent (Chart 7.1). Estimates from 644 to 485 BC can be found in Table 7.4.

Table 7.4: Population estimates of Kasmenai from foundation to the end of the Archaic period

	FOUNDATION 644 BC	600 BC	550 BC	525 BC	500 BC	485 BC
URBAN	1,350 – 1,800	2,200 – 3,270	3,650 – 5,390	4,470 – 6,660	5,400 – 8,100	6,010 – 9,060
RURAL	90 – 110	110 – 140	140 – 180	160 – 200	180 – 230	200 – 240
TOTAL	1,440 – 1,910	2,310 – 3,410	3,790 – 5,570	4,630 – 6,860	5,580 – 8,330	6,210 – 9,300

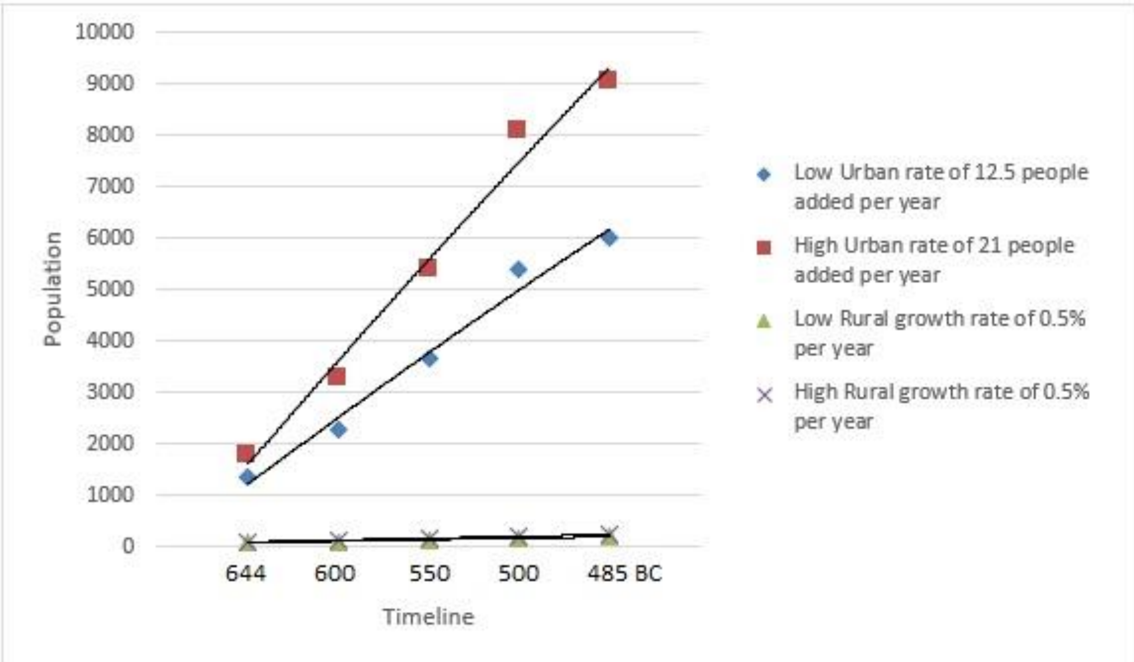

Chart 7.1: Population models of Kasmenai from foundation to 485 BC.

Population modelling estimates 1,350–1,800 members in the foundation party, providing a workforce of 304–405 men potentially able to work 11,000–36,500 md per year.[110] A population this size requires 338–450 houses; labour costs have been calculated to 200–700 md. The quickest timeline estimate utilises 405 labourers, working 90 days a year, building houses with the lowest labour costs, and would have resulted in permanent shelter for every family in 2.5 years, using a workforce of 169–203 men at any one time.[111] A high timeline estimate using 338 labourers, working 36 days a year, constructing houses at the highest labour cost, would have resulted in decades of work, an unlikely outcome.[112] Therefore, the expectation here can be that permanent housing was a priority and completed in a timeline more closely aligned to the low estimate presented here. Beyond the necessary skilled labour, an influx of workmen from Syracuse, or Akrai, can be suggested to complete the permanent housing in a reasonable timeframe, for instance if the community wished to complete the project before the winter. The ox-carriage days are addressed below.

The fortifications at Kasmenai are dated historically to the foundation period; the labour costs have been estimated at 113,500–208,900 md and 75,500 od. The foundation party could have begun construction on the fortifications and residential construction simultaneously, extending the timelines for both. However, there is no evidence of any conflict in the region at the time that would demand the fortifications be completed immediately. It can be expected, therefore, that the residential construction was completed first, and then construction on the wall began soon after. Given the timeline proposed above, then, the urban population and workforce size estimates for foundation will suffice in the calculations for the fortifications. The fortifications could have been completed in 3–19 years.[113] The quicker timeline utilises the same workforce as the residential construction, while the longer estimate would have required 51–68 labourers at any one time. This latter estimate also can be expected to have been shorter with the influx of people into the community. In addition, if the settlement expected construction of the fortifications to have lasted for decades, then a full-time labour force of 50 men could complete the project in 10–19 years,[114] leaving the rest of the workforce to devote themselves to the establishing the settlement and any pastoral duties.

---

[110] 10,994 md/year at 304 labourers working 36 days/year; 36,450 md/year at 405 labourers working 90 days/year.

[111] (450 houses x 196.23 md) / 36,450 md/year ≈ 2.42 years; (((2.42 years x 5 families/year) + 450 houses) x 196.23 md) / 36,450 md/year ≈ 2.49 years.

[112] (338 houses x 695.57 md) / 10,994 md/year ≈ 21.38 years. This does not include houses built for immigrating families.

[113] Low estimate: 113,474 md / 36,450 md/year ≈ 3.11 years. High estimate: 208,947 md / 10,994 md/year ≈ 19.01 years.

[114] Low estimate: 113,474 md / 11,000 md/year ≈ 10.32 years. High estimate: 208,947 md / 11,000 md/year ≈ 19 years.

Above it has been proposed that the rural hinterland of Kasmenai was largely pastoral in nature, and as such the ox-carriage days would have required oxen to be brought to the site from other settlements, likely Akrai and Syracuse. Each house has been estimated to require 90 od, and in the timeline estimated 76 ox-carriages would be needed each year.[115] Mid-seventh century population modelling estimates place 29–63 farmsteads in the hinterland of Akrai and 107–330 farmsteads near Syracuse.[116] If each farmstead had a single oxen team, then it can be expected that at least a small portion of the ox-carriages had to be supplied from the rural population of Syracuse. The latter timeline for the fortifications utilising full-time labourers would have demanded 8–10 ox-carriages per year, a much less labour-intensive expectation.[117] This highlights the extent to which a settlement foundation can involve the metropolis' community beyond the foundation party.

The first phase of the Temple of Ares is expected to have been completed within the last half of the seventh century BC. The labour costs of this project are estimated at 2,300–2,900 md and 146 od. Taking the population modelling estimates for upon foundation and in 600 BC, the population average is 1,875–2,660 (1,775–2,535 urban, 100–125 rural) providing an estimated workforce size of 422–599 labourers. A labour force this size can potentially work 15,200–53,900 md per year.[118] With this workforce, the first phase of the Temple of Ares would have been completed in 1–2 months,[119] an unreasonably fast expectation. A more reasonable estimate would involve a minimal labour force, working full-time: 3 men could complete the first phase project in around 4 years,[120] requiring only a single ox-carriage. The second phase, dated to the mid-sixth century BC, is estimated at 1,500–1,900 md and 230 od. This project could also have been completed with a small number of men working full-time: 3 men in 2–3 years,[121] with up to 2 ox-carriages.

These analyses suggest that Kasmenai would have had a sufficient number of unskilled workmen to complete the monumental projects. The complexity of the houses at Kasmenai

[115] (450 houses x 90 od/house) / 90 days/year / 2.42 years ≈ 185 ox-carriages; 185 ox-carriages / 2.42 years ≈ 76 ox-carriages/year.

[116] Akrai: 430 rural population / 15 people per farmstead ≈ 29 farmsteads; 940 rural population / 15 people per farmstead ≈ 63 farmsteads. Syracuse: 1,600 rural population / 15 people per farmstead ≈ 107 farmsteads; 4,950 rural population / 15 people per farmstead ≈ 330 farmsteads. See sections 6.8 (Akrai) and 4.10 (Syracuse) above.

[117] 75,454 od / 90 days/year / 10.32 years ≈ 81 ox-carriages; 75,454 od / 36 days/year / 19 years ≈ 110 ox-carriages.

[118] 15,192 md/year at 422 labourers working 36 days/year; 53,910 md/year at 599 labourers working 90 days/year.

[119] Low estimate: 2,334.53 md / 53,910 md/year ≈ 0.04 years. High estimate: 2,877.90 md / 15,192 md/year ≈ 0.19 years.

[120] Low estimate: 2,334.53 md / 660 md/year ≈ 3.54 years. High estimate: 2,877.90 md / 660 md/year ≈ 4.36 years.

[121] Low estimate: 1,503.70 md / 660 md/year ≈ 2.28 years. High estimate: 1,851.73 md / 660 md/year ≈ 2.81 years.

would propose that additional labourers would have been needed to expedite residential construction, especially if the community desired to be in permanent shelter prior to the winter. The fortifications and first phase of the Temple of Aphrodite are dated to the foundation period or soon after, and as such it can be expected that skilled workmen would have been brought in from Syracuse, but by the mid-sixth century Kasmenai may have had the skilled labourers available to complete the second phase temenos wall without assistance.

Next, the population estimates from this and previous chapters are discussed within a macro-level analysis of the region and in comparison to the other Greek settlements of Sicily. Then the discussion turns to the conclusions gathered from the econometric calculations, and a complete picture is proposed of the hegemonic expansion of Syracuse through the desire of the elite of the metropolis to extend their wealth and power through land accumulation and inland trade routes.

Chapter 8: Discussion

In previous chapters the archaeological data and individual sites have been discussed in detail, and in this chapter the observations will be pulled together. Population modelling, through demography and methodological estimations, provides a basis for macro-level comparison. Rank-size distributions and primacy values organise the estimates into graphs and figures to analyse the settlement system as a whole. Architectural energetics examines each site individually comparing the labour costs of construction projects, which can then provide comparanda for discussion of the relationship of the settlements within the system. Together, these methodologies build a clearer picture of the settlements at key stages of their development from foundation to the end of Archaic period.

Population modelling in the previous four chapters have arrived at estimates of the number of inhabitants, both urban and rural, connected to Syracuse and each settlement, Heloros, Akrai, Kasmenai and Kamarina, within the Archaic period. Urban and rural estimates can be found in Table 8.1 and Table 8.2, and total figures are found in Table 8.3.

Most recently, De Angelis estimates the population of Syracuse at 2,500–6,700 urban and 5,000–13,300 rural.[1] His methodology, however, is based solely on the broad standards established by Hansen for the Greek world. As is explained above,[2] I have adjusted his estimates to 3,800–10,000 urban and 7,500–20,000 rural; 11,300–30,000 total.[3] Population modelling here estimates a population of 9,100–20,100 urban and 6,000–20,200 rural in Syracuse at the end of the Archaic period, following closely Muggia's estimate of 20,000 people within the urban centre.[4] For the entirety of south-east Sicily at this time, this is an estimated 18,600–33,800 urban and 9,200–24,900 rural population.

[1] 2,498–6,660 and 5,002–13,340. De Angelis 2016, pp.142-3.
[2] See section 3.8 above.
[3] De Angelis does admit that his numbers could be towards the low end and that they could possibly be multiplied by two or three, De Angelis 2016, p.142, n.47.
[4] See section 4.10 above.

Table 8.1: Urban population estimates of Syracuse and its settlements to the end of the Archaic period

CITY-STATE (DATE OF FOUNDATION)	UPON FOUNDATION	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
SYRACUSE (734/3 BC)	90 – 450	1,980 – 4,580	3,560 – 8,030	5,590 – 12,450	6,810 – 15,120	8,200 – 18,130	9,110 – 20,130
HELOROS (C. 700 BC)	16 – 81	130 – 220	290 – 390	480 – 620	600 – 750	730 – 900	820 – 1,010
AKRAI (664 BC)	330 – 810	450 – 950	940 – 1,530	1,580 – 2,270	1,960 – 2,720	2,390 – 3,230	2,680 – 3,560
KASMENAI (644 BC)	1,350 – 1,800	–	2,200 – 3,270	3,650 – 5,390	4,470 – 6,660	5,400 – 8,100	6,010 – 9,060
KAMARINA (599 BC)	5,500 – 7,400	–	8,060 – 10,760 (575 BC)	10,810 – 14,370 (552 BC)	–	–	–
TOTALS:		2,560 – 5,750	15,050 – 23,980	22,110 – 35,100	13,840 – 25,250	16,720 – 30,360	18,620 – 33,760

Table 8.2: Rural population estimates of Syracuse and its settlements to the end of the Archaic period

CITY-STATE (DATE OF FOUNDATION)	UPON FOUNDATION	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
SYRACUSE (734/3 BC)	450 – 900	1,600 – 4,950	2,570 – 8,340	3,800 – 12,680	4,550 – 15,290	5,390 – 18,250	5,950 – 20,220
HELOROS (C. 700 BC)	8 – 41	70 – 110	140 – 200	240 – 310	300 – 380	360 – 450	410 – 500
AKRAI (664 BC)	310 – 780	430 – 940	920 – 1,600	1,550 – 2,450	1,920 – 2,960	2,350 – 3,540	2,640 – 3,920
KASMENAI (644 BC)	90 – 110	–	110 – 140	140 – 180	160 – 200	180 – 230	200 – 240
KAMARINA (599 BC)	9,750 – 14,630	–	15,470 – 21,420 (575 BC)	21,620 – 28,740 (552 BC)	–	–	–
TOTALS:		2,100 – 6,000	19,210 – 31,700	27,350 – 44,360	6,930 – 18,830	8,280 – 22,470	9,200 – 24,880

The largest number of inhabitants within the Syracusan hegemony can be estimated as 49,500–79,500 people in the mid-sixth century prior to the destruction of Kamarina in 552 BC. This is due to the substantial indigenous population expected to have been present at Kamarina in the early sixth century.[5] The minimum estimate of 5,500 inhabitants at foundation might seem high, but it mainly reflects the general population pattern in the region and not so much the number of new Greek settlers. However, there may have been a sizable contingent of Corinthians that joined those from Syracuse.[6] The large rural population attached to Kamarina would have included the well-established indigenous sites prior to the Greek arrival, instantly

[5] Di Vita 1956a, p.199.

[6] Pelagatti 1985, p.295; Cordano 1987, p.121; Di Vita 1987, p.85.

associated with the new city-state.[7] The hinterland does not border other settlements, and as such Kamarina has the largest estimated *chora* (650 km²). Given the multiple avenues from which Kamarina may have drawn their settlers and the possibility of developed indigenous settlement pattern in the *chora*, it becomes understandable that such a large population can be estimated, and with what is known historically about this settlement, with its two *oikists*, the apparent significance in establishing the site is clear. Although it cannot be expected that the entirety of the *chora* was immediately loyal to Kamarina, looking at the estimated number of people under their influence, it becomes clear why the rebels of Kamarina had the courage to face Syracuse so early in their history. As of 552 BC, estimations suggest that the conflict versus Syracuse and the other settlements would have slightly favoured Kamarina, at least in the way of numbers.

Table 8.3: Total population estimates of Syracuse and its settlements to the end of the Archaic period

CITY-STATE (DATE OF FOUNDATION)	UPON FOUNDATION	650 BC	600 BC	550 BC	525 BC	500 BC	485 BC
SYRACUSE (734/3 BC)	540 – 1,350	3,580 – 9,530	6,130 – 16,370	9,390 – 25,130	11,360 – 30,410	13,590 – 36,380	15,060 – 40,350
HELOROS (C. 700 BC)	24 – 122	200 – 330	430 – 590	720 – 930	900 – 1,130	1,090 – 1,350	1,230 – 1,510
AKRAI (664 BC)	640 – 1,590	880 – 1,890	1,860 – 3,130	3,130 – 4,720	3,880 – 5,680	4,740 – 6,770	5,320 – 7,480
KASMENAI (644 BC)	1,440 – 1,910	–	2,310 – 3,410	3,790 – 5,570	4,630 – 6,860	5,580 – 8,330	6,210 – 9,300
KAMARINA (599 BC)	15,250 – 22,030	–	23,530 – 32,180 (575 BC)	32,430 – 43,110 (552 BC)	–	–	–
TOTALS:		4,660 – 11,750	34,260 – 55,680	49,460 – 79,460	20,770 – 44,080	25,000 – 52,830	27,820 – 58,640

De Angelis suggests in Sicily a household of five people would have needed three to four hectares for their own personal subsistence.[8] The hinterland of Heloros has been estimated above at 100 km², equal to 10,000 hectares. If 86.5% of the land was exploited, as De Angelis suggests,[9] then 2,200 households, or 8,700 people, could be fed from a *chora* of this size.[10] It can be expected that this itself was more than necessary to feed the combined populations of Heloros and Syracuse in the early seventh century BC, and fits into the theory of

[7] Di Stefano 1987b.

[8] De Angelis 2000a, p.118. Although for Classical Attica this may have been around five to six hectares, see Morris 2006, p.33.

[9] De Angelis 2000a, p.124; De Angelis 2000b, p.114; De Angelis 2016, p.232, Table 7. He chooses this from three figures suggested in the mid-twentieth century: 83%, Antonietti & Vanzetti 1961, p.81, 86.5%, Pollastri 1948-9, pp.58-9, 72-3, 78-9, and 95.5%, Milone, 1960, p.75.

[10] (10,000 hectares x 86.5%) / 4 hectares per household ≈ 2,163 households of 4 people. 2,163 x 4 people ≈ 8,652 people.

Heloros as an agricultural centre to feed the population of Syracuse.[11] With the addition of Akrai (260 km²), the agricultural capacity of the Syracusan territory could support up to 57,100 people, sufficient for decades to come.[12] This supports the theory presented above that the hinterland of Kasmenai likely was not reserved for agricultural use, but instead pastoral. Attention could then be turned towards commercial possibilities. De Angelis, in his estimates on the agricultural capacity of Syracuse, puts the extent of the land under the Syracusan hegemony at 1,000 km², able to support between 108,000 and 144,000 people.[13] This hinterland is in total larger than that estimated based on the landscape studies discussed in this thesis. But using either estimates, the lands under Syracusan control could support well beyond that necessary for the populations expected by the end of the seventh century.

Kamarina is addressed separately by De Angelis, and his territory size of 670 km² is slightly larger than the 650 km² estimated in this thesis.[14] He suggests up to 90 per cent of the Kamarina hinterland was for agricultural use, supporting 73,000 to 100,500 people. For comparison, the 650 km² falls slightly shy of his lower estimate.[15] However, given the agricultural capacity of the other settlements, Kamarina's hinterland would not have needed to have been fully exploited to provide for the entire population. Even if the amount of land in agricultural use in the Archaic period is not to the extent accounted for here, it still becomes obvious that the Sicilian Greeks had the ability to exploit their terrain for high agricultural gain. Being able to produce an ample amount of agricultural goods allowed the Greek city-states of south-eastern Sicily to play a large role in trade with other regions that were not as agriculturally productive. This then put Syracuse in the position to shape history, as De Angelis suggests, where the agricultural capacity of Syracuse could have been a deciding factor in the Sicilian Expedition by the Athenians.[16] Focusing solely on south-east Sicily, this highlights well the wealth to be had in possessing land, where the excess goods make for lucrative trade opportunities. As well, this could have been a motive behind the push by the people of Kamarina to exert their independence. The population estimates support the arguments that a trade motivation was also behind the Syracusan hegemonic expansion. These estimates can now be used in a larger comparison of settlements in the region and throughout Greek Sicily.

[11] This falls in line with De Angelis and his belief that Sicily could have agriculturally supported twice its population, see De Angelis 2000a, p.139.

[12] 300 km² (Syracuse) + 100 km² (Heloros) + 260 km² ≈ 660 km². (66,000 hectares x 86.5%) / 4 hectares per household ≈ 14,273 households of 4 people. 14,273 x 4 people ≈ 57,092 people.

[13] De Angelis 2000a, p.125 provides a range of figures for the 3 to 4 hectares of land needed to support 5 people.

[14] De Angelis 2000a, pp.124-6.

[15] (65,000 hectares x 90%) / 4 hectares per household ≈ 14,625 households of 4 people. 14,625 x 4 people ≈ 58,500. If the average Greek household consisted of 5 members, 650 km² would support De Angelis' lower estimate: 14,625 x 5 people ≈ 73,125 people.

[16] De Angelis 2000a, pp.139-40.

8.1 Rank-Size Distributions and Primacy Values

Outlined in the Methodology chapter above is the application of rank-size distribution.[17] In the following charts the high-end population estimates are used. As expected, the charts show a concave shape, symbolic of a primate settlement system in which one settlement is much larger than the rest. In a hierarchical society, this can demonstrate the governance of the larger site and conversely the dependence of the smaller settlements on the larger. Chart 8.1 shows the estimated populations of the Syracusan settlements immediately prior to the foundation of Kamarina. At this stage Syracuse has established claim over a large territory, enough to support everyone in the region, and a foothold into the centre of the Hyblaian Mountains. Trade at this time was likely based on land routes towards Gela and Selinous in the west. With the foundation of Kamarina, Syracuse gains a place on the southern coast of the island to open trade routes by sea reaching the African coast and western Mediterranean. Trade is discussed further below. However, as Chart 8.2 demonstrates, based on the total territory and the derived population estimates Kamarina immediately becomes the largest settlement in south-east Sicily. Such a change in the settlement system could eventually result in a change in the hierarchy of the region, a threatening possibility to Syracuse, and perhaps this issue underscored the conflict between it and Kamarina. In fact, it has been hypothesised that the placement of Heloros was in part due to the possibility of a competing group of settlers establishing a settlement that may one-day rival Syracuse.[18] With Kamarina's destruction in 552 BC, Syracuse once again is the dominant settlement in the region (Chart 8.3). Together, these charts demonstrate the shift in population hierarchy brought about by the foundation of Kamarina, as well as the dominance Syracuse maintained before and after.

[17] See section 3.9 above.

[18] Copani 2005, pp.246, 263; De Angelis 2016, p.229.

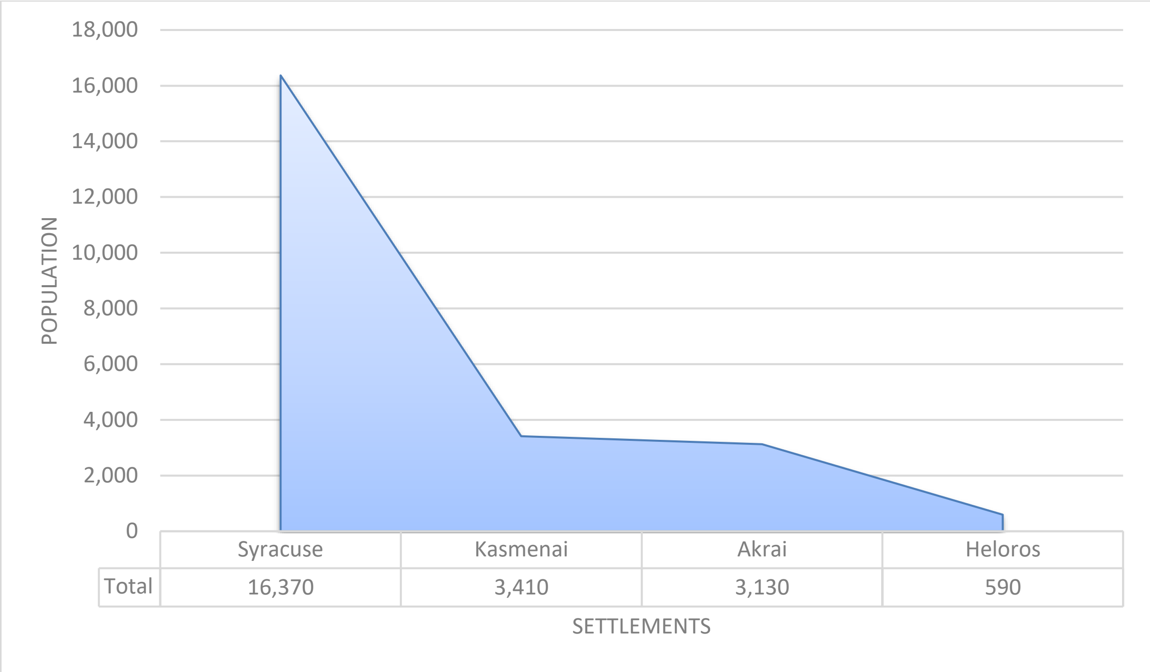

Chart 8.1: Total populations of Syracuse and its settlements in 600 BC.

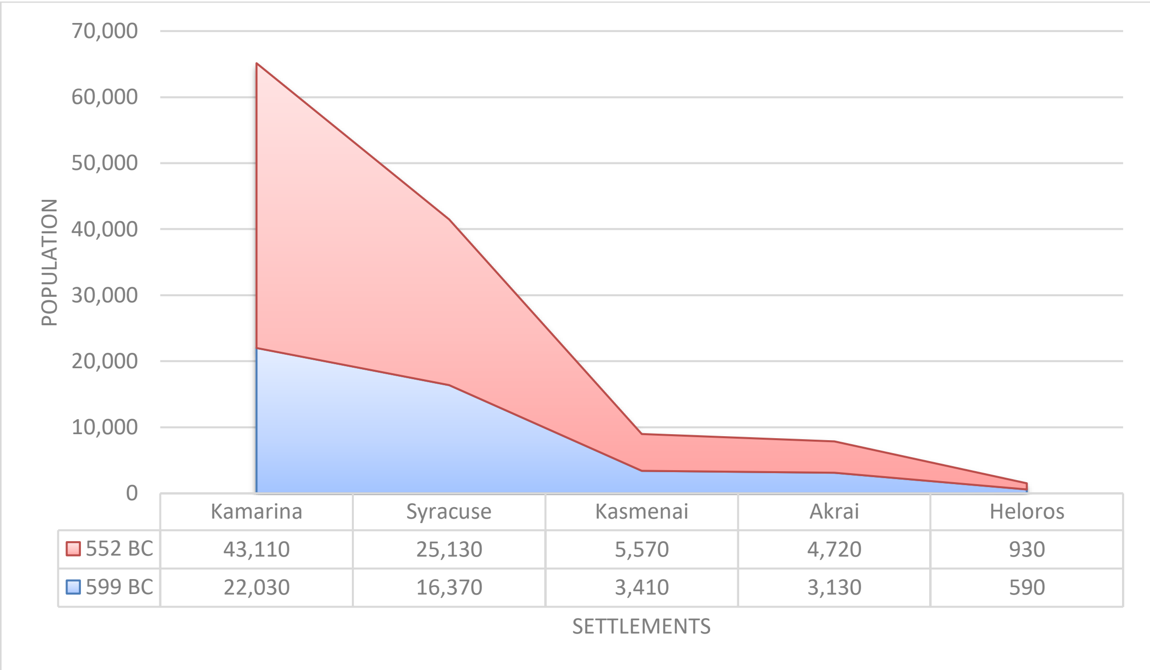

Chart 8.2: Total populations of Syracuse and its settlements in 599 and 552 BC.[19]

A cross-comparison with other Sicilian Greek sites allows for a macro-level view of Syracuse and its settlements within the entirety of Sicily, and for this De Angelis' most recent estimates will be used.[20] He provides urban and rural figures for Akragas, Gela, Himera, Katane, Leontinoi, Megara Hyblaia, Naxos, Selinous and Zankle. The issues with De Angelis' estimates

[19] Population estimates in 600 BC are taken for Akrai, Heloros, Kasmenai and Syracuse as representative of the population in 599, as well as 550 BC for 552. This is also the case for Charts 8.4 and 8.5 and Table 8.5.
[20] De Angelis 2016, p.143, Table 5.

are stressed above, and the same adjustments are made here. These population estimates will be taken as that present at the end of the Archaic period, 485 BC (Table 8.4). For comparison with the inclusion of Kamarina, total estimates can be backdated to 552 BC (Table 8.5) using De Angelis' estimated 0.50 per cent growth rate.[21]

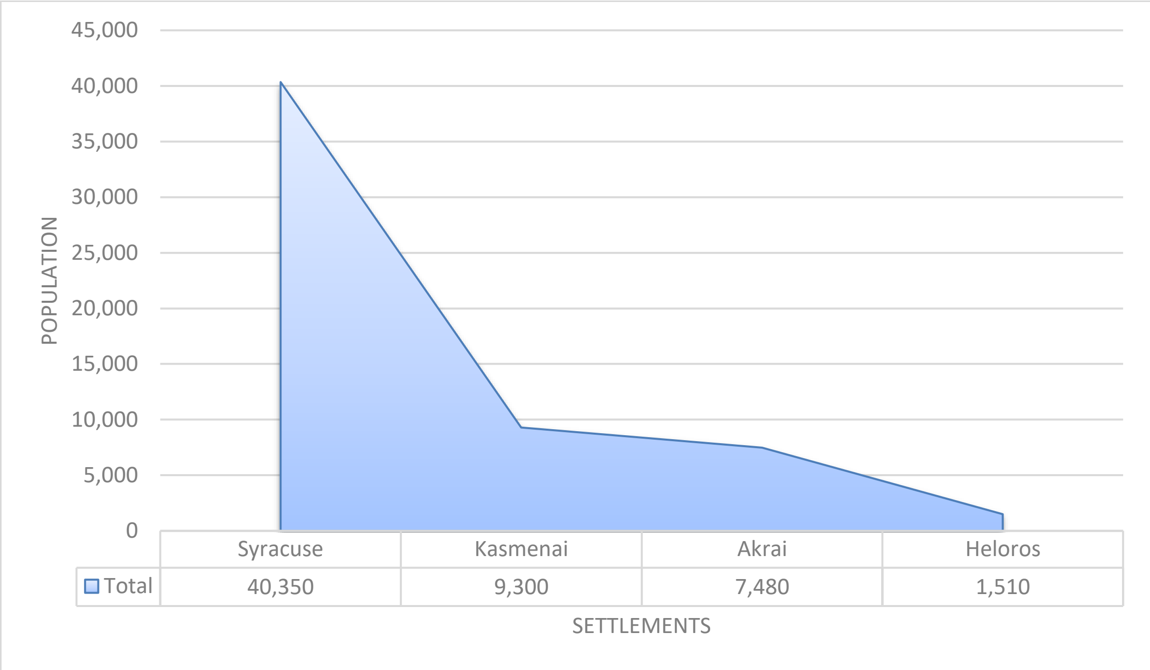

Chart 8.3: Total populations of Syracuse and its settlements at the end of the Archaic period.

Table 8.4: Total population estimates of Archaic period Sicilian city-states in 485 BC

CITY-STATE	URBAN	RURAL	TOTAL	CITY-STATE	URBAN	RURAL	TOTAL
AKRAGAS	30,000 – 40,000	60,000 – 80,000	90,000 – 120,000	**MEGARA HYBLAIA**	9,200 – 12,200	9,200 – 12,200	18,400 – 24,200
GELA	15,000 – 20,000	30,000 – 40,000	45,000 – 60,000	**NAXOS**	6,000 – 8,000	12,000 – 16,000	18,000 – 24,000
HIMERA	18,000 – 26,000	36,000 – 52,000	54,000 – 78,000	**SELINOUS**	16,500 – 22,000	33,000 – 44,000	49,500 – 66,000
KATANE	7,500- 20,000	15,000 – 40,000	22,500 – 60,000	**SYRACUSE**	9,100 – 20,100	6,000 – 20,200	15,100 – 40,300
LEONTINOI	6,000 – 12,000	12,000 – 24,000	18,000 – 36,000	**ZANKLE**	7,500 – 17,600	15,000 – 35,200	22,500 – 42,800
TOTAL	124,800 – 197,900			228,200 – 363,600		353,000 – 561,500	

[21] See section 3.8 above.

Table 8.5: Total population estimates of Archaic period Sicilian city-states in 552 BC

CITY-STATE	URBAN	RURAL	TOTAL	CITY-STATE	URBAN	RURAL	TOTAL
AKRAGAS[22]	21,500 – 28,600	43,000 – 57,300	64,500 – 85,900	**MEGARA HYBLAIA**[23]	6,500 – 8,700	6,500 – 8,700	13,000 – 17,400
GELA[24]	10,700 – 14,300	21,500 – 28,600	32,200 – 42,900	**NAXOS**[25]	4,300 – 5,700	8,600 – 11,500	12,900 – 17,200
HIMERA[26]	12,900 – 18,600	25,800 – 37,200	38,700 – 55,800	**SELINOUS**[27]	11,800 – 15,800	23,600 – 31,500	35,400 – 47,300
KAMARINA	10,800 – 14,400	21,600 – 28,700	32,400 – 43,100	**SYRACUSE**	5,600 – 12,500	3,800 – 12,700	9,400 – 25,200
KATANE[28]	5,400 – 14,300	10,700 – 28,600	16,100 – 42,900	**ZANKLE**[29]	5,400 – 12,600	10,700 – 25,200	16,100 – 37,800
LEONTINOI[30]	4,300 – 8,600	8,600 – 11,500	12,900 – 20,100	**TOTAL**	99,200 – 154,100	184,400 – 281,500	283,600 – 435,600
TOTAL	99,200 – 154,100		184,400 – 281,500		283,600 – 435,600		

Chart 8.4 includes Kamarina as part of the Greek settlement landscape, showing that by the time of its destruction the settlement was one of the largest on the island. Beyond Kamarina's position on the southern coast and its access to trade with Africa, the combined size of Syracuse and Kamarina would have lifted them to a higher position within the Greek settlements of Sicily. This point would have supported the desire for the mother city to maintain some control over its settlement, for Syracuse and its other three settlements were among the smaller sites in population numbers. Chart 8.5 stresses this issue. At the same time, however, Kamarina's size and position among the Greek settlements would have reinforced its desire for independence. Therefore, these charts further stress the implications the establishment of Kamarina had upon south-east Sicily and the island. From population size alone, Kamarina had the ability to become a major Greek presence in Sicily and possibly the western Mediterranean, challenging its mother city. Next, the primacy values of the Syracusan communities will be calculated to approach the relationship of the poleis from a different

[22] Urban: 30,000 / $(1 + 0.0050)^{67}$ ≈ 21,478; 40,000 / $(1 + 0.0050)^{67}$ ≈ 28,637. Rural: 60,000 / $(1 + 0.0050)^{67}$ ≈ 42,956; 80,000 / $(1 + 0.0050)^{67}$ ≈ 57,275.

[23] Urban: 9,150 / $(1 + 0.0050)^{67}$ ≈ 6,551; 12,200 / $(1 + 0.0050)^{67}$ ≈ 8,734. Following Hansen, Megara Hyblaia's *chora* size of 400 km² equates to an even urban to rural ratio.

[24] Urban: 15,000 / $(1 + 0.0050)^{67}$ ≈ 10,739; 20,000 / $(1 + 0.0050)^{67}$ ≈ 14,319. Rural: 30,000 / $(1 + 0.0050)^{67}$ ≈ 21,478; 40,000 / $(1 + 0.0050)^{67}$ ≈ 28,637.

[25] Urban: 6,000 / $(1 + 0.0050)^{67}$ ≈ 4,296; 8,000 / $(1 + 0.0050)^{67}$ ≈ 5,727. Rural: 12,000 / $(1 + 0.0050)^{67}$ ≈ 8,591; 16,000 / $(1 + 0.0050)^{67}$ ≈ 11,455.

[26] Urban: 18,000 / $(1 + 0.0050)^{67}$ ≈ 12,887; 26,000 / $(1 + 0.0050)^{67}$ ≈ 18,614. Rural: 36,000 / $(1 + 0.0050)^{67}$ ≈ 25,774; 52,000 / $(1 + 0.0050)^{67}$ ≈ 37,229.

[27] Urban: 16,500 / $(1 + 0.0050)^{67}$ ≈ 11,813; 22,000 / $(1 + 0.0050)^{67}$ ≈ 15,751. Rural: 33,000 / $(1 + 0.0050)^{67}$ ≈ 23,626; 44,000 / $(1 + 0.0050)^{67}$ ≈ 31,501.

[28] Urban: 7,500 / $(1 + 0.0050)^{67}$ ≈ 5,370; 20,000 / $(1 + 0.0050)^{67}$ ≈ 14,319. Rural: 15,000 / $(1 + 0.0050)^{67}$ ≈ 10,739; 40,000 / $(1 + 0.0050)^{67}$ ≈ 28,637.

[29] Urban: 7,500 / $(1 + 0.0050)^{67}$ ≈ 5,370; 17,600 / $(1 + 0.0050)^{67}$ ≈ 12,600. Rural: 15,000 / $(1 + 0.0050)^{67}$ ≈ 10,739; 35,200 / $(1 + 0.0050)^{67}$ ≈ 25,201.

[30] Urban: 6,000 / $(1 + 0.0050)^{67}$ ≈ 4,296; 12,000 / $(1 + 0.0050)^{67}$ ≈ 8,591. Rural: 12,000 / $(1 + 0.0050)^{67}$ ≈ 8,591; 16,000 / $(1 + 0.0050)^{67}$ ≈ 11,455.

angle.[31] Deriving primacy values for all Sicilian Greek poleis would only provide a comparison figure in relation to Akragas as the largest settlement, so it is reasonable to concentrate here on south-east Sicily.

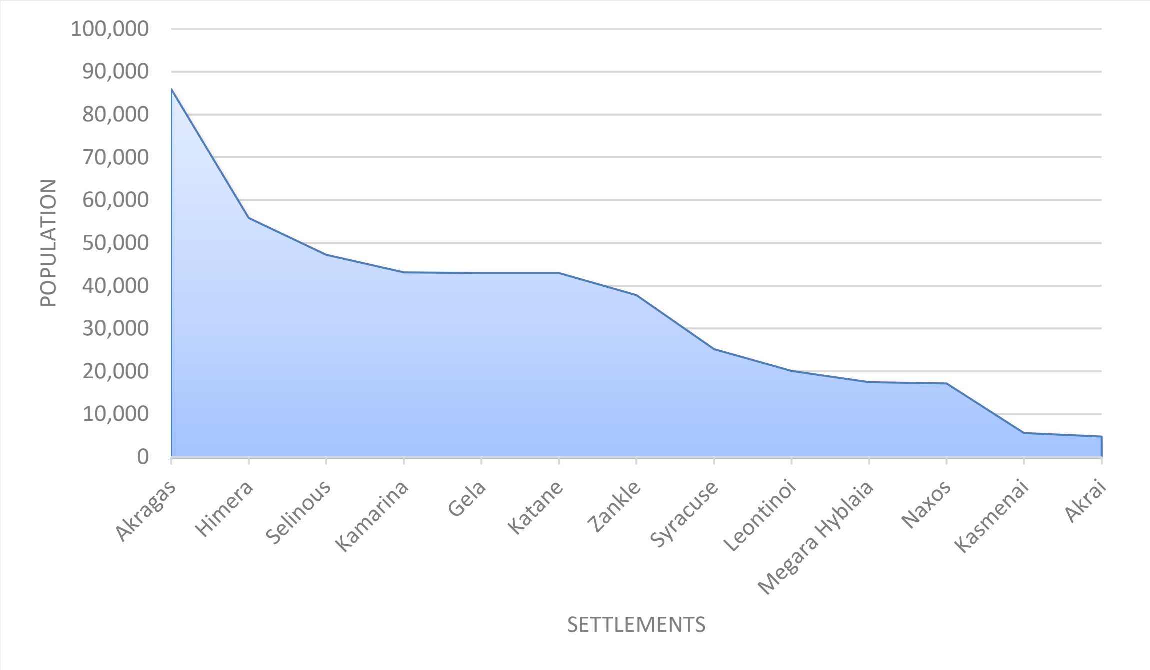

Chart 8.4: Total populations of Greek city-states and Syracuse's settlements in Sicily in 485 BC.

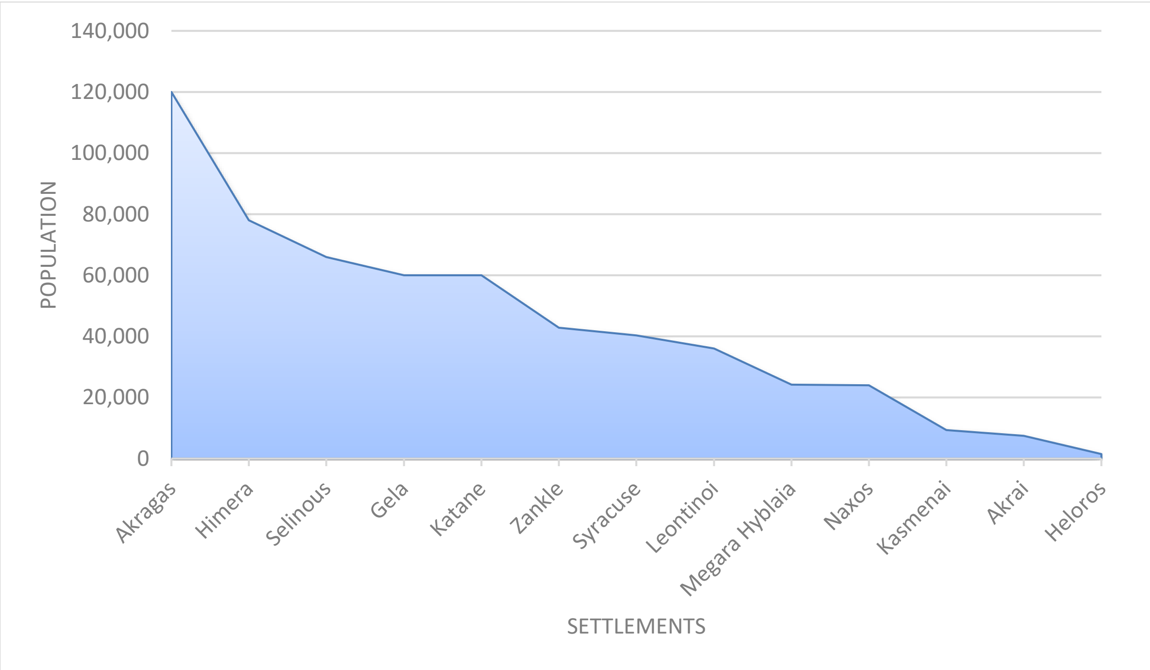

Chart 8.5: Total populations of Greek city-states and Syracuse's settlements in Sicily in 485 BC.

In finding the degree of primacy for each city, each is compared to those settlements of smaller size. Therefore, in the case of urban population in 600 BC, Akrai will be compared only with Heloros. Since Heloros is the smallest city-state, its degree of primacy is zero. Yet, when finding the degree of primacy for the entire system, which is the average of each site's primacy

[31] See section 3.9 above.

degrees, Heloros must be included. Thus, the degrees of primacy for Syracuse, Kasmenai and Akrai in 600 BC are added together but divided by four to find the average degree of primacy for the entire system. When Kamarina is considered, the average for the system will be divided by five. Primacy degrees are found for three points in time: 600, 599, 552 and 485 BC, the calculations of which can be found in Appendix 2. Total primacy values and the degrees of primacy for the largest settlements in each system are listed in Table 8.6.

Table 8.6: Calculated primacy values

	600 BC	599 BC	552 BC	485 BC
SETTLEMENT SYSTEM	0.53	0.57	0.60	0.54
LARGEST SETTLEMENT	Syracuse 0.84	Kamarina 0.74	Kamarina 0.78	Syracuse 0.84

From the calculated values, a few deductions can be made. Prior to the foundation of Kamarina, Syracuse has a large value of governance over the other settlements (0.84), but the system as a whole is relatively integrated (0.53).[32] With the establishment of Kamarina, the value increases within the entire system (0.57), signifying a larger degree of dominance by the largest settlement, Kamarina itself. On the other hand, Kamarina's position relative to the other settlements (0.74) is less dominant than Syracuse's position prior. Overall the value changes are not substantial, however the trend in the first half of the sixth century indicates an increase in the hierarchical position of Kamarina, which continues to increase until its destruction in 552 BC. After this, the system returns to its previous state. These primacy values produce numerical figures that reiterate the same results as the charts above: the foundation of Kamarina altered the established hierarchy of the settlements in south-east Sicily.

There are, of course, inherent difficulties with this approach, starting with the obvious issues of the population estimates. Beyond that, only 250 years will pass before Syracuse is defeated by Gela, 159 years after Kasmenai was settled and Kamarina only survived forty-seven years before its demise. Therefore, the overall age of the Syracusan settlement system was quite young, and given the expansion of settlements westward culminating in the short-lived Kamarina, it can be argued that south-east Sicily was not fully developed. Further, at only five sites, the system is quite small, the minimum according to El-Shakhs.[33] The peaceful co-existence of Kamarina with the nearby local populations has been addressed in the second chapter.[34] The tensions between Kamarina and its mother city may have arisen in part due to the large rural/Sicilian population. The extensive hinterland between the Achates and

[32] A system of log-normal distribution, if calculated to a degree of primacy, would result in a value of 0.33.
[33] El-Shakhs 1972, p.19.
[34] See section 2.4.6 above.

Herminius does not border another Syracusan settlement. The same cannot be said of Akrai, Heloros or Syracuse itself. This large area and its inhabitants were then likely under the influence of their Greek neighbour almost immediately. With such a large population, Kamarina soon became a major factor in Greek Sicily as the fourth-largest city-state. Further, the agricultural capacity of this area could have supported up to an estimated 100,000 people,[35] allowing Kamarina to be self-sustainable. The settlers, even in 599 BC, knew the importance of the settlement and the profit to be made from its position in the Sicilian landscape. It could not have been long before these Greeks realised the power they held within the settlement system.

In the third chapter, a hypothetical three-step spatial transformation was briefly summarized through which a settlement system could evolve, from a highly primate one, with a large site in an authoritative position, to a developed and fully integrated one.[36] This usually happens through a conflict between the core population and those in the periphery which is either resolved peacefully or through a major revolution. The further a system develops, the primacy value tends to rise, reaching a peak during the middle or transition stage and then declining with higher integration of all aspects of the system. In south-east Sicily, the primacy values as listed in Table 8.6 do not correlate directly with such a developmental pattern. Prior to the rebellion in 552 BC Syracuse was developing to a peak primacy value. Upon foundation of Kamarina, the settlement took the position of the largest total population, raising the system degree of primacy and transitioning the region to Kamarina as the major settlement player. With two paths available in the hypothetical middle stage, peaceful resolution or major revolution, Kamarina chose the latter, resulting in its demise and essentially a step backwards in the settlement system development. The population evolution in general does not follow one of the three developmental patterns discussed in Chapter 3. However, the settlement system fits the mould of 'primate' with Syracuse as the larger settlement dominating the smaller settlements. In the end, due to events taking place in the area, this pattern did not have the time to evolve further. By 485 BC, the primacy value had returned to its pre-Kamarina value, showing a devolution to the first stage, but the defeat of Syracuse by Gela put an end to the entire process initiated in the Archaic period.

With the Syracusan expansion of south-east Sicily studied regionally through the population figures and primacy values, the internal conflict in the first half of the sixth century BC gains a new perspective, as does the overall settlement expansion process from the end of the eighth. Combining this macro-view with discussions of each settlement of Syracuse, some further conclusions will be reached in the next section. The architectural energetics calculations of the sites fit into this picture well: the early settlements were largely self-sufficient when

[35] De Angelis 2000b, p.125, Table 4.

[36] See section 3.9 above. Cf. El-Shakhs 1972, pp.15-6.

initiating construction projects, but the calculations suggest additional assistance, often in the form of skilled labour and oxen, was necessary. The Syracusan expansion process will be summarized with new views to the arguments outlined throughout this work, placing Syracuse, Heloros, Akrai, Kasmenai and Kamarina within a territorial expansion through planned endeavours influenced by commercial interests and involving a socio-political environment of governance by Syracuse.

8.2 Architectural Energetics and Conclusions

Using the exercises in architectural energetics and the accompanying population assessments detailed in the previous chapters, an attempt can be made to reach a fuller picture of the late Archaic settlements of Syracuse, their rural and urban patterns and political, social and economic roles within south-east Sicily. A range of comparative data can be used to overcome the relative lack of the archaeological data in the region. This is due to few systematic research programmes from the end of the nineteenth through most of the latter half of the twentieth century. These instances have been stressed above. The construction projects would have required human and material resources while the populations at the time were often self-sufficient, at the very least Heloros, Akrai and Kasmenai each would have needed assistance, most often in the form of skilled labour, from Syracuse. Control over resources, whether material or human, can be argued to have largely been in the control of the ruling elite at Syracuse. Estimates of total man-days per construction project can be found in Table 8.7. In general, as sites grew in size and residential construction became more complex, the labour costs increased. However, housing remained just a fraction of the labour costs when compared to the fortifications or monumental construction projects. Further, the labour costs associated with the temples seem to reflect not only monumentality over time, but the ability of the community to sufficiently provide the majority of the costs themselves. For instance, Heloros and Kasmenai have temple construction beginning in the seventh century, soon after foundation. On the other hand, the Temple of Aphrodite at Akrai and the Temple of Apollo at Syracuse were most likely sixth century projects that convey a higher standard of monumentality, but seemingly not more than the community could handle. The location of the quarries within the Akrai urban centre allows for a vast reduction in transport costs, while Syracuse by this time had already had a population in the thousands, likely providing the wealth and resources able to sustain such a grandiose project. The fortifications required the largest amount of labour, indicating that safety and protection was paramount to religious or secular construction. Each settlement will now be discussed individually.

Table 8.7: Architectural Energetics total calculations (md = man-day; od = ox-carriage day)

CITY-STATE	FORTIFICATIONS	HOUSING	TEMPLES
AKRAI	65,100–80,200 md	83–290 md	28,100–34,400 md
	+ 4,500 od	+ 28 od	+ 480 od
HELOROS	42,300–64,000 md	20–75 md	100–380 md
	+ 4,800 od	+ 8 od	+ 13 od
		13–42 md	77–250 md
		+ 7 od	+ 10 od
KAMARINA	112,900–293,100 md	–	–
	+ 14,700 od		
KASMENAI	113,500–208,900 md	200–700 md	3,800–4,700 md
	+ 75,500 od	+ 90 od	+ 370 od
SYRACUSE	–	27–76 md	88,900–109,900 md
		+ 24 od	+ 149,000 od
		19–42 md	
		+ 24 od	

At Heloros, help from Syracuse is not unlikely in the initial stages of development. With an estimated 16–81 settlers, residential construction could have been completed within a year, but additional labour from Syracuse would have allowed the settlement to build quickly the residences and any important infrastructure before the winter months. On the other hand, the simple construction of the early Archaic sanctuary, the Koreion, may not have demanded much of Heloros or its mother city. Skilled labour and supervision would have become more essential in the sixth century with the construction of the fortifications. Events surrounding and following the Kamarina rebellion may have resulted in an environment in south-east Sicily that required more attention be placed on security and defence. In this case, completing the Archaic period wall more speedily would have necessitated additional skilled labour and a larger workforce.

The foundation party at Akrai has been estimated at up to ten times larger than Heloros in its infancy. Yet, the more complex housing styles result in a fivefold increase in building expenditure. The minimum estimated timeline to provide permanent shelter for the population is 2 years; this suggests additional labourers would have been needed from Syracuse if quick completion of the residential construction was prioritised. However, perhaps Syracuse was not as insistent in the rapid development of Akrai as it was with Heloros. While the latter site secured its location from other colonial powers and increased the agricultural capacity of Syracuse, the position of Akrai may have been viewed as less precarious also due to the larger foundation party.

In the second half of the sixth century the fortifications and Temple of Aphrodite were completed, perhaps simultaneously. Based on the labour cost and workforce estimates, both projects could have been completed within a decade. Although a longer timeline is also possible, this indicates that Akrai was quite self-sufficient in procuring the unskilled labour and material resources. Akrai would have grown in importance with Syracuse, and the bulk of the rural population can be expected to have resided within the Syracuse-Heloros-Akrai triangle. The role of the settlement as part of the trade route and local agriculture, therefore, served to raise the status of Akrai. Indeed, the two construction projects are expressions of its importance.

Placing any potential social factors aside, the settlement at Kasmenai claimed the land west of Akrai, securing the sources of the rivers Anapos, Heloros and Herminius and extending land trade routes through the mountains and to the southern coast. The urban centre of Kasmenai formed the largest settlement to date, yet the rural population is estimated to have been rather small. Economic value in the site must have largely come from its setting within the regional landscape and its participation in the local economy. Melfi outlines probable artisanal practices of the community, based on the iron weapons found as votive offerings.[37] Also, a pastoral economy of herding goats and sheep is likely. Yet, unless these practices blossomed to large-scale, profitable endeavours, and were a part of the trade, the economic impact would have been relatively small though locally significant. Perhaps what best reflects the role of Kasmenai in the commercial interests of south-east Sicily is its abandonment by the mid-fourth century. In the century after the destruction of Syracuse, the tyrants of Gela would have seen the benefit of using the area for herding, but the turmoil that followed in the region would seem to have resulted in the eventual end of the endeavour.

As a reflection of rising living standards, the houses at Kasmenai were even more complex than Akrai while the population at the beginning was not much more than Akrai at the same stage. An estimate to provide permanent shelter for the entire population is 2.5 years, at the earliest. The expansion process was quite determined. Heloros was founded around a generation after Syracuse is settled, Akrai and Kasmenai only twenty years apart and Kamarina less than fifty years later: Syracuse was clearly eager to establish its position in the region and to solidify its commercial interests. Again, this suggests Syracuse must have been even more involved in the foundation processes if the residences were to be completed fairly quickly.

The fortifications may also suggest this. Historically, the walls are thought to be present soon after foundation, yet the construction technique suggests a century later. If the former, the eagerness of Syracuse to secure the area is more than obvious, if the latter, then a similar need can be suggested in securing each of the colonies that remained following the disaster of Kamarina. The quickest timeline estimated for the construction of the fortifications is 8 years, and, therefore, if the walls were a priority, support from Syracuse, beyond skilled labour, is expected.

[37] Melfi 2000. See section 2.4.4 above.

Lastly, the two phases of temple construction at Kasmenai, in the early and mid- to late sixth century, can quite possibly demonstrate the willingness on the part of Syracuse to reward its settlement, especially in the more expensive materials of the second phase. As with the previous settlements, the construction style of the Temple of Ares was not more than the settlement could handle in a relatively quick amount of time. The events of the early fifth century also attest to the close socio-political relationship between Kasmenai and Syracuse.[38] After the expulsion of the *Gamoroi*, they sought refuge at Kasmenai where they likely retained interests and property.

For comparison, De Angelis estimates the costs of constructing Temples A, O and G at Selinous.[39] He only accounts for men working 200 days a year, less than estimated here, eight hours a day, and includes just the stone costs, but the comparisons are relevant nonetheless. The total population at Selinous is estimated (Table 8.4) as 35,400–47,300 in 552 BC and 49,500–66,000 in 485 BC. The city-state is larger than Syracuse, and comparable to Kamarina in the mid-sixth century, and the estimated 1,600 talents spent to fund the seven temples under construction from 550 to 460 BC imply a great wealth. Implications from this provide an image of a city-state flourishing in an environment of great prosperity where monumental projects are under construction, stretching the workforce more than would be possible at a smaller centre such as the Syracusan settlements. Again, the accounts provided by De Angelis do not include roofing structures, foundation digging or even the element of transport by work-animals, as is required for a thorough assessment. However, when considering the socio-political implications of the cost analysis at Selinous, a model could be conceived based on comparison with Syracuse: the ruling elite established settlements beyond the chora of the polis, helped funding monumental construction projects, gained notoriety and social standing that in turn stimulated their political position to further influence the community and increase personal wealth. This in turn then can be extrapolated to a macro level incorporating the rank-size structures established above: higher ranking communities garnered larger construction projects to perpetuate their regional standing.

Therefore, the conclusions provided by the calculations through architectural energetics can outline quite convincingly the connections of the Syracusan settlements with their mother city. In the Late Bronze Age of the East Mediterranean, the elites often consolidated their power and prestige through large-scale public events, including the funding of labour and resources for massive building programmes.[40] The construction projects under consideration here did not require much more than the settlements could achieve themselves,

[38] Greco & Torelli 1983, pp.183-4.
[39] De Angelis 2003, pp.163-9.
[40] Brysbaert 2013, pp.84-5.

beyond the expected influx of skilled labour. However, circumstances may have required at least additional labour from Syracuse. At times, the number of oxen available for transport may have been the largest hurdle to overcome. The fact that Dionysios I was able to muster 6,000 pairs of oxen for his Epipolae project gives an idea of what was available centuries later,[41] although this may be more credit to the power of Dionysios I than the agricultural capacity of Syracuse. Overall, the construction projects analysed here indicate that by and large the settlements could have provided the majority of the necessary human and material resources.

The enthusiastic nature of the expansion process at times becomes quite clear, such as the mid-sixth century BC fortifications of Kamarina. Constructing a wall seven kilometres long is an extensive project, estimated as 112,900–293,100 man-days. Yet, what may be the largest undertaking is supplying enough oxen to support the 14,700 ox-carriage days. The excavations have shown that the fortifications were constructed quickly and without proper quarrying techniques.[42] While this fits perfectly into the time period, immediately before the war with Syracuse, it also suggests that much of the work must have involved cutting of corners and poor craftsmanship, which has been taken to account in the econometric calculations. Even further, there cannot be any certainty that the project was actually finished. The destruction of Kamarina attests that the fortifications did not save the settlement, whatever the reason.

Still, through these estimates, it becomes evident that Kamarina believed they had a large enough workforce with which to accomplish such a large feat, presumably jointly with the large indigenous population within their *chora*. The calculations in section 4.10 estimate the quickest timeline at a couple months. This is quite reasonable given that the workmanship was of low quality. Assuming all these factors, achieving such a spectacular accomplishment as building a four-metre-high wall seven kilometres in distance in only a couple months could easily inspire a city-state. Even if the labour pool was significantly lower and the process took the better part of a year, no more proof should be needed that Kamarina could survive and flourish without the watchful eye of Syracuse. Unfortunately, the confidence of the community may have verged on arrogance, and the events following their crossing of the Herminius would serve as testimony.

Focusing specifically on the fortifications, these construction projects could have had socio-political ramifications and have related to displays of power.[43] Because of the large undertaking through manpower, resources and enough space for construction, the process had to be approved by the entire community. In south-east Sicily, it is possible that each community had to get the acceptance of Syracuse before beginning the project as the metropolis was often

[41] Diod. Sic. 14.18.2-8.
[42] Orsi 1899b, pp.209-10.
[43] Lang 2007, pp.185-6.

expected to have had to provide assistance, even if Syracuse did not initiate their construction. Kamarina, on the other hand, would not have had prior consent from Syracuse, proving once again that Kamarina did not need Syracuse to survive. This would have certainly provided Kamarina with more confidence and Syracuse with further reason to assert its dominance.

The use of architectural energetics provides further evidence towards what the socio-political landscape was in the Archaic period of south-east Sicily. From quite the beginning, the population of Syracuse was able to establish a powerful position as part of the commerce of the Mediterranean. They made steps quickly towards their own self-preservation while stretching the influence of the city-state westward through establishing settlements. The expansion process involved the foundation of city-states which would have had to have been relatively self-sufficient, and even in the instances where additional resources were initially needed, these would not have been too large for Syracuse to assist. Through the first century, the strategy worked well, but perhaps the fatal error made by Syracuse was in providing Kamarina too large of a colonial party and by extension it was soon able to establish itself as a regional power. Maybe even Syracuse underestimated the impact of the local population and how soon the fledgling settlement could gain their loyalty.

The establishment of the settlement pattern in south-east Sicily by Syracuse can now be perceived in a different light, with different emphasis in the historiographical narrative of the area during the Archaic period. Upon the foundation of Syracuse in 734/3 BC, the colonial party would have already been aware of the importance of their endeavour. Regardless of the reasons behind their migration to Sicily, the economic opportunities afforded to the settlers, discussed further below, were attractive. The first priority was to find a suitable place to establish the city-state. The island of Ortygia provided a secure area with access from land only at the northern end, and ports available on both the eastern and western sides. Within a few years of its foundation, Syracuse consolidated its position. The next logical step is to look outwards for expansion.

Access to the north was hindered by Megara Hyblaia, a contemporary settlement less than twenty kilometres north along the coast.[44] Advancement in this direction ended before it began. Instead, looking south, a suitable place for a new settlement sat on the coast at the mouth of the river Heloros. The river valley had much agricultural potential for a fair-sized settlement, and its location near the south-eastern tip of Sicily would allow for a final stop by traders along a route around the island and to northern Africa. Indeed, this site may have

[44] Thucydides (6.4.2) places the foundation in 728 BC, but Strabo (6.2.4) suggests 735, the same year as Naxos.

already been known to the Greeks in the homeland as an appropriate site to settle.[45] With an eye towards increasing their domain, providing further food supplies as well as eliminating any possible competing Greek populations, Syracuse chose to place a settlement at Heloros around the beginning of the seventh century.

Heloros was likely a tool of the *Gamoroi* from the very beginning. The acquisition of land by the Syracusans can be viewed as securing resources for future growth and expansion, while the aspiration for greater wealth through landholding was, or soon became, equally motivating. Thus, whilst securing the area around Heloros from competing Greeks, the community predominantly played a role for the benefit of the Syracusan elite class, while also maintaining a relationship with local indigenous populations. Quite likely there was an indigenous presence in the Greek settlement.[46]

The population size at Heloros was small throughout its history, suggesting that this was part of Syracusan strategy from foundation. With such a key location near the southern tip of Sicily, the area could have been developed into a metropolis at the crossroads of trade in the Mediterranean. Perhaps external pressure came from the sea due to piracy, making the venture less appealing.[47] Further to this, it is possible that Syracuse saw the economic potential of the interior of the island already at this point. If Heloros had been allowed to grow as a trade port, the aspirations that the *Gamoroi* at Syracuse had for their own city-state could have been hindered.[48] Irony can be found in the fact that 150 years later, this exact problem befell Syracuse with its last settlement, Kamarina.

Akrai was founded in 664 BC in the highlands west of Syracuse, at the source of the rivers Anapos and Heloros, upon the cliff edge overlooking the river valleys. With a view to the east, the settlement represents the final vertex of an enclosure of land between the three settlements with the two rivers and coast as borders. The agricultural capabilities within this triangle were easily exploitable with its entirety virtually a day's walk from a Greek settlement (Fig. 8.1). This allowed for Syracuse to divide the land among its citizens securely. Akrai also represents a major inroad for Syracuse into the interior of the island at the southern foot of the Hyblaian Mountains. To the west, Akrai also serves as a watchful eye over the source of the Herminius. At the time, Akrai was an important part of Syracusan strategy in its position at the western end of the immediate hinterland of Syracuse, while also essentially acting as a landmark to assert control over the lands stretching to the west. Whereas this can be viewed as an act of aggression towards the indigenous populations of the interior, in fact the placement of

45 Copani 2009, pp.12-3.
46 Copani 2005, pp.257-8.
47 Diod. Sic. 5.6.2; Hdt. 2.152; Thuc. 1.7; 6.4.5; Strab. 1.3.2. Cf. De Souza 1999, p.22; Greco 2008, pp.36-7; De Angelis 2010b, p.31.
48 Copani 2005, pp.246, 263.

Akrai wards off any actions of opposing Greek parties that could have wished to annex the nearby territory. In essence, Syracuse was laying claim to all that lies south of Monte Lauro, the highest peak of the mountain range. At this stage, Akrai can be viewed as the centre of the continued expansion process across the south-east tip of Sicily.

Fig. 8.1: Hypothetical extent of Archaic Syracusan territory with estimated extent of hinterlands attached to Syracuse and its settlements. De Angelis 2016, p.67, Map 4 with additions.

Looking at how the hinterlands of Syracuse, Heloros and Akrai overlap (Fig. 8.1), a gap in coverage becomes noticeable due to the hypothetical hinterland of Heloros being limited to the lowland, coastal area. Therefore, this may then suggest an unknown intermediary settlement existed on the edge of the upland area south of the river Kakyparis (modern Cassibile) or on the coast, at the mouth of the river, where the modern city of Cassibile now sits.[49] Barring these possibilities, Heloros would seem the nearest urban centre for any population within the uncovered area.

De Angelis has hypothetically suggested that Archaic and Classical Greek Sicily could have supported well over one million people, but may have only had a population of little more than half of that, 600,000.[50] This population number is an estimate based on Muggia's calculations to include the Greek city-states not discussed by her.[51] This is in comparison to Beloch's total population of Classical Sicily at around 300,000, and Pounds' slightly higher figure of 350,000.[52] De Angelis' most recent estimates, adjusted here to follow more strictly Hansen's Shotgun Method, and the population assessments given above provide an estimated 366,000–580,000 people in Greek settlements at the end of the Archaic period.[53] These Sicilian

[49] Muggia, 1997, p. 59.
[50] De Angelis 2000a, pp.138-9.
[51] Muggia (1997, pp.56-115) population estimates, as summed up by De Angelis, provide a range of 315,785 – 317,785. Cf. De Angelis 2000a, p.139.
[52] Beloch 1886, pp.261-305; Pounds 1973, p.54.
[53] 27,820–58,640 (Table 8.3) + 337,800–521,200 (Table 8.4) ≈ 365,620–579,840.

population numbers can be compared with Hansen's total of 7.5 to 10 million inhabitants of the entire Greek World at the end of the Classical period.[54] The Syracuse-Heloros-Akrai triangle could agriculturally support 57,000 people;[55] the 650 km² of Kamarina increases that total to 113,000.[56] By the mid-sixth century BC, the population of south-east Sicily can be estimated as 49,500–79,500, only 44–70 per cent of the agricultural capability. Therefore, the agricultural capacity of south-east Sicily increased the importance of the region, and the island, in the eyes of the Greek world, especially among those city-states that needed to import food. The potential of the fertile Sicilian landscape has been listed as one reason behind the reigns of tyrants and their wars which plagued Sicily.[57] With enough agricultural land to provide for the growing population and its position in the Mediterranean commerce established, Syracuse shifted its expansionist gaze westward.

A generation after Akrai, Kasmenai was founded on top of the plateau of Monte Casale, only twelve kilometres west of Akrai.[58] Akrai could after that focus its attention on the plains to the east within the Syracuse-Heloros-Akrai triangle. Additionally, given the fairly quick turnaround from Akrai to Kasmenai and their close proximity, it could even be suggested that both sites were planned simultaneously.[59] While this is not unreasonable, it is difficult to substantiate. Either way, Kasmenai increased the amount of land under the influence of Syracuse and provided the next Syracusan step westward and to the southern coast of Sicily.[60] This settlement then allowed Syracuse to solidify its territory in the interior towards Gela (Fig. 8.2), which itself was founded forty-four years prior. Evidence even suggests an emporium may have existed prior to the foundation of Gela, indicating that trade routes were already in place there.[61] The Syracusans may have even planned the establishment at Monte Casale decades prior. Greek trade with the indigenous peoples of the Hyblaian Mountains attested by the Khalkidian influence at Monte Casasia could have sparked a response by Syracuse to quickly establish their control through the mountains to maintain their dominance in the Western Mediterranean. From a socio-political standpoint, the events in the mother city in the mid-seventh century, discussed in the first two chapters, may have had an effect on the two

[54] Hansen 2006b, pp.27-8.
[55] 300 km² (Syracuse) + 100 km² (Heloros) + 260 km² ≈ 660 km². (66,000 hectares x 86.5%) / 4 hectares per household ≈ 14,273 households of 4 people. 14,273 x 4 people ≈ 57,092 people.
[56] (65,000 hectares x 86.5%) / 4 hecatres per household ≈ 14,056 households of 4 people. 14,056 x 4 people ≈ 56,224 people. 57,092 + 56,224 ≈ 113,317 people.
[57] De Angelis 2006, p.35. However, the passage quoted by De Angelis (Hdt. 7.154-5) does not specifically mention the role of fertile land as a reason for conquest.
[58] It has been hypothesised that the line of penetration to Kasmenai went up the river Tellaro, in contrast to going through Akrai, Di Vita 1999, pp.366-7. The purpose of this was to solidify or strengthen the hegemony of the Syracusan, particularly over the indigenous communities around Monte Finocchito.
[59] Copani 2009, p.21.
[60] Di Vita 1999, p.368.
[61] De Angelis 2016, p.167.

settlements, perhaps forcing the hand of Syracuse to found Kasmenai so quickly, and Monte Casale was the best location known at the time.[62]

As of 644 BC, Syracuse had a secure hinterland, providing plenty of land to its citizens, and a foothold in the trade opportunities of the interior. Initially, the western extension of trade seems to have stretched to Gela, naturally the most convenient partner on the southern coast (Fig. 8.2).[63] This would have fostered peaceful relations between the two city-states, likely resulting in the refusal of Gela to assist Kamarina in its rebellion less than a century later. However, it would not have been long before Syracuse wished to establish its own port on the southern coast to gain complete control over the entire commercial avenue.[64] Almost fifty years later, at the beginning of the sixth century, Kamarina was settled at the mouth of the river Hypparis. The Achates, under the cultural influence of Kamarina, became the western extent of Syracuse's extensive hinterland, securing the entire south-eastern tip of Sicily. Essentially, this eliminated any actions within the region from outside Greeks, an issue already evident in the foundation of Heloros. The Achates also inhibits Gela from expanding eastward, lowering the influence of that settlement on the populations of the area.[65] In addition, having a secure overland route from Syracuse to Kamarina was economically beneficial. With a large territory and several ports Syracuse was a major player in trade flowing not only inter-regionally, but more widely between Greece and Carthage, including establishing an emporium on the southern coast, east of Kamarina, at contrada Maestro.[66] As a result, in the first half of the sixth century, Syracuse became one of the most important Greek settlements in the Mediterranean.

De Angelis has recently published the most up-to-date examination of Sicilian Greek economies in his *Archaic and Classical Greek Sicily*.[67] Agricultural and non-agricultural production (pottery, minerals and metalworking) thrived throughout the island in the Archaic period. Agricultural production has been addressed above, and a case has been made that Syracuse and its settlements had ample land and an excess of agricultural produce beyond their own needs. At the very least, Syracuse and Kamarina were producing pottery for export. Sea salt is expected to have been widely exploited along the coast, while local metal-working is hypothesized in Kasmenai, mentioned above, and at Syracuse. On the other end, Gela also developed traditions of clay-working by the sixth century, and likely produced sea salt. Minerals

[62] De Luna 2009, p.78 suggests these social and political pressures also led to the foundation of Kamarina.
[63] Di Vita 1956a, pp.185-6; Domínguez 2006, p.281. Although the western gate at Akrai has been identified as the Selinuntian (Selinous) gate (Bernabò Brea 1956, p.24) with the idea that the road from Akrai led to Selinous, it can be argued that the initial trade route from Syracuse would have been established with Gela as the natural end point, being the dominant city-state in the early Archaic period prior to the foundation of Selinous by Megara Hyblaia in 628 BC.
[64] Anello 2002, p.68; De Luna 2009, p.78.
[65] Domínguez 2006, p.289.
[66] Di Stefano 1987a; De Angelis 2016, pp.98, 169.
[67] De Angelis 2016, pp.222-318.

are expected to have been exploited even during prehistoric times in the central southern part of the island. All of these goods would have provided trade opportunities within the region and across the sea. Indeed, De Angelis argues that the Sicilian Greeks had plans toward external trade from foundation.

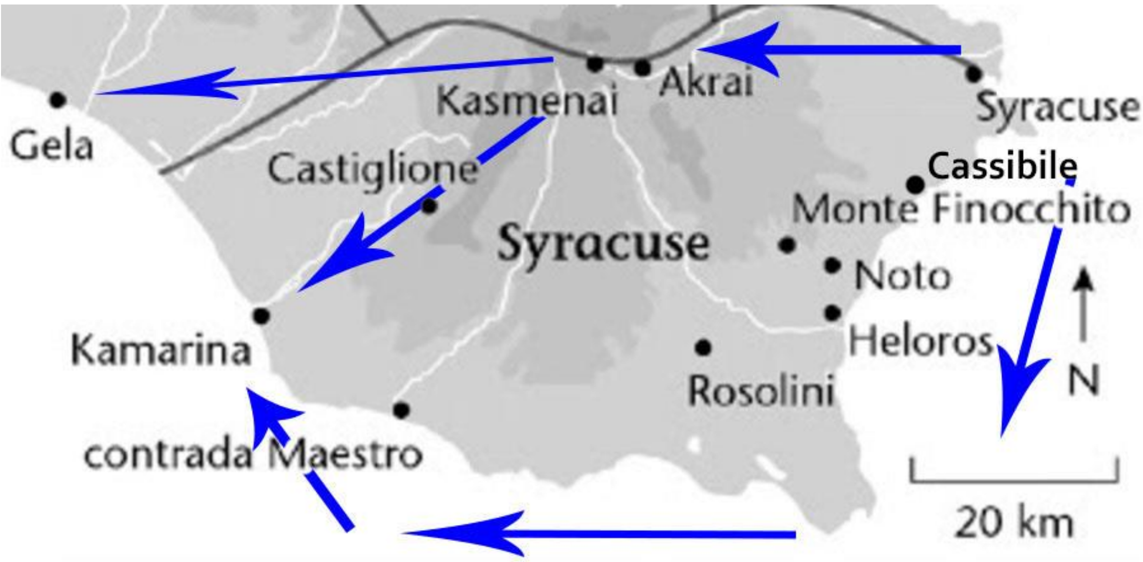

Fig. 8.2: Trade routes from Syracuse: Land-based through Akrai and Kasmenai, first to Gela prior to the sixth century, then to Kamarina after its foundation. Sea-based around the south-east corner of Sicily. De Angelis 2016, p.67, Map 4 with additions.

Shipwrecks dated to the Archaic period have been found off the coasts of Syracuse, Kamarina and Gela.[68] Among the cargoes are transport amphorae and fine wares from Corinth, Attica and the Aegean islands, among other places. These provide ample evidence of a large number of ships frequently loading and unloading trade goods throughout the region and the wide-ranging connections these trade networks had with Syracuse and its settlements. Imported Phoenician wares found in archaeological contexts on the island demonstrate that the trade extended westward. Further, evidence suggests that Archaic trade networks were not intermittent and opportunistic, but rather interdependent and consistent, no matter the fluctuating status of supply and demand.[69] All of this makes clear that trade was not only well-established but likely highly lucrative already in the Archaic period.

Thucydides (6.5.3) makes it clear that Kamarina was to be an independent settlement. A route from Syracuse to Kamarina through Akrai and Kasmenai is about 100 km.[70] Using thirty kilometres as an average day's walk,[71] it would take more than three days to complete the journey one way. A sea route would have been seasonally dependent and faced pressure from

[68] De Angelis 2016, pp.256-7.
[69] Osborne 1996.
[70] Found using Google Maps and following walking distance along modern roads. It is expected that in the Archaic period the distance would have been much harder to traverse.
[71] Using Bintliff's maximum of 15 km for a rural settlement attached to a city-state to account for walking to and from the urban market daily.

piracy.[72] This suggests that Syracuse may have had little choice but to provide the settlement with independence.[73] However, Syracuse would have wanted to maintain some control over the site, or at least expected Kamarina to fall in line with its wishes.[74]

The colonial party at Kamarina, on the other hand, were privy to the importance of their enterprise prior to arrival.[75] The settlers were well aware of Syracuse's own colonial past and its evolution into a major centre of trade. Given the usually peaceful relations between the Greeks and indigenous peoples, Kamarina would have been quick to take stock of the indigenous populations within their influence. Only two generations passed before the rebellion, so it is likely that Kamarina made several attempts to assert more independence from Syracuse prior to the rebellion, as Kamarina would not have crossed the Herminius without reason, and Syracuse would not have waged war without prior provocation.[76] As De Angelis suggests, competition among elite may have laid the groundwork for the foundation of Kamarina.[77] The level of independence Kamarina would be given was obviously a cantankerous issue not fully resolved until its fateful end.

In 552 BC, Syracuse found itself in a position where the destruction of Kamarina ended a century long colonial expansion only fifty years after its completion.[78] The regional rivalry continued after Kamarina with Gela, causing the two city-states to fall out of favour through the actions of tyrants, resulting in the destruction of Syracuse by the latter party in 485 BC. Contributing to this would have been the democratic uprising six years prior in 491, where the *Gamoroi* were expelled from Syracuse, fleeing to Kasmenai for secure refuge, only to return in 485 with Gelon.[79] Whatever the events that occurred in the second half of the sixth century, the Syracuse that enacted the colonial expansion encompassing south-east Sicily had ceased to exist.

Throughout this thesis it has been stressed that the Syracusan settlement expansion across south-east Sicily in the Archaic period was one of planned endeavours for the sake of self-preservation and the accumulation of wealth. Each settlement played many roles within this process, allowing Syracuse to gain large tracts of agricultural land, dividing it among the citizens, feeding its population and to carve out a land trade route through the Hyblaian

---

72 Diod. Sic. 5.6.2; Hdt. 2.152; Thuc. 1.7; 6.4.5; Strab. 1.3.2. Cf. De Souza 1999, p.22; Greco 2008, pp.36-7; De Angelis 2010b, p.31.
73 De Luna 2009, p.78.
74 De Luna 2009, p.81.
75 De Luna 2009, p.79.
76 Dion. Hal. *Pomp.* 5.4; Domínguez 2006, p.290.
77 De Angelis 2016, p.169.
78 Anello 2002, p.71.
79 Hdt. 7.155; Di Vita 1956a, p.188. Yet, Di Vita believes Kasmenai was chosen as a place of refuge by the *Gamoroi* because it was a better defended *phrourion* than Akrai. This idea can now be laid to rest.

mountains to the southern coast. The settlements were largely self-sufficient, though the construction projects often required skilled labour from their mother city. However, the more monumental buildings gave an additional avenue through which the wealthy citizens could gain and solidify status and prestige. The final step of Syracuse's plan ultimately involved allowing its last, and only independent, settlement too much power, influence and control. This resulted in its rebellion within two generations and the end of the controlled economic enterprise. Syracuse would remain the controlling force of the region before its own demise at the hands of an outside tyrant.

There have been multiple avenues through which evidence has been presented leading to this series of events. The socio-political culture at play in Syracuse relied upon the distribution of wealth to advance the status of its citizens. An overall peaceful and mutually beneficial relationship between the Greeks and the indigenous population of Sicily allowed for the establishment of the area to advance relatively quickly with little conflict. Architectural energetics coupled with population estimates have demonstrated numerically the ability for the settlements to complete construction projects, but also a manner in which the wealthy elite provide the sites with monumental buildings to legitimise their socio-political positions. The presented case studies are among the first instances where this methodology has been used within the archaeological landscape of the area. Although having to overcome gaps in available evidence, in it is demonstrated that well-argued population figures for the region can be suggested. For example, using these two methods in combination shows that Kamarina had a large labour pool and the ability to complete a large-scale project in a minimal amount of time. The adaptation of the population estimates to indicate degrees of primacy validated not only the hierarchical position of Syracuse during most of the Archaic period, but also brought to light how the foundation of Kamarina impacted the region. This is also the first use of primacy in the region, and provides a different view on possible causes to the rebellion of the mid-sixth century BC.

Through the analysis using these methodologies within this thesis, some long-standing views associated with Syracuse and its settlements have been contested. Chief among these is the interpretation of the Syracusan settlements as purely military ones for the pacification of their respective *chorai* against the local populations. It seems as though these views are deeply rooted, however unintentionally, in the preconceived notions of colonisation based on recent modern history. This dissertation does not dismiss entirely the notion of a settlement serving a defensive role, but the reasons for the Syracusan settlements being founded as such can be argued against. Along the same lines, the continual state of conflict between the Greeks and Sicilians can be questioned, although the importance of this view has been diminishing in the recent years. New avenues of research can still be opened into the scholarship on the Greek settlements of Sicily.

Appendix 1: Gazetteer of Sites

Akrai (A)

A: Geographical Location: (Fig. 1.6; Fig. 6.3; Fig. 6.4; Fig. 6.9; Fig. 6.10; Fig. 6.11)

- Flat top of a plateau separating the valleys of the rivers Anapos (modern Anapo) and Heloros (modern Tellaro). Isolated, high, commanding slopes on three sides, with less difficult access available on the eastern end. Immediately west of modern Palazzolo Acreide.

B: Selected Historical Sources/Events:[1]

- **Thucydides 6.5.2:** '**Acrae** and Casmenae were founded by the Syracusans; **Acrae** seventy years after Syracuse, Casmenae nearly twenty years after **Acrae'** (c. 664/3, 644/3 BC).
- ***FGrH* 3 559 F 5**:[2] **Akrai** and Kasmenai fight alongside Syracuse in the rebellion of Kamarina (c. 553/2 BC).

C: Archaeological Investigations:

- Archaeological interest in sixteenth century, debate over location of Akrai; association with Palazzolo Acreide largely accepted by eighteenth century; subsequent small-scale archaeological investigation. Garozzo 1994, pp.190-1.
- **1809-1817**: Baron Judica excavates, publishes first monograph dedicated to site, Judica 1819. Much of this is dedicated to the excavations of nearby necropolis and quarries. In 1817, remains of houses and architectural fragments including inscription *IG* XIV, 217 with the list of citizen lands to rebuild. Also identified the site of the sanctuary of Aphrodite.
- **1820**: Baron Judica discovers the bouleuterion. Judica 1820.
- **1824**: Baron Judica uncovers the theatre (third century BC); performs some restoration, including the orchestra and lower steps of the auditorium. Judica 1824.
- **1840**: Further work on the bouleuterion and theatre by Cavallari. Lo Faso Pietrasanta 1840, pp.158-61.
- **1878**: Excavations around and within the catacombs of Intagliateli by Messina. Fiorelli 1879.
- **1888**: Orsi in the necropolis of Pinita. Orsi 1889.
- **1891**: Excavations of a Sicilian necropolis by Orsi in the Grotta di Sparano. Orsi 1891.
- **1897**: Burials and various finds in the area surrounding Akrai bringing to light material from tenth century BC to fifth century AD. This includes Greek silver coins, inscriptions and ceramic and limestone materials. Orsi 1897, pp.308-11; Salinas 1897; Orsi 1899a.
- **1900-1937**: Discoveries arising from agricultural work and chance encounters largely involve funerary good and monuments. Garozzo 1994, pp.194-5.

---

[1] For all the ancient literary sources that mention Akrai, see D'Agata 1994, p.189.

[2] This is based on the widely accepted amendment by Pais of the fragment. Cf. Di Vita 1956a, pp.187 n.49, 200 n.95; Martin et al. 1980a, p.529; Di Vita 1987, pp.82-3; Moreschini 1992a, p.289.

- **1940s**: Bernabò Brea, after being appointed director of the Soprintendenza Archeologica di Siracusa in 1941, collects human bones and prehistoric pottery in the Grotta Tiné, and discovers Sicilian tombs near the river Anapo. Bernabò Brea 1950.
- **1953**: Systematic excavations by Bernabò Brea at Akrai which has provided much of that known about the Greek city-state. Extent of survey includes continued work on the theatre and bouleuterion, the area surrounding these, including the quarries to the south-west, and the discovery of the Temple of Aphrodite. Bernabò Brea 1953; Bernabò Brea 1956; Bernabò Brea 1986.
- **1960-1964:** The Associazione Archeologica Acrense, under direction of the Soprintendenza, further explored the area surrounding Akrai, including a cistern at contrada Aguglia, 8 km from Palazzolo Acreide, and five tombs in the district of Fùrmica. Various finds include a limestone slab bearing an inscription from the fifth to fourth century BC, ceramic pots and busts dated between the second and first centuries, Hellenistic-Roman period mosaic tiles and column drums and coins of the Roman period. In nearby contrada Mandre Alte, a probable stoa of considerable size was uncovered with unknown religious relevance, as well as a Byzantine church. Garozzo 1994, p.196.
- **1964:** Continued work by the Associazione Archeologica Acrense, in Akrai. Plateia discovered, 4.5 m wide, crossing the city from Syracusan Gate in the East to the Selinuntian Gate in the West. Stenopoi found perpendicular to the plateia, flanked on each side by late Hellenistic houses built atop layers of Archaic period pottery. Pelagatti 1966a, p.92.
- **1969-1979:** Systematic excavations by the Soprintendenza alle Antichità della Sicilia Orientale in the heart of the urban area, reconstructing planned layout: seven stenopoi, five north and two south of main plateia; plateia 4.5 m wide, c. 250 m long; stenopoi intersect plateia at N-NW/S-SE angle; blocks approx. 27 m wide; stenopoi 3 m wide, do not cross plateia; likely organised from foundation. Voza 1971; Voza 1973a; Martin et al. 1980a, pp.504-6.
- **1988-1995:** Hieronian period stoa uncovered south of the main plateia, along with contemporary monumentalisation of the agora. Wilson 1995-1996, p.68.
- **2008-2014:** Non-invasive work is conducted by the University of Warsaw over the entire site, but focuses largely on the urban plan. Chowaniec 2015.

D: Fortifications: (AF) (Fig. 1.6; Fig. 6.1)

- Two main gates: Syracusan (east), Selinuntian (west).
- Blocks (up to 3) full width of wall, not double curtain, built into terrace, one external face.
- Dating unknown. Bernabò Brea supposes construction between beginning 4th to second half 3rd century based on historical probability.
- Sources: Bernabò Brea 1956, pp.21-3; Martin et al. 1980a, p.500; Garozzo 1994, p.197.

E: Housing: (AH) (Fig. 6.4; Fig. 6.5; Fig. 6.6)

- Habitation blocks 27 m wide, divided by stenopoi (3 m wide).
- Plateia only known access between stenopoi.
- Sources: Pelagatti 1966a, p.92; Voza 1973a, pp.127-8; Martin et al. 1980a, p.506; Voza 1999, pp.137, 139.

F: Temple of Aphrodite: (AT) (Fig. 6.6; Fig. 6.7; Fig. 6.8)

- Sicilian Doric with Ionic influence.
- Follows closely theoretical Acrense foot of 30.74 cm.
- Outer wall of peristasis in levels (6 total in places) upon bedrock; bedrock used as foundation in places; likely 0.5 m drop between levels; thickness of wall in two quadrangular limestone blocks, perpendicular to trend; blocks of varying size; interior 33 m x 12.5 m, almost equally divided in two.
- Axis of temple stereobate approx. 39.52 m x 18.24 m; East side 19.6 m, West side 19.1 m, North side 40.5 m, South side 40.4 m; stylobate axis 37.68 m x 16.4 m.[3]
- Stereobate presumed only two steps.
- Peripteral temple likely of six columns on short sides, thirteen on long sides, four interior.
- Each column approx. 0.98 m upper diameter; approx. 10 cm between column and step.
- Sekos consists of three rooms: pronaos, antecella and cella; two smaller columns in antis in pronaos of unknown dimensions; dimensions of the rooms are unknown.
- Height unknown.
- Comparisons with Syracusan Athenaion, Apollonion and Olympieion, Temple of Victory at Himera.
- Dated to second half/third quarter 6th century BC.
- Sources: Barletta 1983, p.113; Bernabò Brea 1986; Wilson 1987-1988, p.114; Spawforth 2006, p.125.

G: Quarries: (AQ1, AQ2) (Fig. 1.6)

- Two quarries, Intagliata Grande and Intagliatella, in south-east corner of urban centre; likely provided the stone for all construction during Archaic period.
- Source: Bernabò Brea 1956, pp.59-72.

Heloros (H)

A: Geographical Location: (Fig. 1.5; Fig. 5.13; Fig. 5.14; Fig. 5.15)

- Coastal location on low, limestone hill, c. 20 m, south-east of Noto; 400 metres north of mouth of river Heloros (modern Tellaro); urban centre of 9 hectares within fortifications c. 1,420 m. Orsi 1899c, p.242.

B: Selected Historical Sources/Events:[4]

- **Herodotus 7.154.3:** ‘Of the towns here mention not one escaped subjection except Syracuse, which, after a defeat on the river **Elorus**, was saved by the intervention of Corinth and Corcyra, who negotiated peace on the condition that Syracuse should cede Camarina, a town that in old days belonged to it, to Hippocrates’ (c. 493/2 BC).
- **Thucydides 6.66.3:** ‘At first they (Syracusan army) marched up close to the Athenian army, then, when the Athenians did not move out against them, turned back, crossed the road to **Helorus**, and camped there for the night’ (413 BC).

[3] Long sides: (13 columns x 1 m diameter) + (12 gaps of 2.04 m) + (2 margins between column and step x 0.10 m) = 37.68 m; Short sides: (6 columns x 1 m diameter) + (5 gaps x 2.04 m) + (2 margins between column and step x 0.10 m) = 16.4 m.

[4] For all the ancient literary sources that mention Heloros, see Corsaro & D'Agata 1989, pp.157-8.

- **Thucydides 6.70.5:** ‘The Syracusans rallied together again at the road to **Helorus**, formed up as well as they could under the circumstances, and even sent a garrison of their own citizens to the Olympieium, since they were afraid that the Athenians might make off with some of the treasure there’ (413 BC).
- **Thucydides 7.80.5:** ‘Nevertheless, they reached the sea at dawn and, taking the **Helorine** road, marched on with the intention of getting to the river Cacyparis and following its course up into the interior, where they hoped to join forces with the Sicels whom they had sent for’ (413 BC).
- **Diodorus Siculus 13.19.2:** ‘For three days following close on their heels and encompassing them on all sides they prevented them from taking a direct road toward Catane, their ally; instead they compelled them to retrace their steps through the plain of **Elorium**, and surrounding them at the river Ainarus, slew eighteen thousand and took captive seven thousand, among whom were also the generals Demosthenes and Nicias.’ (413 BC).

C: Archaeological Investigations:

- **1899**: Paolo Orsi first identified sites archaeologically, unearthed Hellenistic fortifications, temple, houses and theatre; placed foundation in sixth century; labelled the settlement as a ‘modest fortress’. Orsi 1899c; Orsi 1966b.
- **1927**: Orsi’s second excavation, published by Maria Teresa Currò; excavation notes lost, however surveys by R. Carta provided material; focused on southern urban area; reinvestigating the temple, Hellenistic houses. Currò 1966b.
- **1958-59**: Militello’s two campaigns provided ceramic evidence of a foundation in the seventh century BC; uncovered the Archaic fortifications (HF), behind a later Hellenistic refortification, including a gate that was closed in the fourth century; further investigation of the temple discovered by Orsi; exposed the foundations of a stoa below a Byzantine basilica. Militello 1966.
- **1960-61**: Piscione continued work in the south-western corner of the urban centre; discovered the temenos wall of the small temple previously uncovered by Orsi and Militello. Piscione 1966.
- **1967**: Currò, through plan of Soprintendenza BB. CC. AA, revealed more of the Hellenistic fortifications; conducted test excavations at the Asklepion; continued research on the Hellenistic stoa. Voza 1968-1969, pp.360-2.
- **1972**: Continuing investigations around the stoa; traces of occupation in the area found dating from the end of the eighth to the first half of the fourth century BC; examinations of the urban centre temple to Demeter dated to the first half of the second century BC; work on the South gate, connected to the North gate by the Helorine road. Voza 1972-1973, p.189.
- **1980-81**: Excavations beneath the urban Sanctuary of Demeter, highlighting occupation phases in the southern sector of the urban centre. Earliest phase documented by houses dated to end eighth/early seventh century BC (Fig. 5.5, Fig. 5.6). Evidence also uncovered between second half seventh and sixth centuries and houses from late fifth and fourth centuries, before the area becomes the sacred temenos of the sanctuary in the same century. Monumental stoa added in second century, north of the temple, then later a Byzantine basilica. Further work on the urban layout, including the highest point of the hill. Here a trapezoidal square

surrounded by buildings has been interpreted as an agora or religious area. Material from this area dates Archaic to Hellenistic. Voza 1980-1981.

D: Archaic Fortifications: (HF) (Fig. 1.5; Fig. 5.1; Fig. 5.2; Fig. 5.3)

- Archaic construction; later Timoleon reconstruction reusing or replacing original wall; Archaic period remains uncovered in northwest corner.
- Grey limestone ashlar blocks in pseudo-isodomic technique; Double-curtain with rubble infill; 2.80 m thick.
- Remains of three courses of external face, each 30 cm.
- Dated third quarter sixth century through Proto-Corinthian, Corinthian Siciliote and Proto-Attican ceramic remains.
- Sources: Militello 1966, pp.310-4; Orsi 1966b, pp.215, 221-2; Voza 1970, p.297; Martin et al. 1980a, p.549; Frederiksen 2011, p.147.

E: Housing: (HH) (Fig. 5.4; Fig. 5.5, Fig. 5.6; Fig. 5.11)

- End eighth/beginning seventh century construction.
- Limestone orthostat construction; 3 to 4 m a side; thinly beaten earth interior.
- Historical comparisons with Megara Hyblaia and Syracuse.
- Dated through Proto-Geometric ceramic remains.
- Sources: Voza 1970, p.298; Martin et al. 1980a, p.551; Voza 1980-1981, pp.685-6; Voza 1989, p.162.

F: Koreion: (HK) (Fig. 1.5; Fig. 5.7; Fig. 5.8; Fig. 5.12)

- Archaic period construction, later Timoleon additions.
- In use from sixth to fourth century BC.
- 50 m north of urban centre; Two-roomed sacellum; Wall remains 2.20 m in height.
- Sources: Currò 1966a, p.98; Voza 1973b, p.117; Martin et al. 1980a, p.547.

G: Quarries:

- Quarries identified c. 0.5 km north and south of urban centre; traces of ancient quarrying; likely provided all stone necessary for Archaic constructions.
- Source: Adam 2013, pp.21-31.

Kamarina (KM)

A: Geographical Location: (Fig. 1.8; Fig. 4.14)

- Southern coast of Sicily, near the mouth of the river Hypparis (modern Ippari); promontory 60 m above sea level; natural defences with rivers Oanis (modern Rifriscolaro) (south) and Hypparis (north), swamp in north.
- Planned urban layout in orthogonal subdivisions, likely from foundation, although not in current form; E-W central plateia; approx. 150 hectares.
- Western area earliest occupied; family units including women and children.
- Trade connections throughout Mediterranean, through ceramic remains; three known ports.
- Ceramic evidence supports foundation date.
- Sources: Martin 1972-1973, p.352; Pelagatti 1973, pp.133-52; Pelagatti et al. 1976, pp.122, 124-5; Martin et al. 1980a, pp.510-4; Pelagatti 1985, pp.295-6.

B: Selected Historical Sources/Events:[5]

- **Thucydides 6.5.3**: '**Camarina** was first founded by the Syracusans 135 years (to the best of one's reckoning) after the foundation of Syracuse. Its founders were Daxon and Menecolus.' (c. 599/8 BC) 'But the people of **Camarina** were driven out of their city by the Syracusans, who made war on them because they revolted,' (553 BC) 'and some time later Hippocrates, the tyrant of Gela, took over their land in exchange for some Syracusan prisoners of war and resettled the city of **Camarina**, acting as founder himself.' (492 BC) 'Once again the inhabitants were driven out, this time by Gelon,' (484 BC) 'and the city was settled for the third time by the people of Gela' (461 BC).
- ***FGrH* 3 559 F 5**:[6] Akrai and Kasmenai fight alongside Syracuse in the rebellion of **Kamarina** (c. 553/2 BC).
- **Herodotus 7.154.3:** 'Of the towns here mention not one escaped subjection except Syracuse, which, after a defeat on the river Elorus, was saved by the intervention of Corinth and Corcyra, who negotiated peace on the condition that Syracuse should cede **Camarina**, a town that in old days belonged to it, to Hippocrates' (c. 493/2 BC).
- **Herodotus 7.156.2:** 'At once Syracuse shot up and budded like a young tree; Gelon brought to it all the people of **Camarina**, which he had razed to the ground, and gave them citizen rights, and he did the same for more than half the population of Gela' (484 BC).

C: Archaeological Investigations:

- **1874-1881:** Brief research by Cavallari. (Cavallari, 1880).
- **1896-1910:** First systematic excavations continued annually by Orsi on urban area, mouth of the Ippari, and the surrounding necropoleis. Attention paid to temple of Athena (first half 5th century BC) and port. Limited results of work between 1904 and 1907 lead Orsi to believe site too destroyed in ancient times for further work. Orsi 1899b; Orsi 1903; Orsi 1904; Orsi 1904-1905; Orsi 1905; Orsi 1907; Orsi 1909; Orsi 1966a; Lanza 1991.[7]
- **1910-1925**: Pace makes several minor explorations around Kamarina; provides better knowledge of the site's *chora* and its connection to the history of the area. Pace 1927.
- **1950-1961**: Di Vita explores further urban area, including the temenos wall of the temple of Athena, as well as important hinterland centres. Di Vita 1956b; Di Vita 1958; Di Vita 1959.
- **1961-1980**: Pelagatti continues systematic excavations, throughout urban area (approx. 150 ha) and along the Ippari and Rifriscolaro. Pelagatti 1962; Pelagatti 1966b; Pelagatti 1970; Pelagatti 1976; Pelagatti 1977; Pelagatti 1980-1981.[8]
- **1980-1985**: Continued research in the *chora* and hinterland of Kamarina, including the emporio at contrada Maestro and at ancient Ragusa Ibla. Further work on agora and necropolis. Di Stefano 1984-1985; Di Stefano 1987a; Manni Piraino 1987; Wilson 1987-1988, p.116.

[5] For all the ancient literary sources that mention Kamarina, see Buongiovanni & Cordano 1985.
[6] See footnote 2.
[7] Amongst others; for full bibliography see Pelagatti 1985, pp.300-1.
[8] Amongst others; for full bibliography see Pelagatti 1985, pp.306-13.

- **1990s**: Di Stefano concentrates on the agora, clearly planned from foundation. Theatre expected south of agora. Nearby shipwrecks investigated further, copper cache discovered north of mouth of river Herminius. Wilson 1995-1996, pp.69-73; Di Stefano 1995; Di Stefano 2000a; Di Stefano 2000b; De Angelis 2000-2001, pp.165-66; De Angelis 2006-2007, p.154.

D: Fortifications: (KMF) (Fig. 4.12)

- 7 km long; double-curtain socle; rock and earth infill; 2.20 to 2.60 m thick in areas; mudbrick superstructure.
- Small stones; poor construction; leaning against earthen rampart.
- Measurements of blocks: 0.80 m x 0.52 m; 0.96 m x 0.45 m; 1.08 m x 0.98 m.
- Three gates: NW, SE and E.
- Early to mid-sixth cent. construction; built quickly, lacking time to quarry proper stone
- Sources: Orsi 1899b, pp.209-10; Pelagatti 1973, p.134; Pelagatti et al. 1976, p.124; Martin et al. 1980a, pp.510-2; Pelagatti 1985, p.295; Pelagatti 2000, p.181; Frederiksen 2011, p.154.

Kasmenai (K)

A: Geographical Location: (Fig. 1.7; Fig. 7.7; Fig. 7.8)

- Plateau of Monte Casale, 1,370 m x 450 m, 830 m above sea level, 12 km west of Palazzolo Acreide (and Akrai). Steep and inaccessible from North and North-east, small valley begins in the centre of the plateau and increases as it proceeds south-west. South of Monte Lauro, origin of rivers Anapos (modern Anapo), Herminius (modern Irminio) and Heloros (modern Tellaro).
- Identification of Kasmenai with Monte Casale first suggested by Pace 1935-49, I, p.183; II, p.367, supported by Di Vita 1956a, pp.185, 188-91, now generally accepted.

B: Selected Historical Sources/Events: [9]

- **Thucydides 6.5.2**: 'Acrae and **Casmenae** were founded by the Syracusans; Acrae seventy years after Syracuse, **Casmenae** nearly twenty years after Acrae' (c. 664/3, 644/3 BC).
- ***FGrH* 3 559 F 5**:[10] Akrai and **Kasmenai** fight alongside Syracuse in the rebellion of Kamarina (c. 553/2 BC).
- **Herodotus 7.155**: 'The Syracusan landowners (*Gamoroi*) had been expelled by the commons with the help of their slaves (known as Cyllyrii), and had fled for refuge to **Casmene**.' (491 BC) 'Gelon brought them back to Syracuse and got possession of the town; for the commons made no resistance, but surrendered as soon as they saw him coming' (c. 485 BC).
- Abandoned by mid-fourth century. Martin et al. 1980a, p.535

[9] For all the ancient literary sources that mention Kasmenai, see Moreschini 1992a, p.289.
[10] See footnote 2.

C: Archaeological Investigations:

- **1922-1931**: Excavations by Orsi (unpublished), numerous houses uncovered from sixth to fifth century BC, as well as foundations of a temple. General site plan drafted. Rizza 1957, p.205; Voza 1968-1969, p.360; Pelagatti 2002, pp.141-8.
- **1952**: Rizza investigates wall uncovered by recent flooding. Wall followed edge of cliff surrounding site, making it inaccessible and easily defensible, found at bottom of valley, south-west of plateau. Made of large blocks of volcanic stone, average 1.10 m x 0.50 m x 0.50 m, likely part of a defensive structure across valley opening. Rizza 1957, pp.205-7.
- **1967**: Led by the Soprintendenza, rediscovered temple on acropolis, highly damaged since initial excavations by Orsi. Further work on urban plan, search for roads running E-W. Voza 1968-1969, p.360.
- **1970s**: Further work on the urban layout, entire block of houses brought to light (Fig. 7.3). Urban plan of approx. 40 stenopoi, running N-NW/S-SE; no transverse plateia; habitation blocks 25 m wide, up to 55 m long; narrow, irregular passages c. 3.1 – 3.5 m wide connect stenopoi. Martin et al. 1980a, pp.532-3; Collura 2012, p.3.

D: Fortifications: (KF)

- Closely follows edge of plateau.
- Exclusive use of unworked local volcanic stone, up to 3 m wide; double curtain.
- Two gates: west and south.
- Dated to time of foundation (historically) or late sixth century (construction technique); no archaeological dating material.
- Average block size: 1.10 m x 0.50 m x 0.50 m.
- Sources: Rizza 1957, p.206; Martin et al. 1980a, pp.530-1; Miller 1995, p.261; Moreschini 1992b, p.290; Frederiksen 2011, p.155.

E: Housing: (KH) (Fig. 7.1; Fig. 7.3; Fig. 7.4)

- Obvious planned urban layout.
- Consistent plan of quadrangular housing complexes, groups of four houses, each complex 25 m a side; each house c. 12.5 m a side (approx. 156 m^2); ambitus 0.5 m wide (or wall) divides blocks longitudinally; stenopoi c. 3.1 – 3.5 m wide; narrow passages connect stenopoi providing access to houses, or access at times from stenopoi.
- Built in polygonal technique, lava stone rock resting on bedrock, some white limestone.
- Access generally onto stenopoi; entrance hall leading to courtyard; 3 habitation rooms, outer two c. 12 – 15 m^2 (middle smaller), aligned E-W, courtyard open to south.
- Courtyards sometimes shared by two units, passage at times replaced by open area.
- Sources: Di Vita 1956a, p.191; Voza 1973c, p.130; Martin et al. 1980a, pp.532-3; Di Vita 1986, p.386; Moreschini 1992b, p.290; Voza 1999, pp.141, 143; Collura 2012, p.10.

F: Temple of Ares: (KT) (Fig. 7.2; Fig. 7.5; Fig. 7.6)

- Only temple in Kasmenai, at highest part of site, NW corner; Two phases.
- First phase: inner structure, c. 25.7 m x 4.5 m axis, aligned to urban plan, apterous, irregular lava stone blocks, dated beginning sixth century.

- Second phase: outer structure, c. 26.98 m x 7.8 m axis, regular white limestone blocks, dated mid- to late sixth century.
- Compared to Temple south of Archaic agora at Megara Hyblaia and Megaron B of Gaggera at Selinous.
- Sources: Martin et al. 1980a, p.532; Moreschini 1992b, p.290; Voza 1999, p.143; Melfi 2000, pp.39-41.

Syracuse (*S*)

A: Geographical location: (Fig. 1.4; Fig. 4.7; Fig. 4.13)

- Island of Ortygia, approx. 50 ha; Miocene limestone, two harbours: 'Small' facing east and 'Great' facing west to bay; approx. 3 km from mouth of river Anapos (modern Anapo); nearby Epipoli limestone plateau to the north; mainland between Epipoli and 'Great' harbour part Lysimeleia swamp in ancient time (Thuc. 6.101.1-3; 7.53.2; Diod. Sic. 13.12.1).

B: Selected Historical Sources/Events: [11]

- **Thucydides 6.3.2**: '**Syracuse** was founded the year afterwards (c. 734/3) by Archias, one of the Heraclids from Corinth, who began by driving out the Sicels from the island upon which the inner city now stands, though it is no longer surrounded by water: in process of time the outer town also was taken within the walls and became populous.'
- **Strabo 6.2.4**: '**Syracuse** was founded by Archias, who sailed from Corinth about the same time that Naxus and Megara were colonized. … whereas Archias landed at Zephyrium, found that some Dorians who had quit the company of the founders of Megara and were on their way back home had arrived there from Sicily, took them up and in common with them founded **Syracuse**. … As for these barbarians, some were native inhabitants, whereas others came over from the mainland. The Greeks would permit none of them to lay hold of the seaboard, but were not strong enough to keep them altogether away from the interior.'
- **Strabo 8.6.22**: 'Tenea, also, is in Corinthia, and in it is a temple of the Teneatan Apollo; and it is said that most of the colonists who accompanied Archias, the leader of the colonists to **Syracuse**, set out from there.'
- **Thucydides 6.5.1**: 'After Zancle was built Himera (648 BC), by Eucleides, Simus, and Sacon, the most of which colony were Chalcideans; but there were also amongst them certain outlaws of **Syracuse**, the vanquished part of a sedition, called the Myletidae.'
- **Thucydides 6.5.2**: 'Acrae and Casmenae were founded by the **Syracusans**; Acrae seventy years after **Syracuse**, Casmenae nearly twenty years after Acrae' (c. 664/3, 644/3 BC).
- **Thucydides 6.5.3**: '**Camarina** was first founded by the Syracusans 135 years (to the best of one's reckoning) after the foundation of Syracuse. Its founders were Daxon and Menecolus.' (c. 599/8 BC) 'But the people of **Camarina** were driven out of their city by the Syracusans, who made war on them because they revolted,' (553 BC)

[11] For all the ancient literary sources that mention Syracuse, see Facella, 2005.

'and some time later Hippocrates, the tyrant of Gela, took over their land in exchange for some Syracusan prisoners of war and resettled the city of **Camarina**, acting as founder himself.' (492 BC) 'Once again the inhabitants were driven out, this time by Gelon,' (484 BC) 'and the city was settled for the third time by the people of Gela' (461 BC).

- ***FGrH* 3 559 F 5**:[12] Kasmenai fights alongside **Syracuse** in the rebellion of Kamarina (c. 553/2 BC).
- **Herodotus 7.154.3:** 'Of the towns here mention not one escaped subjection except **Syracuse**, which, after a defeat on the river Elorus, was saved by the intervention of Corinth and Corcyra, who negotiated peace on the condition that **Syracuse** should cede Camarina, a town that in old days belonged to it, to Hippocrates' (c. 493/2 BC).
- **Herodotus 7.155**: 'The **Syracusan** landowners (*Gamoroi*) had been expelled by the commons with the help of their slaves (known as Cyllyrii), and had fled for refuge to Casmene.' (491 BC) 'Gelon brought them back to **Syracuse** and got possession of the town; for the commons made no resistance, but surrendered as soon as they saw him coming' (c. 485 BC).
- **Herodotus 7.156.2:** 'At once **Syracuse** shot up and budded like a young tree; Gelon brought to it all the people of Camarina, which he had razed to the ground, and gave them citizen rights, and he did the same for more than half the population of Gela' (484 BC).

C: Archaeological Investigations:[13]

- **1800s**: Systematic coverage of history, archaeology and topography of Syracuse by Cavallari and Holm, including early work on the Temple of Apollo. Cavallari 1864; Cavallari 1875; Cavallari & Holm 1883; Koldewey & Puchstein 1899.
- **1943, 1948**: Complete excavation of the Temple of Apollo. Cultrera 1951.
- **1960-1970**: Excavations provide concrete traces of an urban plan on the island of Ortygia with parallel and perpendicular streets. Pelagatti & Voza 1973; Voza 1979.
- **1977-1980**: Pelagatti leads excavations in the courtyard of the Prefecture revealing more of the urban plan and foundation period housing. Martin et al. 1980a, pp.675-6; Pelagatti 1980-1981, pp.707-11; Pelagatti 1982.
- **1980-1981**: Voza uncovers more of the early urban plan, associated in part with that in the courtyard of the Prefecture. Voza 1984-1985, pp.668-76.
- **1990-1995**: Continued work on the urban plan, south of Duomo accompanying sacred area with two-roomed building and altar. Voza 1993-1994, Wilson 1995-1996, p.67.
- **2000's**: Continued work on urban plan of Ortygia and nearby necropoli. De Angelis 2007, p.146.

D: Housing: (SH) (Fig. 1.4; Fig. 4.1; Fig. 4.9)

- 3.50 m x 3.50 m, 0.50 m width, orthostat technique.
- Lack of associated mudbrick, likely constructed entirely in stone, no traces of roof structure.
- Connecting courtyard of small size expected.

[12] See footnote 2.

[13] Due to the abundance of archaeological material of Syracuse, only that which is relevant to the present discussion is included. For the most complete catalogue of archaeological work on Syracuse (to 2005), see Zirone 2005.

- Comparisons with early houses of Megara Hyblaia.
- Sources: Martin et al. 1980a, p.666; Pelagatti 1982b, pp.126-9.

E: Temple of Apollo: (ST) (Fig. 1.4; Fig. 4.3; Fig. 4.4; Fig. 4.5; Fig. 4.7; Fig. 4.10; Fig. 4.11)

- Doric style, first stone temple in Syracuse, built with excessive means of support.
- Crepidoma of four steps; axis of stereobate approx. 58.10 m x 24.50 m; second step approx. 57.40 m x 23.40 m; third step approx. 56.30 m x 22.50 m; axis of temple stylobate approx. 54.90 m x 21.50 m; crepidoma steps each approx. 0.50 m high; approx. 0.50 m width difference between each step (after first: approx. 0.35 m); approx. 3.50 m width of bottom step.
- Foundation under stereobate 2.30 m deep, substructure reaches same total depth beneath sekos walls (4.30 m total) and interior columns (4.61 m total); 2.20 m distance between substructures of foundation and sekos, 0.75 m between substructures of sekos and interior stylobate; crawl spaces filled with stones, debris and occasional stone slabs.
- Peripteral temple of 17 columns along each side; 4 additional columns on both ends; portico preceded by second row of 4 columns based on third column on long sides; 2 columns in pronaos, 2 rows of 7 columns in cella.
- Monolithic columns 7.98 m high (shaft: 6.62 m, capital: 1.36 m); lower diameters 2.01 m on front end, 1.85 m on sides; upper diameter 1.50 m on sides; 1.40 m – 1.50 m spacing between side columns, 2.30 m spacing between front centre columns, approx. 1.80 m between other front columns.
- Capital height 0.76 m of echinus with hypotrachelion; Abacus height 0.60 m, width 2.86 m, spaced 0.50 m apart; ‘L’ shaped architrave: length 3.52 m, width 1.82 m, height 2.15 m; architrave horizontal arm thickness approx. 0.70 m, vertical 0.63 m; taenia: length 1.02 m, width 0.57 m, height 0.275 m.
- Cornice extends 0.50 m from front of frieze.
- Sekos 9.60 m wide; pronaos 6 m long, cella 24.60 m long, adyton 3.70 m long; walls 1 m thick, entirely of stone; pronaos 0.09 m above outer stylobate; cella 0.22 m above pronaos.
- Cella columns expected 1.50 m from walls, on stylobate 1.40 m wide; interior columns largely hypothetical in nature.
- Roof inclination of 18 degrees; roof tiles 0.70 m wide; expected support on wooden beams rested on inner face of architrave.
- Built of local sandstone.
- Date range from c. 600 through second quarter sixth century BC.
- Sources: Cultrera 1951; Dinsmoor 1975, pp.75-8; Holloway 1991, pp.68-70; Mertens 2006, pp.104-8; Woodward 2012, p.482.

Appendix 2: Degrees of Primacy

Below are the calculations used to find the total degree of primacy for the Syracusan settlement systems of 600, 599, 552 and 485 BC. The degree of primacy is found for each settlement in relation to its system using the total population figures in the table and the equation below.[1] Those degrees are then averaged by the total number of settlements to find the degree of primacy for the entire settlement system for each time period. Population estimates of Akrai, Heloros, Kasmenai and Syracuse for 600 BC are utilised for calculations in 599. For all instances, Heloros has a primacy degree of zero.

$$P_i = \frac{1}{(n-i)}\left[\frac{C_i - C_{(i-1)}}{C_i} + \frac{C_i - C_{(i-2)}}{C_i} + \cdots + \frac{C_i - C_n}{C_i}\right]$$

C	=	city's population size
n	=	number of cities in the system
i and j	=	ranks of cities by size in a descending order so that the largest city is ranked 1 and the smallest city is ranked n
P_i	=	primacy of city with rank i over all smaller cities

Population figures used in Primacy Calculations[2]

	600 BC	552 BC	485 BC
SYRACUSE	16,370	25,310	40,350
HELOROS	590	930	1,510
AKRAI	3,130	4,720	7,480
KASMENAI	3,410	6,860	9,300
KAMARINA	22,030 (599 BC)	43,110	–

600 BC - Total Population

Syracuse: $P = \frac{1}{4-1}\left[\frac{16{,}370-3{,}410}{16{,}370} + \frac{16{,}370-3{,}130}{16{,}370} + \frac{16{,}370-590}{16{,}370}\right]$

$P = \frac{1}{3}[0.79 + 0.81 + 0.96]$

$P = 0.33[2.56]$

$P = 0.84$

Kasmenai: $P = \frac{1}{4-2}\left[\frac{3{,}410-3{,}130}{3{,}410} + \frac{3{,}410-590}{3{,}410}\right]$

Akrai: $P = \frac{1}{4-3}\left[\frac{3{,}130-590}{3{,}130}\right]$

---

[1] El-Shakhs 1972, p.18.

[2] Complete population estimates can be found in Table 8.1 and Table 8.3

$P = \frac{1}{2}[0.08 + 0.83]$ $P = \frac{1}{1}[0.81]$

$P = 0.50[0.91]$ $P = 1[0.81]$

$P = 0.46$ $P = 0.81$

Average: $P = (0.84 + 0.46 + 0.81) / 4$

$\boldsymbol{P = 0.53}$

599 BC - Total Population

Kamarina: $P = \frac{1}{5-1}\left[\frac{22{,}030-16{,}370}{22{,}030} + \frac{22{,}030-3{,}410}{22{,}030} + \frac{22{,}030-3{,}130}{22{,}030} + \frac{22{,}030-590}{22{,}030}\right]$

$P = \frac{1}{4}[0.26 + 0.85 + 0.86 + 0.97]$

$P = 0.25[2.94]$

$P = 0.74$

Syracuse: $P = \frac{1}{4-1}\left[\frac{16{,}370-3{,}410}{16{,}370} + \frac{16{,}370-3{,}130}{16{,}370} + \frac{16{,}370-590}{16{,}370}\right]$

$P = \frac{1}{3}[0.79 + 0.81 + 0.96]$

$P = 0.33[2.56]$

$P = 0.84$

Kasmenai: $P = \frac{1}{4-2}\left[\frac{3{,}410-3{,}130}{3{,}410} + \frac{3{,}410-590}{3{,}410}\right]$ **Akrai**: $P = \frac{1}{4-3}\left[\frac{3{,}130-590}{3{,}130}\right]$

$P = \frac{1}{2}[0.08 + 0.83]$ $P = \frac{1}{1}[0.81]$

$P = 0.50[0.91]$ $P = 1[0.81]$

$P = 0.46$ $P = 0.81$

Average: $P = (0.74 + 0.84 + 0.46 + 0.81) / 5$

$\boldsymbol{P = 0.57}$

552 BC - Total Population

Kamarina: $P = \frac{1}{5-1}\left[\frac{43{,}110-25{,}310}{43{,}110} + \frac{43{,}110-6{,}860}{43{,}110} + \frac{43{,}110-4{,}720}{43{,}110} + \frac{43{,}110-930}{43{,}110}\right]$

$P = \frac{1}{4}[0.41 + 0.84 + 0.89 + 0.98]$

$P = 0.25[3.12]$

$P = 0.78$

Syracuse: $P = \frac{1}{5-2}\left[\frac{25{,}310-6{,}860}{25{,}310} + \frac{25{,}310-4{,}720}{25{,}310} + \frac{25{,}310-930}{25{,}310}\right]$

$P = \frac{1}{3}[0.73 + 0.81 + 0.96]$

$P = 0.33[2.50]$

$P = 0.83$

Kasmenai: $P = \frac{1}{5-3}\left[\frac{6{,}860-4{,}720}{6{,}860} + \frac{6{,}860-930}{6{,}860}\right]$

$P = \frac{1}{2}[0.31 + 0.86]$

$P = 0.50[1.17]$

$P = 0.59$

Akrai: $P = \frac{1}{5-4}\left[\frac{4{,}720-930}{4{,}720}\right]$

$P = \frac{1}{1}[0.80]$

$P = 1[0.80]$

$P = 0.80$

Average: $P = (0.78 + 0.83 + 0.59 + 0.80) / 5$

***P* = 0.60**

---

485 BC - Total Population

Syracuse: $P = \frac{1}{4-1}\left[\frac{40{,}350-9{,}300}{40{,}350} + \frac{40{,}350-7{,}480}{40{,}350} + \frac{40{,}350-1{,}510}{40{,}350}\right]$

$P = \frac{1}{3}[0.77 + 0.81 + 0.96]$

$P = 0.33[2.54]$

$P = 0.84$

Kasmenai: $P = \frac{1}{4-2}\left[\frac{9{,}300-7{,}480}{9{,}300} + \frac{9{,}300-1{,}510}{9{,}300}\right]$

$P = \frac{1}{2}[0.20 + 0.84]$

$P = 0.50[1.04]$

$P = 0.52$

Kasmenai: $P = \frac{1}{4-3}\left[\frac{7{,}480-1{,}510}{7{,}480}\right]$

$P = \frac{1}{1}[0.80]$

$P = 1[0.80]$

$P = 0.80$

Average: $P = (0.84 + 0.52 + 0.80) / 4$

***P* = 0.54**

Ancient Works Cited

Aristotle. *Athenian Constitution. Eudemian Ethics. Virtues and Vices*. Translated by Rackham, H. 1935. Loeb Classical Library, 285. Harvard University Press, Cambridge, MA.

Aristotle. *Politics.* Translated by Jowett, B. 1905. Oxford: Clarendon Press.

Athenaeus. *The Learned Banqueters,* 2. Edited and Translated by Olson, S.D. 2007. Loeb Classical Library, 208. Harvard University Press, Cambridge, MA.

Cato. *On Agriculture.* Translated by Hooper, W.D. and Ash, H.B. 1934. Loeb Classical Library, 283. Harvard University Press, Cambridge, MA.

Columella. *On agriculture and trees.* Translated by Forster, E.S. and Heffner, E.H. 1968. Loeb Classical Library, 408. Harvard University Press, Cambridge, MA.

Demosthanes *Orations,* 3. Translated by Murray, A.T. 1939. Loeb Classical Library, 299. Harvard University Press, Cambridge, MA.

Diocletian. 'Edict on Maximum Prices' in *An Economic Survey of Ancient Rome, Volume V: Rome and Italy of the Empire*. Translated by Frank, T. 1940. The Johns Hopkins Press, Baltimore.

Diodorus Siculus. *Library of History,* 3-6. Translated by Oldfather, C.H. 1939–1954. Loeb Classical Library, 340, 375, 384, 399. Harvard University Press, Cambridge, MA.

Diodorus Siculus. *Library of History,* 7. Translated by Sherman, C.L. 1952. Loeb Classical Library, 389. Harvard University Press, Cambridge, MA.

Diodorus Siculus. *Library of History,* 11. Translated by Walton, F.R. 1957. Loeb Classical Library, 409. Harvard University Press, Cambridge, MA.

Dionysius of Halicarnassus. *The Critical Essays,* 2. Translated by Usher, S. 1974. Loeb Classical Library, 466. Harvard University Press, Cambridge, MA.

Dionysius of Halicarnassus. *Roman Antiquities,* 1. Translated by Cary, E. 1937. Loeb Classical Library, 319. Harvard University Press, Cambridge, MA.

Herodotus. *The Histories*. Translated by De Sélincourt, A. Edited by Marincola, J. 2003. London, Penguin Books.

Hesiod. *Theogony. Works and Days. Testimonia.* Translated by Most, G.W. 2007. Loeb Classical Library, 57. Harvard University Press, Cambridge, MA.

Homer. *The Iliad*. Translated by Murray, A.T. 1924. Loeb Classical Library, 170–171. London, William Heinemann.

Livy. *History of Rome,* 6. Translated by Moore, F.G. 1940. Loeb Classical Library, 355. Harvard University Press, Cambridge, MA.

Pausanius. *Description of Greece,* 1-2. Translated by Jones, W.H.S. and Omerod, H.A. 1918, 1926. Loeb Classical Library, 93, 188. Harvard University Press, Cambridge, MA.

Pindar. *Isthmian Odes.* Translated by Svarlien, D.A. 1990. *The Perseus Digital Library*. www.perseus.tufts.edu.

Plato. *Laws,* 1. Translated by Bury, R.G. 1926. Loeb Classical Library, 187. Harvard University Press, Cambridge, MA.

Pliny the Elder. *The Natural History.* Translated by Bostock, J. 1855. Taylor and Francis, London.

Plutarch. *Moralia*, 10. Translated by Fowler, H.N. 1936. Loeb Classical Library, 321. Harvard University Press, Cambridge, MA.

Plutarch. *Plutarch's Lives.* 1, 3, 6. Translated by Perrin, B. 1914–1918. Loeb Classical Library, 46, 65, 98. Harvard University Press, Cambridge, MA.

Polybius. *Histories.* Translated by Shuckburgh, E.S. 1889. Macmillan, London.

Sextus Julius Frontinus. *The Aqueducts of Rome*. Translated by Bennett, C.E. 1925. Loeb Classical Library, 174. Harvard University Press, Cambridge, MA.

Strabo. *Geography,* 1, 3–5. Translated by Jones, H.L. 1917–1928. Loeb Classical Library, 49, 182, 196, 211. Harvard University Press, Cambridge, MA.

Theodosian Code. *The Theodosian Code and Novels, and the Sirmondian Constitutions.* Translated by Pharr, C. 2001. Princeton University Press, Princeton, NJ.

Theophrastus *De Causis Plantarum,* 1–3. Edited and translated by Einarson, B. and Link, G.K.K. 1976–1990. Loeb Classical Library, 471, 474, 475. Harvard University Press, Cambridge, MA.

Theophrastus *Enquiry into Plants*, 1–2. Translated by Hort, A.F. 1916. Loeb Classical Library, 70, 79. Harvard University Press, Cambridge, MA.

Thucydides. *History of the Peloponnesian War.* Translated by Warner, R. 1972. London, Penguin Books.

Vitruvius. *On Architecture,* 1*.* Translated by Granger, F. 1931. Loeb Classical Library, 251. Harvard University Press, Cambridge, MA.

Xenophon. *Cyropaedia,* 2. Translated by Miller, W. 1914. Loeb Classical Library, 52. Harvard University Press, Cambridge, MA.

Xenophon. *Hellenica,* 1. Translated by Brownson, C.L. 1918. Loeb Classical Library, 88. Harvard University Press, Cambridge, MA.

Works Cited

Abrams, E., 1987. Economic Specialization and Construction Personnel in Classic Period Copan, Honduras. *American Antiquity,* Volume 52, pp. 485-99.

Abrams, E., 1989. Architecture and Energy: An Evolutionary Perspective. *Archaeological Method and Theory,* Volume 1, pp. 47-87.

Abrams, E., 1994. *How the Maya Built Their World.* Austin: University of Texas Press.

Abrams, E. & Bolland, T., 1999. Architectural Energetics, Ancient Monuments, and Operations Management. *Journal of Archaeological Method and Theory,* Volume 6, pp. 263-91.

Adam, J.-P., 2013. *Roman Building: Materials and Techniques.* London: Routledge.

Adams, E., 2007. Approaching monuments in the prehistoric built environment: New light on the Minoan palaces. *Oxford Journal of Archaeology,* Volume 26, pp. 359-94.

Allegro, N., 1999. Imera. In: E. Greco, ed. *La città greca antica: Istituzioni, società e forme urbane.* Roma: Donzelli Editore, pp. 269-302.

Ampolo, C., 1994. Tra empòria ed emporià: note sul commercio greco in età arcaica e classica. In: B. D'Agostino & D. Ridgway, eds. *Ἀποικία: i più antichi insediamenti greci in Occidente: funzioni e modi dell'organizzazione politica e sociale: scritti in onore di Giorgio Buchner (AION n.s. 1).* Napoli: Istituto Universitario Orientale, pp. 29-36.

Anello, P., 2002. L'ambiente greco. In: F. Cordano & M. Di Salvatore, eds. *Il Guerriero di Castiglione di Ragusa: Greci e Siculi nella Sicilia sud-orientale. Atti del Seminario, Milano 15 maggio 2000.* Roma: Hesperia, 16, pp. 59-76.

Antonaccio, C., 2009. The Western Mediterranean. In: K. Raaflaub & H. van Wees, eds. *A Companion to Archaic Greece.* Somerset: Wiley-Blackwell, pp. 314-29.

Antonietti, A. & Vanzetti, C., 1961. *Carta della utilizzazione del suolo d'Italia.* Milan: Feltrinelli.

Asheri, D., 1980. La colonizzazione greca. In: E. Gabba & G. Vallet, eds. *La Sicilia antica. I,1: Indigeni, Fenici-Punici e Greci.* Napoli: Storia di Napoli e della Sicilia Società editrice, pp. 89-142.

Attema, P., Burgers, G.-J. & van Leusen, P., 2010. *Regional Pathways to Complexity.* Amsterdam: Amsterdam University Press.

Bacci, G., 1978. Ceramica dell'VIII e del VII sec. a Messina. *Cronache di archeologia e di storia dell'arte,* Volume 17, pp. 100-3.

Barker, G., 1988. Archaeology and the Etruscan countryside. *Antiquity,* Volume 62, pp. 772-85.

Barletta, B., 1983. *Ionic Influence in Archaic Sicily: The Monumental Art. Studies in Mediterranean Archaeology. Pocket Book 23.* Åströms Förlag ed. Gothenburg: Paul.

Bartosiewicz, L., 2001. Archaeozoology or zooarchaeology?: a problem from the last century. *Archaeologia Polona,* Volume 39, pp. 75-86.

Bekker-Nielsen, T., 1989. *The Geography of Power.* Oxford: Tempus Reparatum.

Belanger, J., 1974. *The Homesteader's Handbook to Raising Small Livestock.* Emmaus, Penns.: Rodale Press, Inc.

Beloch, K., 1886. *Die Bevölkerung der Griechisch-römischen Welt.* Leipzig: Duncker and Humblot.

Beloch, K., 1889. La popolazione antica della Sicilia. *Archivio Storico Siciliano,* Volume 14, pp. 1-83.

Beloch, K., 1895. Nuove osservazioni sulla poplazione antica della Sicilia. *Archivio Storico Sicilano,* Volume 20, pp. 63-70.

Bernabò Brea, L., 1950. Akrai. *Siculorum Gymnasium,* Volume 3, pp. 14-42.

Bernabò Brea, L., 1953. *Fasti Archeologici,* Volume 8, p. 1576.

Bernabò Brea, L., 1956. *Akrai.* Catania: La Cartotecnica.

Bernabò Brea, L., 1973. *Pantalica.* Napoli: Centre Jean Bérard.

Bernabò Brea, L., 1986. *Il Tempio di Afrodite di Akrai.* Naples: Centre Jean Bérard.

Bernal, M., 1987. *Black Athena: the Afroasiatic roots of classical civilization.* New Brunswick, N.J.: Rutgers University Press.

Berry, B., 1961. City Size Distributions and Economic Development. *Economic Development and Cultural Change,* Volume 9, pp. 573-88.

Bessac, J.-C., 1986. Approche des problèmes posés par la construction des remparts grecs en pierre. In: P. Leriche & H. Tréziny, eds. *La fortification dans l'histoire du monde grec. Actes du Colloque International. La fortification et sa place dans l'histoire politique, culturelle et sociale du monde grec. Valbonne, Décembre 1982.* Paris: Éditions du Centre national de la recherche scientifique, pp. 273-82.

Bintliff, J., 1997. Further Considerations on the Population of Ancient Boeotia. In: J. Blintiff, ed. *Recent Developments in the History and Archaeology of Central Greece: Proceedings of the 6th International Boeotian Conference, BAR International Series 666.* Oxford: Tempus Reparatum.

Bintliff, J., 2002. Going to market in antiquity. In: E. Olshausen & H. Sonnabend, eds. *Zu Wasser und zu Land, Stuttgarter Kolloquium 7.* Stuttgart: Franz Steiner, pp. 209-50.

Bintliff, J., 2009. Catchments, settlement chambers and demography: Case studies and general theory in the Greek landscape from Prehistory to Early Modern times. In: F. Favory & L. Nuninger, eds. *Archaedyn. 7 Millenia of Territorial Dynamics. Settlement pattern, production and trades from Neolithic to Middle Ages .* Dijon: University of Burgundy, pp. 107-17.

Blakeway, A., 1932/1933. Prolegomena to the Study of Greek Commerce with Italy, Sicily and France in the Eighth and Seventh Centuries B.C. *The Annual of the British School at Athens,* Volume 33, pp. 170-208.

Bonacasa, N., 1997. Il progetto Himera nel prossimo futura. In: H. Isler, ed. *Wohnbauforschung in Zentral- und Westsizilien. Sicilia occidentale e centro-meridionale: ricerche archeologiche nell'abitato.* Zürich: Archäologisches Institut der Universität, pp. 55-64.

Bottema, S. & Sarpaki, A., 2003. Environmental change in Crete: a 9000-year record of Holocene vegetation history and the effect of the Santorini eruption. *The Holocene,* Volume 13, pp. 733-49.

Bozza, G. C., 2009. Luoghi di culto ed insediamenti fortificati su altura nella Sicilia orientale. In: M. Congiu, C. Miccichè & S. Modeo, eds. *ΕΙΣ ΑΚΡΑ. Insediamenti d'altura in Sicilia dalla Preistoria al III sec. a.C. Atti del V Convegno di stui.* Caltanissetta: Salvatore Sciascia Editore, pp. 245-67.

Bravo, B., 1996. Una società legata alla terra. In: S. Settis, ed. *I Greci: Storia cultura arte società.* Torino: Giulio Einaudi Editore, pp. 527-60.

Brewer, D., 1992. Zooarchaeology: Method, Theory, and Goals. *Archaeological Method and Theory,* Volume 4, pp. 195-244.

Bringmann, K., 2001. Grain, timber and money: Hellenistic kiings, finance, buildings and foundation in Greek cities. In: Z. Archibald, J. Davies, V. Gabrielsen & G. Oliver, eds. *Hellenistic economies.* New York: Routledge, pp. 205-14.

Brysbaert, A., 2013. Set in Stone? Socio-Economic Reflections on Human and Animal Resources in Monumental Architecture of Late Bronze Age Tiryns in the Argos Plain, Greece. *Arctos,* Volume 47, pp. 49-96.

Brysbaert, A., 2015. Set in Stone? Constructed symbolism viewed through an architectural energetics' lens at Bronze Age Tiryns, Greece. *Analecta Praehistorica Leidensia,* Volume 45, pp. 69-90.

Buccellati, F. & Kansa, E., 2016. The value of energetic analysis in architecture as an example for data sharing. *Digital Applications in Archaeology and Cultural Heritage,* Volume 3, pp. 91-7.

Buchner, G., 1966. Pithekoussai, Oldest Greek Colony in the West. *Expedition,* Volume 4, pp. 4-12.

Buongiovanni, A. & Cordano, F., 1985. Camarina. A. Fonti letterarie. In: G. Nenci & G. Vallet, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 286-9.

Burford, A., 1960. Heavy Transport in Classical Antiquity. *The Economic History Review,* Volume 13, pp. 1-18.

Burford, A., 1963. The Builders of the Parthenon. *Greece & Rome, Second Series. Supplement: Parthenos and Parthenon,* Volume 10, pp. 23-35.

Burford, A., 1969. *The Greek Temple Builders at Epidauros: a social and economic study of building in the Asklepian sanctuary, during the fourth and early third centuries B.C.* Liverpool: Liverpool University Press.

Burford, A., 1993. *Land and Labor in the Greek World.* Baltimore: The Johns Hopkins University Press.

Cambitoglou, A., 1971. *Zagora 1: Excavation of a geometric town on the island of Andros. Excavation season 1967; study season 1968-9.* Sydney: Sydney University Press.

Cambitoglou, A., 1988. *Zagora 2: Excavation of a geometric town on the island of Andros. Excavation season 1969; study season 1969-1970. Text.* Athens: Athens Archaeological Society.

Cambitoglou, A. & Coulton, J., 1971. 3. Description of the excavated buildings. In: *Zagora 1: Excavation of a geometric town on the island of Andros. Excavation season 1967; study season 1968-9.* Sydney: Sydney University Press, pp. 13-28.

Cambitoglou, A. & Coulton, J., 1988. B. Architecture. In: A. Cambitoglou, ed. *Zagora 2: Excavation of a geometric town on the island of Andros. Excavation season 1969; study season 1969-1970.* Athens: Athens Archaeological Society, pp. 147-61.

Camp, J., 1979. A Drought in the Late Eighth Century B.C. *Hesperia,* Volume 48, pp. 397-411.

Camp, J., 2001. *The archaeology of Athens.* New Haven: Yale University Press.

Carter, J., 1990. Metapontum - Land, Wealth and Population. In: J. Descœudres, ed. *Greek Colonies and Native Populations: Proceedings of the First Australian Congress of Classical Archaeology held in honour of Emeritus Professor A. D. Trendall.* Oxford: Clarendon Press.

Carter, J., 1996. Insediamenti agricoli. In: G. Pugliese Carratelli, ed. *I Greci in Occidente.* Milano: Bompiani, pp. 361-8.

Carter, J., 2006. Towards a Comparative Study of Chorai West and East: Metapontion and Chersonesos. In: P. Bilde & V. F. Stolba, eds. *Surveying the Greek Chora: The Black Sea Region in a Comparative Perspective. Black Sea Studies 4.* Oakville, CT: Aarhus University Press, pp. 175-206.

Cavallari, F., 1864. Scavi in Siracusa. *Bullettino della Commissione di Antichità e Belle Arti in Sicilia,* Volume 1, pp. 1-5.

Cavallari, F., 1875. Tempio creduto di Diana in Siracusa. *Bullettino della Commissione di Antichità e Belle Arti in Sicilia,* Volume 8, pp. 10-20.

Cavallari, F., 1880. Sulla topografia di talune città greche in Sicilia. *Archivio Storico Siciliano,* Volume 5, p. 326.

Cavallari, F. & Holm, A., 1883. *Topografia archeologica di Siracusa.* Palermo: Tipografia del giornale Lo statuto.

Cerchiai, L., Jannelli, L. & Longo, F., 2004. *The Greek cities of Magna Graecia and Sicily.* Los Angeles: J. Paul Getty Museum.

Cherry, J., Davis, J. & Mantzourani, E., 1991. *Landscape Archaeology as Long-Term History: Northern Keos in the Cycladic Islands.* Los Angeles: Institute of Archaeology, UCLA.

Chester, D., Duncan, A. & James, P., 2011. Mount Etna, Sicily: Landscape Evolution and Hazard Responses in the Pre-industrial Era. In: I. Martini & P. Chesworth, eds. *Landscape and Societies. Selected Cases.* Dordrecht: Springer Netherlands, pp. 235-53.

Chowaniec, R., 2015. *Unveiling the past of an ancient town. Akrai/Acrea in south-eastern Sicily.* Warsaw: Institute of Archaeology, University of Warsaw.

Chowaniec, R. & Misiewicz, K., 2010. Akrai, Sicily. Non-destructive researches in 2009. *Archeologia. Rocznik Instytutu archeologii i etnolgii Polskiej akademii nauk,* Volume 59, pp. 173-86.

Clark, M., 1993. *The Economy of the Athenian Navy in the Fourth Century B.C.,* Oxford University: Unpublished thesis.

Coldstream, J., 2003. *Geometric Greece: 900-700 BC.* 2nd Edition ed. London: Routledge.

Coles, J., 1979. *Experimental archaeology.* New York: Academic Press.

Collura, F., 2012. *Kasmenai. Note sull’urbanistica di una città-fortezza.* [Online] Available at: http://www.academia.edu/2157864/Kasmenai._Note_sullurbanistica_di_una_citta-fortezza [Accessed September 2013].

Cook, R., 1946. Ionia and Greece in the Eighth and Seventh Centuries B.C. *The Journal of Hellenic Studies,* Volume 66, pp. 67-98.

Copani, F., 2005. Alle origini di Eloro. L'espansione meridionale di Siracusa arcaica. *ACME,* Volume 58, pp. 245-63.

Copani, F., 2009. Acre e Casmene: L'espansione siracusana sui Monti Iblei. *Quaderni di acme,* Volume 109, pp. 11-21.

Copani, F., 2010. Greci e indigeni ad Eloro. In: H. Tréziny, ed. *Grecs et indigènes de la Catalogne à la mer Noire: actes des rencontres du programme européen Ramses (2006-2008).* Paris: Édition Errance, pp. 689-93.

Cordano, F., 1986. *Antiche fondazioni greche. Sicilia e Italia meridionale.* Palermo: Sellerio.

Cordano, F., 1987. Contributo onomastico alla storia di Camarina arcaica. *Kokalos,* Volume 33, pp. 121-7.

Cordano, F. & Di Stefano, G., 1997. Il fiume e la città nelle Sicilia meridionale: Il caso di Camarina. In: S. Quilici Gigli, ed. *Uomo, acqua e paesaggio: atti dell'incontro di studio sul tema irreggimentazione delle acque e trasformazione del paesaggio antico: S. Maria Capua Vetere, 22-23 novembre, 1996.* Rome: L'Erma di Bretschneider, pp. 289-300.

Corsaro, M. & D'Agata, A., 1989. Eloro. A. Fonti letterarie, epigrafiche e numismatiche. In: G. Nenci & G. Vallet, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle islole tirreniche.* Pisa: Scuola Normale Superiore, pp. 157-8.

Corvisier, J.-N., 1991. *Aux origines du miracle grec.* Paris: Presses Universitaires France.

Coulton, J., 1977. *Ancient Greek Architects at Work. Problems of Structure and Design.* Ithaca, NY: Cornell University Press.

Coulton, J., 1980. *The Architectural Development of the Greek Stoa.* Oxford: Clarendon Press.

Crouch, D., 2004. *Geology and Settlement: Greco-Roman Patterns.* New York: Oxford University Press.

Cultrera, G., 1951. L’Apollonion-Artemision di Ortigia in Siracusa. *Monumenti Antichi,* Volume 41, pp. 701-860.

Cunningham, P., Heeb, J. & Paardekooper, R., 2008. *Experiencing archaeology by experiment: proceedings of the Experimental Archaeology Conference, Exeter 2007.* Oxford: Oxbow Books.

Currò, M., 1966a. Eloro (Noto-Siracusa). *Bollettino d'Arte,* Volume 51, pp. 97-98.

Currò, M., 1966b. Eloro: II. Campagna di scavo del 1927 e rinvenimenti sporadici. *Monumenti Antichi,* Volume 47, pp. 287-98.

Currò, M., Militello, E. & Piscione, V., 1966. Eloro, campagna di scavo del 1927. Relazione degli scavi del 1958-1959. Relazione dei saggi nel 1961. *Monumenti Antichi,* Volume 47, pp. 287-340.

Daft Logica, 2014a. *Distance Calculator.* [Online] Available at: http://www.daftlogic.com/projects-google-maps-distance-calculator.htm [Accessed 2014].

Daft Logic, 2014b. *Google Maps Area Calculator Tool.* [Online] Available at: http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm [Accessed 2017].

D'Agata, A., 1994. Palazzolo Acreide. A. Fonti letterarie, epigrafiche e numismatiche. In: G. Nenci & G. Vallet, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, p. 189.

D'Agostino, B., 1994. Pitecusa - Una apoikía di tipo particolare. In: B. D'Agostino & D. Ridgway, eds. *Ἀποικία: i più antichi insediamenti greci in Occidente: funzioni e modi dell'organizzazione politica e sociale: scritti in onore di Giorgio Buchner (AION n.s. 1).* Napoli: Istituto Universitario Orientale, pp. 19-28.

D'Agostino, B., 2006. The first Greeks in Italy. In: G. Tsetskhladze, ed. *Greek Colonisation: An Account of Greek Colonies and Other Settlements Overseas. Volume 1.* Leiden: Brill, pp. 201-37.

De Angelis, F., 2000-2001. Archaeology in Sicily 1996-2000. *Archaeological Reports,* Volume 47, pp. 145-201.

De Angelis, F., 2000a. Estimating the Agricultural Base of Greek Sicily. *Papers of the British School at Rome,* Volume 68, pp. 111-148.

De Angelis, F., 2000b. The Agricultural Capacity of Archaic Syracuse. In: F. Krinzinger, ed. *Die Ägäis und das Westliche Mittelmeer. Beziehungen und Wechselwirkungen 8. bis 5. Jh. v. Chr .* Vienna: Verlag der österreichischen Akademie der Wissenschaften, pp. 109-15.

De Angelis, F., 2002. Trade and Agriculture at Megara Hyblaia. *Oxford Journal of Archaeology,* Volume 21, pp. 299-310.

De Angelis, F., 2003. *Megara Hyblaia and Selinous. The Development of Two Greek City-States in Archaic Sicily.* Oxford: Oxford University School of Archaeology.

De Angelis, F., 2006-2007. Archaeology in Sicily 2001-2005. *Archaeological Reports,* Volume 53, pp. 123-90.

De Angelis, F., 2006. Going against the Grain in Sicilian Greek Economies. *Greece & Rome,* Volume 53, pp. 29-47.

De Angelis, F., 2007. Southeast Sicily. *Archaeological Reports,* Volume 53, pp. 146-54.

De Angelis, F., 2009. Colonies and Colonization. In: G. Boys-Stones, B. Graziosi & P. Vasunia, eds. *The Oxford Handbook of Hellenic Studies.* Oxford: Oxford University Press, pp. 48-64.

De Angelis, F., 2010a. Ancient Greek Colonization in the 21st Century: Some Suggested Directions. *Bollettino di Archeologia online,* pp. 18-30.

De Angelis, F., 2010b. Re-assessing the Earliest Social and Economic Developments in Greek Sicily. *Mitteilungen des Deutschen Archäologischen Instituts, Römische Abteilung,* Volume 116, pp. 21-53.

De Angelis, F., 2016. *Archaic and Classical Greek Sicily. A Social and Economic History.* New York: Oxford University Press.

De Luna, M., 2009. Camarina sub-colonia di siracusa: dalla fondazione al conflitto. In: M. Lombardo & F. Frisone, eds. *Colonie di colonie: le fondazioni sub-coloniali greche tra colonizzazione e colonialismo. Atti del Convegno Internazionale (Lecce, 22-24 giugno 2006).* Galatina (Lecce): Congedo, pp. p75-86.

De Miro, E. & Fiorentini, G., 1978. Gela nell'VIII e VII sec. a.C. *Cronache di archeologia e di storia dell’arte,* Volume 17, pp. 90-9.

de Polignac, F., 1995. *Cults, territory, and the origins of the Greek city-state.* Chicago: University of Chicago Press.

De Souza, P., 1999. *Piracy in the Graeco-Roman world.* Cambridge: Cambridge University Press.

De Waele, J., 1971. *Akragas Graeca. Die historische Topographie des griechischen Akragas auf Sizilien.* The Hague: Staatsuitgeverij.

DeLaine, J., 1997. *The baths of Caracalla. A study in the design, construction, and economics of large-scale building projects in imperial Rome.* Portsmouth, Rhode Island: Journal of Roman Archaeology.

Descœudres, J.-P., ed., 1990. *Greek Colonists and Native Populations (Proceedings of the First Australian Congress of Classical Archaeology Held in Honour of Emeritus Professor A. D. Trendall, Sydney 9-14 July 1985).* Oxford: Clarendon Press.

Descœudres, J.-P., 2008. Central Greece on the eve of the colonisation movement. In: G. Tsetskhladze, ed. *Greek colonisation: An account of Greek colonies and other settlements overseas. Volume 2.* Boston: Brill, pp. 289-382.

Devolder, M., 2005. Hâte-toi de bâtir la demeure, hâte-toi d'édifier le palais. *Creta Antica,* Volume 6, pp. 165-86.

Devolder, M., 2013. Manpower and Neopalatial Architecture. The Architectural Project as a Meaningful Experience. In: S. Cappel, U. Gükel-Maschek & D. Panagiotopoulos, eds. *Proceedings of the Conference 'Minoan Archaeology. Challenges and Perspectives for the 21st Century' held in Heidelberg, 23-27 March 2011.* Vienna: Phoibos Verlag, pp. 165-79.

Devolder, M., 2017. *Architectural energetics and Late Bronze Age Cretan architecture. Measuring the scale of Minoan building projects.* [Online] Available at:
http://www.academia.edu/31577562/Architectural_Energetics_and_Late_Bronze_Age_Cretan_Architecture._Measuring_the_Scale_of_Minoan_Building_Projects_in_Letesson_and_Knappett_forthcoming_2017_
[Accessed March 2017].

Di Stefano, G., 1984-1985. Ricerche a Camarina e nel territorio della provincia di Ragusa (1980-1984). *Kokalos,* Volume 30-31, pp. 727-800.

Di Stefano, G., 1987a. Camarina VIII: l'Emporio greco arcaico di contrada Maestro sull'Irminio. Rapporto preliminare della prima compagna di scavi. *Bollettino d'Arte,* Volume 72, pp. 129-40.

Di Stefano, G., 1987b. Il territorio di Camarina in età arcaica. *Kokalos,* Volume 33, pp. 129-207.

Di Stefano, G., 1988-1989. Indigeni e Greci nell'entroterra di Camarina. *Kokalos,* Volume 34-35, pp. 89-105.

Di Stefano, G., 1993-1994. Scavi e ricerche a Camarina e nel Ragusano (1988-1992). *Kokalos,* Volume 39-40, pp. 1367-1421.

Di Stefano, G., 1995. Un triclinio per Afrodite. *Archeologia Viva,* Volume 14, pp. 26-32.

Di Stefano, G., 2000a. I recenti scavi di Camarina. In: *Un ponte frà l'Italia e la Grecia: atti del simposio in onore di Antonino Di Vita. Ragusa, 13-15 febbraio 1998.* Padua: Bottega d'Erasmo, pp. 194-212.

Di Stefano, G., 2000b. Sacelli e alturi nell'agorà di Camarina. In: I. Berlingò, et al. eds. *Damarato. Studi di antichità classica offerti a Paola Pelagatti.* Milan: Electa, pp. 276-87.

Di Stefano, G., 2001. La chora di Camarina. In: A. Stazio, ed. *Problemi della chora coloniale dall'Occidente al Mar Nero: Atti del quarantesimo convegno di studi sulla Magna Grecia, Taranto, 29 settembre-3 ottobre 2000.* Taranto: Istituto per la storia e l'archeologia della Magna Grecia, pp. 689-705.

Di Stefano, G., 2009. Greci di montagna nella chora camarinese in età arcaica. In: M. Congiu, C. Micciché & S. Modeo, eds. *ΕΙΣ ΑΚΡΑ. Insediamenti d'altura in Sicilia dalla Preistoria al III sec. a.C. Atti del V Convegno di stui.* Caltanissetta: Salvatore Sciascia Editore, pp. 163-74.

Di Vita, A., 1956a. La penetrazione siracusana nella Sicilia sud-orientale alla luce delle più recenti scoperte archeologiche. *Kokalos,* Volume 2, pp. 177-205.

Di Vita, A., 1956b. Recenti scoperte archeologiche in provincia di Ragusa. *Archivio Storico Siracusano,* Volume 2, pp. 30-44.

Di Vita, A., 1958. Camarina e Scornavacche in età timoleontea. *Kokalos,* Volume 4, pp. 83-99.

Di Vita, A., 1959. Breve rassegna degli scavi archeologici condotti in provincia di Ragusa nel quadriennio 1955-1959. *Bollettino d'Arte,* Volume 44, p. 347.

Di Vita, A., 1986. L'urbanistica. In: G. Pugliese Carratelli, ed. *Sikanie. Storia e civiltà della Sicilia greca.* Milano: Istituto Veneto di arti grafiche.

Di Vita, A., 1987. Tucidide VI 5 e l'epicrazia siracusana. Acre, Casmene, Camarina. *Kokalos,* Volume 33, pp. 77-87.

Di Vita, A., 1990. Town Planning in the Greek Colonies of Sicily from the Time of their Foundations to the Punic Wars. In: J. Descœudres, ed. *Greek Colonists and Native Populations (Proceedings of the First Australian Congress of Classical Archaeology Held in Honour of Emeritus Professor A. D. Trendall, Sydney 9-14 July 1985).* Oxford: Clarendon Press, pp. 343-63.

Di Vita, A., 1998. La penetrazione siracusana nella Sicilia sud-orientale alla luce delle più recenti scoperte archeologiche. In: *Da Siracusa a Mozia: scritti di archeologia siciliana.* Padova: Bottega d'Erasmo, pp. 7-19.

Di Vita, A., 1999. Siracusa, Camarina, Selinunte: Quale Frontiera?. In: *Confini e frontiera nella grecità d'Occidente: atti del trentasettesimo convegno di studi sulla Magna Grecia. Taranto. 3-6 ottobre 1997.* Taranto: Istituto per la storia e l'archeologia della Magna Grecia, pp. 361-79.

Di Vita, A., 2003. Ancora Casmene: una nota. *La Parola del Passato,* Volume 58, pp. 66-70.

Dinsmoor, W., 1975. *The Architecture of Ancient Greece. An Account of its Historic Development.* 3rd ed. New York: W.W. Norton & Company, Inc.

Dohan, E., 1942. *Italic tomb-groups in the University museum.* London: Oxford University Press.

Domínguez, A., 1989. *La Colonización Griega en Sicilia. Griegos, Indígenas y Púnicos en la Sicilia Arcaica: Interacción y Aculturación.* s.l.:B.A.R International 549.

Domínguez, A., 2006. Greeks in Sicily. In: G. Tsetskhladze, ed. *Greek colonisation: An account of Greek colonies and other settlements overseas. Volume 1.* Boston: Brill, pp. 253-357.

Domínguez, A., 2011. The origins of Greek colonisation and the Greek polis: some observations. *Ancient West & East,* Volume 10, pp. 195-207.

Dunbabin, T., 1948. *The Western Greeks: The History of Sicily and South Italy from the Foundation of the Greek Colonies to 480 B.C.* Oxford: Clarendon Press.

Duplouy, A., 2006. *Le prestige des élites: Recherches sur les modes de reconnaissance sociale en Grèce entre les Xe e Ve siècles avant J.-C.* Paris: les Belles lettres.

Dyson, S., 2006. *In Pursuit of Ancient Pasts: A History of Classical Archaeology in the Nineteenth and Twentieth Centuries.* New Haven, CT: Yale University Press.

El-Shakhs, S., 1972. Development, Primacy, and Systems of Cities. *The Journal of Developing Areas,* Volume 7, pp. 11-36.

Emanuele, P., 1984. *Armour and weapons from pre-lucanian Basilicata.* Ann Arbor: University Microfilms International.

Emery, V., 2011. Mud-Brick. In: *UCLA Encyclopedia of Egyptology Open Version.* Los Angeles: University of California, Los Angeles, Department of Near Eastern Languages and Cultures.

Erasmus, C., 1965. Monument Building: Some Field Experiments. *Southwestern Journal of Anthropology,* Volume 21, pp. 277-301.

Erdas, D., 2006. Forme di stanziamento militare e organizzazione del territorio nel mondo Greco: i casi di Casmene e Brea. In: M. Vaggioli, ed. *Guerra e pace in Sicilia e nel Mediterraneo antico (VIII-III sec. a.C.). Arte, prassi e teoria della pace e della guerra.* Pisa: Edizioni della Normale.

Evans, R., 2009. *Syracuse in Antiquity. History and topography.* Pretoria: University of South Africa Press.

Facella, A., 2005. Siracusa. A. Fonti letterarie, epigrafiche e numismatiche. In: *Bibliografia Topografica della colonizzazione Greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 1-58.

Fagerström, K., 1988. *Greek Iron Age Architecture. Developments Through Changing Times.* Göteborg: Paul Aströms Förlag.

Fathy, H., 1989. *Gourna: A Tale of Two Villages.* Guizeh, Egypt: Foreign Cultural Information Dept.

Finley, M., 1976. An Attempt at a Typology. *Transactions of the Royal Historical Society,* Volume 26, pp. 167-88.

Finley, M., 1980. *Ancient Slavery and Modern Ideology.* London: Chatto & Windus.

Finley, M., 1999. *The Ancient Economy.* Updated Edition ed. Berkeley: University of California Press.

Finley, M., 2001. *Storia della Sicilia antica.* Roma: Laterza.

Fiorelli, G., 1879. Palazzolo Acreide. *Notizie degli Scavi di Antichità,* pp. 208-9.

Fischer-Hansen, T., 1996. The Earliest Town-Planning of the Western Greek Colonies, with special regard to Sicily. In: M. Hansen, ed. *Introduction to an Inventory of Poleis, Symposium August, 23-26 1995. Vol. 3. Acts of the Copenhagen Polis Centre.* Copenhagen: Commissioner: Munksgaard, pp. 317-73.

Fischer-Hansen, T., 2002. Reflections on native settlements in the dominions of Gela and Akragas -- as seen from the perspective of the Copenhagen Centre. In: T. Nielsen, ed. *Even More Studies in the Ancient Greek Polis: Papers from the Copenhagen Polis Centre 6.* Stuttgart: Franz Steiner, pp. 125-86.

Fischer-Hansen, T., Nielsen, T. & Ampolo, C., 2004. Sikelia. In: M. Hansen & T. Nielsen, eds. *An Inventory of Archaic and Classical Poleis: An Investigation Conducted by The Copenhagen Polis Centre for the Danish National Research Foundation.* Oxford: Oxford University Press, pp. 172-248.

Fitzjohn, M., 2007. Equality in the Colonies: Concepts of Equality in Sicily during the Eighth to Six Centuries BC. *World Archaeology,* Volume 39, pp. 215-28.

Fitzjohn, M., 2013. Bricks and mortar, grain and water: tracing tasks and temporality in Archaic Sicily. *World Archaeology,* Volume 45, pp. 624-41.

Forbes, H., 1995. The Identification of Pastoralist Sites within the Context of Estate-Based Agriculture in Ancient Greece: Beyond the 'Transhumance versus Agro-Pastoralism' Debate. *The Annual of the British School at Athens,* Volume 90, pp. 325-38.

Foxhall, L., 2005. Village to City: Staple and Luxuries? Exchange Networks and Urbanization. In: R. Osborne & B. Cunliffe, eds. *Mediterranean Urbanization 800-600 BC.* Oxford: Oxford University Press, pp. 233-48.

Frederiksen, R., 2011. *Greek City Walls of the Archaic Period: 900 - 480 BC.* Oxford: Oxford University Press.

Freeman, E., 1891-94. *The history of Sicily from the earliest times.* Oxford: Clarendon Press.

Freeman, P., 1972. Sequential estimation of the size of a population. *Biometrika,* Volume 59, pp. 9-17.

Frisone, F., 2012. Rivers, land organization, and identity in Greek Western Apoikíai. *Mediterranean Historical Review,* Volume 27, pp. 87-115.

Gaastra, J., 2014. Shipping sheep or creating cattle: domesticate size changes with Greek colonisation in Magna Graecia. *Journal of Archaeological Science,* Volume 52, pp. 483-496.

Gabrici, E., 1913. Cuma. *Monumenti Antichi dell'Academia dei Lincei,* Volume 22, p. 70.

Gallant, T., 1991. *Risk and Survival in Ancient Greece: Reconstructing the Rural Domestic Economy.* Stanford: Stanford University Press.

Gallo, L., 1989. Produzione cerealicola e demografia siciliana. *Annali dell'Istituto Universitario Orientale di Napoli, Dipartimento di Studi del Mondo Classico e del Mediterraneo Antico, Sezione di Archeologia e Storia Antica,* Volume 11, pp. 31-53.

Garnsey, P., 1998. *Cities, Peasants and Food in Classical Antiquity. Essays in Social and Economic History.* Cambridge: Cambridge University Press.

Garozzo, B., 1994. Palazzolo Acreide. B. Storia della ricerca archeologica. In: G. Nenci & G. Valley, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 190-8.

Gates, S., 1997. *Extending Syracuse: the Nature of the Territory and Boundaries of Syracuse from its Foundation to 480 BC.* Oxford: University of Oxford, B.A. dissertation.

Giangiulio, M., 1996. 'Avventurieri, mercanti, coloni, mercenari. Mobilità umana e circolazione di risorse nel Mediterraneo arcaico'. In: S. Settis, ed. *I Greci: Storia Cultura Arte Società.* Torino: Giulio Einaudi Editore, pp. 497-525.

Giordano, A., 2013. Vegetation and Land Use. In: E. Costantini & C. Dazzi, eds. *The Soils of Italy.* Dordrecht: Springer, pp. 57-91.

Goff, B., 2005. *Classics & Colonialism.* London: Duckworth.

Gosden, C., 2004. *Archaeology and Colonialism.* Cambridge: Cambridge University Press.

Graham, A., 1982. The colonial expansion of Greece. In: *The Cambridge ancient history. Vol. 3: Part 3: The expansion of the Greek world, eighth to sixth centuries B.C.* 2nd Edition ed. Cambridge: Cambridge University Press, pp. 83-162.

Graham, A., 1984. Commercial Interchanges between Greeks and Natives. *Ancient World,* Volume 10, pp. 3-10.

Graham, A., 1990. Pre-colonial Contacts: Questions and Problems. In: J. Descœudres, ed. *Greek Colonists and Native Populations (Proceedings of the First Australian Congress of Classical Archaeology Held in Honour of Emeritus Professor A. D. Trendall, Sydney 9-14 July 1985).* Oxford: Clarendon Press, pp. 45-60.

Gras, M. & Tréziny, H., 2004. Reflectures Thématiques. In: *Mégara Hyblaea 5: La ville archaïque. L'espace urbain d'une cité grecque de Sicile orientale.* Rome: École française de Rome, pp. 459-521.

Gras, M., Tréziny, H. & Broise, H., 2004. *Mégara Hyblaea 5: La ville archaïque. L'espace urbain d'une cité grecque de Sicile orientale.* Rome: École française de Rome.

Great Britain Naval Intelligence Division, 1944. *Italy. Geographical Handbook.* B.R. 517 ed. Oxford: Oxford University Press for H.M. Stationery Office.

Greco, E., 1992. *Archeologia della Magna Grecia.* Roma: Laterza.

Greco, E., 1994. Pithekoussai: empòrion o apoikía?. In: B. D'Agostino & D. Ridgway, eds. *Ἀποικία: i più antichi insediamenti greci in Occidente: funzioni e modi dell'organizzazione politica e sociale: scritti in onore di Giorgio Buchner (AION n.s. 1).* Napoli: Istituto Universitario Orientale.

Greco, E., 2000. Tradizione ed innovazione nell'urbanistica greca in età arcaica. In: F. Krinzinger, ed. *Die Ägäis und das Westliche Mittelmeer. Beziehungen und Wechselwirkungen 8. bis 5. Jh. v. Chr.* Vienna: Verlag der österreichischen Akademie der Wissenschaften, pp. 13-21.

Greco, E., 2008. *Archaeologia della Grecità Occidentale. 1: la Magna Grecia.* Bologna: Monduzzi Editore.

Greco, E., 2009. Discussione. In: M. Lombardo & F. Frisone, eds. *Colonie di colonie: Le fondazioni sub-coloniali greche tra colonizzazione e colonialismo. Atti del Convegno Internazionale (Lecce, 22-24 giugno 2006).* Galatina (Lecce): Congedo Editore, pp. 257-8.

Greco, E. & Torelli, M., 1983. *Storia dell'urbanistica: Il mondo greco.* Rome: Editori Laterza.

Grote, G., 1946-56. *A History of Greece.* London: Murray.

Guidi, A., 1985. An Application of the rank size rule to protohistoric settlements in the middle Tyrrhenian area. In: C. Malone & S. Stoddart, eds. *Papers in Italian Archaeology IV. Part III. Patterns in Protohistory.* BAR International Series 245 ed. Oxford: British Archaeological Reports, pp. 217-42.

Guzzardi, L., 2001. Il territorio di Noto nel periodo greco. In: F. Balsamo & V. La Rosa, eds. *Contributi alla geografia storica dell'Agro Netino. Atti delle giornate di studio, Noto, Palazzo Trigona, 29-30-31 maggio 1998.* Noto: I.S.V.N.A., pp. 97-109.

Guzzo, P., 2011. *Fondazioni greche. L'Italia meridionale e la Sicilia (VIII e VII sec. a.C.).* Roma: Carocci.

Haggett, P., 1965. *Locational Analysis in Human Geography.* London: Edward Arnold.

Haggett, P., Cliff, A. & Frey, A., 1977. *Locational Analysis in Human Geography.* 2nd ed. London: Edward Arnold Ltd.

Hall, J., 2007. *A History of the Archaic Greek World. ca. 1200 - 479 BCE.* Oxford: Blackwell Publishing.

Halstead, P., 1987. Traditional and Ancient Rural Economy in Mediterranean Europe: Plus ça Change?. *The Journal of Hellenic Studies,* Volume 107, pp. 77-87.

Hansen, M., 1986. *Demography and Democracy. The Number of Athenian Citizens in the Fourth Century B.C.* Herning: Systime.

Hansen, M., 1988. *Three Studies in Athenian Demography.* Copenhagen: The Royal Danish Academy of Sciences.

Hansen, M., 2004. The Concept of the Consumption City Applied to the Greek Polis. In: T. Nielsen, ed. *Once Again: Studies in the Ancient Greek Polis. Papers from the Copenhagen Polis Centre 7.* Stuttgart: Franz Steiner, pp. 9-47.

Hansen, M., 2006a. Emporion. A study of the use and meaning of the word in the archaic and classical periods. In: G. Tsetskhladze, ed. *Greek: colonisation: An account of Greek colonies and other settlements overseas.* Boston: Brill, pp. 1-39.

Hansen, M., 2006b. *The Shotgun Method: The Demography of the Ancient Greek City-State Culture.* Columbia: University of Missouri Press.

Hansen, M., 2008. [Online] Available at:
https://web.duke.edu/classics/grbs/FTexts/48/Hansen2.pdf
[Accessed June 2014].

Hansen, M., 2011. How to Convert an Army Figure into a Population Figure. *Greek, Roman, and Byzantine Studies,* Volume 51, pp. 239-53.

Hansen, M. & Neilsen, T., 2004. *An Inventory of Archaic and Classical Poleis.* Oxford: Oxford University Press.

Haselberger, L., 1985. *Befestige Turmgehöfte im Hellenismus auf den Kykladeninseln Naxos, Andros und Kea,* Technische Universität, Munich: Ph.D. thesis.

Henfrey, A., 1977. *The vegetation of Europe, its conditions and causes.* New York: Arno Press.

Hill, G., 1903. *Coins of Ancient Sicily.* Westminster: Archibald Constable & Co. Ltd.

Hingley, R., 1997. *Resistance and domination: social change in Roman Britain.* Portsmouth, Journal of Roman Archaeology, pp. 81-100.

Hodge, A., 1960. *The woodwork of Greek roofs.* Cambridge: Cambridge University Press.

Hodos, T., 1999. Intermarriage in the Western Greek Colonies. *Oxford Journal of Archaeology,* Volume 18, pp. 61-78.

Hodos, T., 2006. *Local Responses to Colonization in the Iron Age Mediterranean.* London: Routledge.

Hodos, T., 2010a. Globalization and Colonization: A View from Iron Age Sicily. *Journal of Mediterranean Archaeology,* Volume 23, pp. 81-106.

Hodos, T., 2010b. Local and Global Perspectives in the Study of Social and Cultural Identities. In: S. Hales & T. Hodos, eds. *Material culture and social identities in the ancient world.* Cambridge: Cambridge University Press, pp. 3-31.

Hoepfner, W. & Schwandner, E.-L., 1994. *Haus und Stadt im klassischen Griechenland.* 2nd Edition ed. München: Deutscher Kunstverlag.

Holleran, C. & Pudsey, A. eds., 2011. *Demography and the Graeco-Roman world: new insights and approaches.* Cambridge: Cambridge University Press.

Holloway, R., 1991. *The Archaeology of Ancient Sicily.* London: Routledge.

Holm, A., 1870-1898. *Geschichte Siciliens im Alterthum.* Leipzig: Engelmann.

Hugues, T., Steiger, L. & Weber, J., 2005. *Dressed Stone: Types of Stone, Details, Examples.* Munich: Institut für internationale Architektur-Dokumentation.

Hurst, J., 1937. *A handbook for formulae, tables and memoranda for architectural surveyors, draughtsmen and others engaged in building.* 17th Edition ed. London: E.& F.N. Spon Ltd.

Isager, S. & Skydsgaard, J., 1992. *Ancient Greek agriculture: An introduction.* London: Routledge.

Iversen, J., 1956. Forest Clearance in the Stone Age. *Scientific American,* 194(3), pp. 36-41.

Jameson, M., Runnels, C. & van Andel, T., 1994. *A Greek Countryside: The Southern Argolid from Prehistory to the Present Day, with a Register of Sites by Curtis N. Runnels and Mark H. Munn.* Stanford: Stanford University Press.

Jefferson, M., 1939. The Law of the Primate City. *Geographical Review,* Volume 29, pp. 226-32.

Jenkins, K., 1976. *Coins of Greek Sicily.* 2nd Edition ed. London: British Museum Publications Ltd.

Johnson, G., 1980. Rank-Size Convexity and System Integration: A View from Archaeology. *Economic Geography,* Volume 56, pp. 234-47.

Judica, G., 1819. *Le Antichitá di Acre, scoperte descritte e illustrate.* Messina: Pappalardo.

Judica, G., 1820. Notizie sulle antichità di Arce recentemente scoperte in Sicilia, e su una colonna migliare di Melfi. *Biblioteca Italiana,* Volume 17, pp. 219-31.

Judica, G., 1824. Lettera del Barone Gabriele Judica al Sign. D. Agostino Gallo. *Giornal di Scienze, Lettere ed Arti per la Sicilia,* Volume 5, pp. 74-6.

Kemp, B., 2000. Soil (including mud-brick architecture). In: P. Nicholson & I. Shaw, eds. *Ancient Egyptian Materials and Technology.* Cambridge: Cambridge University Press, pp. 78-103.

Kidder, F. & Parker, H., 1947. *Kidder - Parker architects and builders handbook.* 18th Edition ed. London: Wiley.

Klein, N., 1998. Evidence for West Greek Influence on Mainland Greek Roof Construction and the Creation of the Truss in the Archaic Period. *Hesperia: The Journal of the American School of Classical Studies at Athens,* Volume 67, pp. 335-74.

Klein, N., 2016. How Buildings Were Constructed. In: M. Miles, ed. *A Companion to Greek Architecture.* Chichester, West Sussex: John Wiley & Sons, Inc., pp. 105-18.

Koldewey, R. & Puchstein, O., 1899. *Die griechische Tempel in Unteritalien und Sizilien.* Berlin: Asher.

Koskela, T., forthcoming. Econometrics and Epidauros building accounts: a reassessment. In: J. Pakkanen, ed. *Greek Building Projects, Papers and Monographs of the Finnish Institute at Athens 24.* Helsinki: Finnish Institute at Athens.

La Torre, G., 2011. *Sicilia e Magna Grecia. Archeologia della colonizzazione greca d'Occidente.* Roma: Laterza.

Lang, F., 2005. Structural Change in Archaic Greek Housing. In: *Ancient Greek Houses and Households: Chronological, Regional, and Social Diversity.* Philadelphia: University of Pennsylvania Press, pp. 12-35.

Lang, F., 2007. House-community-settlement: the new concept of living in Archaic Greece. In: *British School at Athens Studies. Building Communities: House, Settlement and Society in the Aegean and Beyond.* Athens: British School at Athens, pp. 183-93.

Lanza, M., 1991. P. Orsi, La necropoli di Passo Marinaro, Camarina. *Monumenti Antichi Serie Miscellanea,* Volume 4.

Lawrence, A. & Tomlinson, R., 1996. *Greek Architecture.* 5th ed. New Haven: Yale University Press.

Lawrence, B., 1997. Greece. In: J. Rodriguez, ed. *The Historical Encyclopedia of World Slavery, Volume 1.* Santa Barbara: ABC-CLIO, pp. 312-4.

Laxton, R. & Cavanagh, W., 1995. The Rank-Size Dimension and the History of Site Structure from Survey Data. *Journal of Quantitative Anthropology,* Volume 5, pp. 327-58.

Lentini, M., 2006. Naxos of Sicily: The First Colonial Settlement. *Annuario della Scuola Archeologica di Atene e delle Missioni Italiane in Oriente,* Volume 84, pp. 493-507.

Lentini, M., 2009. Ultime indagini archeologiche nell'area urbana dell' antica Naxos. Scavi 2003–2006. Rapporto preliminare. In: *Naxos di Sicilia. L'abitato coloniale e l'arsenale navale. Scavi 2003-2006.* Messina: Sicania, pp. 9-37.

Lentini, M., Blackman, D. & Pakkanen, J., 2008. The Shipsheds of Sicilian Naxos: A Second Preliminary Report (2003-6). *The Annual of the British School at Athens,* Volume 103, pp. 299-366.

Lepore, E., 1968. Per una fenomenologia storica del rapporto città-territorio in Magna Grecia. In: P. Romanelli, ed. *La città e il suo territorio: atti del settimo convegno di studi sulla Magna Grecia, Taranto 8-12 ottobre 1967.* Naples: L'Arte Tipografica, pp. 29-66.

Lepore, E., 1970. Classi e ordini in Magna Grecia. In: C. Nicolet, ed. *Recherches sur les structures sociales dans l'antiquité classique, Caen 25-26 avril 1969.* Paris: Éditions du Centre national de la recherche scientifique, pp. 43-62.

Lepore, E., 1973. Problemi dell'organizzazione della chora coloniale. In: M. Finley, ed. *Problèmes de la terre en Grèce ancienne.* Paris: Mouton, pp. 15-48.

Lepore, E., 2000. *La Grande Grèce. Aspects et problèmes d'une 'colonisation' ancienne. Quatre conférences au Collège de France (Paris, 1982).* Naples: Centre Jean Bérard.

Lintott, A., 1982. *Violence, Civil Strife and Revolution in the Classical City.* London: Croom Helm Ltd.

Lo Faso Pietrasanta, D. D. D. S., 1840. *Le antichità della Sicilia esposte ed illustrate: Antichità di Siracusa e delle sue colonie.* Palermo: Presso La Reale Stamperia.

Lombardo, M., 2009. Da apoikiai a metropolis. Dal progetto al convengo. In: M. Lombardo & F. Frisone, eds. *Colonie di colonie: le fondazioni sub-coloniali greche tra colonizzazione e colonialismo. Atti del Convegno Internazionale (Lecce, 22-24 giugno 2006).* Galatina (Lecce): Congedo, pp. 17-30.

Lombardo, M., 2012. Greek colonization: small and large islands. *Mediterranean Historical Review,* Volume 27, pp. 73-85.

Loomis, W., 1998. *Wages, welfare costs, and inflation in classical Athens.* Ann Arbor: The University of Michigan Press.

Malacrino, C., 2010. *Constructing the Ancient World: Architectural Techniques of the Greeks and Romans.* Los Angeles: J. Paul Getty Museum.

Malkin, I., 1994. Inside and Outside: Colonization and the Formation of the Mother City. In: B. D'Agostino & D. Ridgway, eds. *ΑΠΟΙΚΙΑ: i più antichi insediamenti greci in occidente: funzioni e modi dell'organizzazione politica e sociale: scritti in onore di Giorgio Buchner.* Napoli: Istituto Universitario Orientale.

Malkin, I., 2004. Postcolonial Concepts and Ancient Greek Colonization. *Modern Language Quarterly,* Volume 65, pp. 341-64.

Malkin, I., 2011. *A Small Greek World. Networks in the Ancient Mediterranean.* Oxford: Oxford University Press.

Malkin, I., 2016. Greek colonisation: The Right to Return. In: L. Donnellan, V. Nizzo & G. Burgers, eds. *Conceptualising early Colonisation.* Roma: Instituto Storico Belga di Roma, pp. 27-50.

Manni Piraino, M., 1987. Camarina - Rifriscolaro graffiti su anfore. *Kokalos,* Volume 33, pp. 89-120.

Manni, E., 1974. Fidone d'Argo, i Bacchiadi di Corinto e le fondazioni di Siracusa e di Megara Iblea. *Kokalos,* Volume 20, pp. 77-91.

Manni, E., 1977. La Sicilia antica nella storiografia straniera degli ultimi cento anni. In: *La presenza della Sicilia nella cultura degli ultimi cento anni.* Palermo: Palumbo, pp. 19-31.

Manni, E., 1990. *Σικελικὰ καὶ Ἰταλικά: scritti minori di storia antica della Sicilia e dell'Italia meridionale.* Roma: Giorgio Bretschneider.

Marconi, C., 2007. *Temple Decoration and Cultural Identity in the Archaic Greek World: The Metopes of Selinous.* Cambridge: Cambridge University Press.

Margaritis, E. & Jones, M., 2008. Crop processing of Olea europaea L.: an experimental approach for the interpretation of archaeobotanical olive remains. *Vegetation History and Archaeobotany,* Volume 17, pp. 381-92.

Marotta D'Agata, A. & Moreschini, D., 1992. Monte Casale. In: G. Nenci & G. Vallet, eds. *Bibliografia topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 289-96.

Marshal, A., 2011. *Experimental archaeology.* British Archaeological Reports. British Series, 530 ed. Oxford: Archaeopress.

Martin, R., 1965. *Manuel d'architecture grecque, I: Matériaux et techniques.* Paris: Éditions A. et J. Picard et Cie.

Martin, R., 1972-1973. Problémes d'urbanisme dans les cités grecques de sicile. Comunicazione di R. Martin (Paris). *Kokalos,* Volume 18-19, pp. 348-65.

Martin, R., Pelagatti, P. & Vallet, G., 1980. Alcune osservazioni sulla cultura materiale. In: E. Gabba & G. Vallet, eds. *La Sicilia antica. I,2: Le città greche di Sicilia.* Palermo: Storia di Napoli e della Sicilia Società editrice, pp. 397-448.

Martin, R., Pelagatti, P., Vallet, G. & Voza, G., 1980a. Le città greche. In: E. Gabba & G. Vallet, eds. *La Sicilia Antica. I,3: Città greche ed indigene di Sicilia.* Palermo: Storia di Napoli e della Sicilia Società editrice, pp. 483-705.

Martin, R., Pelagatti, P., Vallet, G. & Voza, G., 1980b. Le strutture urbane e il loro rapporto con la storia. In: E. Gabba & G. Vallet, eds. *La Sicilia Antica. I,2: La città greche di Sicilia.* Palermo: Storia di Napoli e della Sicilia Società editrice, pp. 235-70.

Mathieu, J. & Meyer, D., 1997. Comparing Axe Heads of Stone, Bronze, and Steel: Studies in Experimental Archaeology. *Journal of Field Archaeology,* Volume 24, pp. 333-51.

Mazarakis Ainian, A., 1997. *From Rulers' Dwellings to Temples: Architecture, Religion and Society in Early Iron Age Greece (1100-700 B.C.).* Jonsered: Aström.

McInerney, J., 2004. Nereids, Colonies and the Origin of Isegoria. In: I. Sluiter & R. Rose, eds. *Free Speech in Classical Antiquity. Mnemosyne Suppl. Vol. 254.* Leiden: Brill, pp. 21-40.

Mehta, S., 1964. Some Demographic and Economic Correlates of Primate Cities: A Case for Revaluation. *Demography,* Volume 1, pp. 136-47.

Meiggs, R., 1982. *Trees and timber in the ancient Mediterranean world.* Oxford: Oxford University Press.

Melfi, M., 2000. Alcune osservazioni sul cosiddetto tempio di Ares a Monte Casale-Kasmenai. *Geo-Archeologia,* Issue 2, pp. 39-48.

Mertens, D., 2006. *Città e monumenti dei greci d'occidente: dalla colonizzazione alla crisi di fine V secolo a.C.* Rome: L'Erma di Bretschneider.

Métraux, G., 1978. *Western Greek Land-use and City-planning in the Archaic Period.* New York: Garland Publishing, Inc.

Militello, E., 1966. Eloro: III. Relazione degli scavi del 1958-59. *Monumenti Antichi,* Volume 47, pp. 299-335.

Miller, M., 1970. *The Sicilian colony dates.* Albany: State University of New York Press.

Miller, M., 1995. *Befestigungsanlagen in Italien vom 8. bis 3. Jahrhundert vor Christus.* Hamburg: Verlag Dr. Kovač.

Milone, F., 1960. *Sicilia: la natura e l'uomo.* Turin: Editore Paolo Boringhieri.

Morakis, A., 2011. Thucydides and the character of Greek colonisation in Sicily. *Classical Quarterly,* Volume 61, pp. 460-92.

Morakis, A., 2015. The Gamoroi and the history of archaic Syracuse: a new examination. *Studi di Antichità,* Volume 13, pp. 33-50.

Morel, J.-P., 1997. Problématiques de la colonisation grecque en Méditerranée occidentale: l'exemple des réseaux. In: *Il dinamismo della colonizzazione greca.* Naples: Loffredo, pp. 59-70.

Moreschini, D., 1992a. Monte Casale. A. Fonti letterarie, epigrafiche e numismatiche. In: G. Nenci & G. Vallet, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 289-90.

Moreschini, D., 1992b. Monte Casale. B. Storia della ricerca archeologica. In: *Bibliografia Topografica della colonizzazione Greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 290-91.

Morley, N., 2004. *Theories, Models and Concepts in Ancient History.* London: Routledge.

Morris, I., 1994. Archaeologies of Greece. In: I. Morris, ed. *Classical Greece: ancient histories and modern archaeologies.* Cambridge: Cambridge University Press, pp. 8-47.

Morris, I., 1998. Archaeology and archaic Greek history. In: N. Fisher & H. van Wees, eds. *Archaic Greece: New approaches and new evidence.* London: Duckworth.

Morris, I., 2005. Archaeology, Standard of Living, and Greek Economic History. In: J. Manning & I. Morris, eds. *The Ancient Economy: Evidence and Models.* Stanford: Stanford University Press, pp. 91-126.

Morris, I., 2006. The Growth of Greek Cities in the First Millennium BC. In: *Urbanism in the Preindustrial World: Cross-Cultural Approaches.* Tuscaloosa: The University of Alabama Press, pp. 27-51.

Morris, I. et al., 2003. Stanford University Excavations on the Acropolis of Monte Polizzo, Sicily, III: Preliminary Report on the 2002 Season. *Memoirs of the American Academy in Rome,* Volume 48, pp. 243-315.

Mosca, A., 2010. Insediamenti rurali greci in Sicilia: una frontiera verso gli indigeni? Le fattorie come demarcatori territoriali nel contesto camarinese. *Bollettino di Archeologia on line,* I (Volume speciale), pp. 55-64.

Muggia, A., 1997. *L'area di rispetto nelle colonie magno-greche e siceliote.* Palermo: Sellerio editore.

Murray, O., 1993. *Early Greece.* 2nd Edition ed. London: Fontana.

Nenci, G., 1979. Spazio civico, spazio religioso e spazio catastale nella polis. *Annali della Scuola Normale Superiore di Pisa. Cl. di Lettere e Filosofia,* Volume 3.9, pp. 459-77.

Nicholls, R., 1958/1959. Old Smyrna: The Iron Age Fortifications and Associated Remains on the City Perimeter. *The Annual of the British School at Athens,* Volume 53/54, pp. 35-137.

Nielsen, T., 2002. Phrourion. A Note on the Term in Classical Sources and in Diodorus Siculus. In: T. Nielsen, ed. *Even More Studies in the Ancient Greek Polis. Papers from the Copenhagen Polis Centre, 6. Historia Einzelschriften, 162.* Stuttgart: Franz Steiner, pp. 49-64.

Noti, R. et al., 2009. Mid- and late-Holocene vegetation and fire history at Biviere di Gela, a coasta lake in southern Sicily, Italy. *Vegetation History and Archaeobotany,* Volume 18, pp. 371-87.

Orlandos, A., 1966. *Les matériaux de construction et la technique architecturale des anciens Grecs, i.* Paris: Ecole française d'Athènes.

Orsi, P., 1889. Palazzolo Acreide (Akrai). *Notizie degli Scavi di Antichità,* pp. 387-9.

Orsi, P., 1891. Palazzolo Acreide (Akrai). *Notizie degli Scavi di Antichità,* pp. 355-7.

Orsi, P., 1897. Scolture Greche del R. Museo Archeologico di Siracusa. *Rendiconti dell'Accademia dei Lincei,* pp. 301-12.

Orsi, P., 1899a. Buscemi. Sacri specchi con iscrizioni greche scoperti presso Akrai. *Notizie degli Scavi di Antichità,* pp. 453-71.

Orsi, P., 1899b. Camarina (campagna archeologica del 1896). *Monumenti Antichi,* Volume 9, pp. 201-78.

Orsi, P., 1899c. Eloro - Ubicazione di questa antica città sulla sinistra del Tellaro nel Comune di Noto. *Notizie degli Scavi di Antichità,* pp. 241-244.

Orsi, P., 1903. Kamarina. Scavi nella necropoli. *Notizie degli Scavi di Antichità,* p. 430.

Orsi, P., 1904-1905. Camarina. Campagne archeologiche del 1899 e 1903. *Monumenti Antichi,* Volume 14, pp. 757-956.

Orsi, P., 1904. Camarina. Necropoli di Passo Marinaro. *Notizie degli Scavi di Antichità,* pp. 369-71.

Orsi, P., 1905. Camarina. Nuovi scavi nella necropoli. *Notizie degli Scavi di Antichità,* pp. 429-30.

Orsi, P., 1907. Camarina, scavi nella necropoli. *Notizie degli Scavi di Antichità,* pp. 484-5.

Orsi, P., 1909. Camarina. VIII campagna nella necropoli di Passo Marinaro. *Notizie degli Scavi di Antichità,* pp. 349-82.

Orsi, P., 1928. Miscellanea sicula. *Bullettino di Paletnologia Italiana,* Volume 48, pp. 44-98.

Orsi, P., 1930. Campagne di scavi nella Sicilia orientale nel 1930. *Bollettino d'Arte,* Volume 10, pp. 143-4.

Orsi, P., 1931. Notiziario archeologico sulla Sicilia orientale. *Il Mondo Classico,* 1(2), pp. 40-52.

Orsi, P., 1966a. Appunti inediti su Camarina (a cura di P. Pelagatti). *Archivio Storico Siracusano,* Volume 12, pp. 121-44.

Orsi, P., 1966b. Eloro, campagna di scavo del 1899, postumo di P. Orsi con aggiunte e note di M.T. Currò. *Monumenti Antichi,* Volume 47, pp. 204-87.

Osanna, M., 1992. *Chorai coloniali da Taranto a Locri: documentazione archeologica e riconstruzione storica.* Roma: Istituto Poligrafico e Zecca dello Stato, Libreria dello Stato.

Osborne, J. & Summers, G., 2014. Visibility Graph Analysis and Monumentality in the Iron Age City at Kerkenes in Central Turkey. *Journal of Field Archaeology,* Volume 39, pp. 292-309.

Osborne, R., 1987. *Classical Landscape with Figures. The Ancient Greek City and its Countryside.* London: George Philip.

Osborne, R., 1996. Pots, trade and the archaic Greek economy. *Antiquity,* Volume 70, pp. 31-44.

Osborne, R., 1998. Early Greek colonization?: The nature of Greek settlement in the West. In: N. Fisher & H. van Wees, eds. *Archaic Greece: New approaches and new evidence.* London: Duckworth, pp. 251-69.

Osborne, R., 2009. *Greece in the Making, 1200-479 BC.* London: Routledge.

Outram, A., 2008. *Experimental archaeology.* Abingdon: Routledge.

Pace, B., 1927. *Camarina. Topografia, storia, archeologia.* Catania: Libreria Tirelli di F. Guaitolini.

Pace, B., 1935-49. *Arte e civiltà della Sicilia antica.* Milano: Società editrice Dante Alighieri.

Pace, B., 1958. *Arte e civiltà della Sicilia antica, I.* Milano: Società editrice Dante Alighieri.

Pakkanen, J., 2013a. *Classical Greek Architectural Design: A Quantitative Approach. Papers and Monographs of the Finnish Institute at Athens 18.* Helsinki: Foundation of the Finnish Institute at Athens.

Pakkanen, J., 2013b. The economics of shipshed complexes: Zea, A case study. In: B. Rankov & D. Blackman, eds. *Shipsheds of the Ancient Mediterranean.* Cambridge: Cambridge University Press.

Parisinou, E., 2007. Lighting dark rooms: some thoughts about the use of space in early Greek domestic architecture. *British School at Athens Studies,* Volume 15, pp. 213-23.

Pastore, M., 1997. Taxation, Coercion, Trade and Development in a Frontier Economy. Early and Mid Colonial Paraguay. *Journal of Latin American Studies,* Volume 29, pp. 329-354.

Pegoretti, G., 1865. *Manuale pratico per l'estimazione dei lavori architettonici, stradali, idraulici e di fortificazione, per l'uso degli ingegneri ed architetti.* 2nd Edition ed. Milan: Presso l'Editore Librajo Angelo Monti.

Pelagatti, P., 1962. Camarina. Relazione preliminare della campagna di scavi 1961-62. *Bollettino d'Arte,* Volume 47, pp. 251-64.

Pelagatti, P., 1966. Saggi di scavo nell'area urbana. *Bollettino d'Arte,* Volume 51, p. 92.

Pelagatti, P., 1966. Scavi e ricerche archeologiche nella provincia di Ragusa 1961-1966. *Archivio Storico Siracusano,* Volume 12, pp. 5-23.

Pelagatti, P., 1970. Un decennio di ricerche archeologiche in provincia di Ragusa 1960-1970. I - Camarina. Scavi recenti e prospettive future. *Sicilia Archeologica,* Volume 3, pp. 5-16.

Pelagatti, P., 1973. Camarina. In: P. Pelagatti & G. Voza, eds. *Archeologia nella Sicilia sud-orientale.* Napoli: Centre Jean Bérard, pp. 133-52.

Pelagatti, P., 1976. Nuove ricerche lungo la costa di Camarina e alla foce dell'Ippari. *Sicilia Archeologica,* Volume 9, pp. 15-24.

Pelagatti, P., 1977. Camarina 1970-1976. Ricerche e difesa di un sito. *Magna Graecia,* Volume 1-2, pp. 1-4.

Pelagatti, P., 1980-1981. L'attività della Soprintendenza alle Antichità per la Sicilia Orientale, Parte II. *Kokalos,* Volume 26-27, pp. 694-730.

Pelagatti, P., 1980. Naxos. In: E. Gabba & G. Vallet, eds. *La Sicilia Antica.* Napoli: Storia di Napoli e della Sicilia Società editrice, pp. 619-35.

Pelagatti, P., 1982a. I più antichi materiali di importazione a Siracusa, Naxos e in altri siti della Sicilia Orientale. In: *La céramique grecqué ou de tradition grecque au VIIİ siècle en Italie centrale et méridionale.* Naples: Institut français de Naples, pp. 113-80.

Pelagatti, P., 1982b. Siracusa: gli ultimi scavi a Ortigia. *Annuario della Scuola Archeologica di Atene e delle Missioni Italiane in Oriente,* Volume 60, pp. 117-64.

Pelagatti, P., 1985. Camarina. B. Storia della ricerca archeologica. In: G. Nenci & G. Vallet, eds. *Bibliografia topografica della colonizzazione Greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 291-8.

Pelagatti, P., 2000. Camarina nel VI e V sec. Problemi di cronologia alla luce della documentazione archeologica. In: G. Chessari, ed. *Un ponte fra l'Italia e la Grecia. Atti del Simposio in onore di Antonino di Vita (Ragusa 13-15 febbraio 1998).* Padova: Bottega d'Erasmo.

Pelagatti, P., 2002. Incinerazione primaria a Camarina e a Monte Casale. Con note di Paolo Orsi. In: F. Cordano & M. Di Salvatore, eds. *Il Guerriero di Castiglione di Ragusa: greci e siculi nella Sicilia sud-orientale: atti del Seminario, Milano, 15 maggio 2000.* Rome: L'Erma di Bretschneider, pp. 141-8.

Pelagatti, P., Ceschi, F. & Tonca, E., 1976. Sul parco archeologico di Camarina. Le fasi edilizie dell'abitato. *Bolletino d'Arte,* Volume 61, pp. 122-41.

Pelagatti, P. & Voza, G. eds., 1973. *Archeologia nella Sicilia sud-orientale.* Napoli: Centre Jean Bérard.

Piscione, V., 1966. Eloro: IV. Relazione del saggi effettuati all'interno dell'area urbana di Eloro, nell'anno 1961. *Monumenti Antichi,* Volume 47, pp. 335-41.

Pollastri, F., 1948-9. *Sicilia: notizie e commenti ecologici di agricoltura siciliana.* Palermo: Industrie Riunite Editoriali Siciliane.

Pounds, N., 1973. *An Historical Geography of Europe 450 B.C. - A.D. 1330.* Cambridge: Cambridge University Press.

Price, B., 1982. Cultural Materialism: A Theoretical Review. *American Antiquity,* Volume 47, pp. 709-41.

Quayson, A., 2005. Postcolonialism and Postmodernism. In: H. Schwartz & S. Ray, eds. *A Companion to Postcolonial Studies.* Oxford: Blackwell Publishing, pp. 87-111.

Rallo, A., 1982. Selinunte: le ceramiche di VII sec. a.C. della necropoli meridionale di Manuzza dopo gli scavi 1978. *Annuario della Scuola archeologica di Atene e delle Missioni italiane in Oriente,* Volume 60, pp. 203-18.

Randall, R. J., 1953. The Erectheum Workmen. *American Journal of Archaeology,* Volume 57, pp. 199-210.

Rea, J., 1956. *How to estimate.* 12th Edition ed. London: Batsford.

Ridgway, D., 1992. *The First Western Greeks.* Cambridge: Cambridge University Press.

Rijsberman, M., 1995a. Gela (Caltanissetta, Italy). In: T. Ring & R. Salkin, eds. *International Dictionary of Historic Places: Southern Europe.* Chicago: Fitzroy Dearborn Publishers, pp. 271-4.

Rijsberman, M., 1995b. Syracuse (Siracusa, Italy). In: T. Ring & R. Salkin, eds. *International Dictionary of Historic Places: Southern Europe.* Chicago: Fitzroy Dearborn Publishers, pp. 674-8.

Riva, C., 2005. The culture of urbanization in the Mediterranean c. 800-600. In: R. Osborne & B. Cunliffe, eds. *Mediterranean Urbanisation 800–600 BC.* Oxford: Oxford University Press, pp. 203-32.

Rizza, G., 1957. Giarratana (Ragusa). Resti di fortificazione greca su Monte Casale. *Notizie degli scavi di antichità,* pp. 205-7.

Rizza, G., 1981. Leontini e Katane nell'VIII e nel VII sec. a.C. *Annuario della Scuola archeologica di Atene e delle Missioni italiane in Oriente,* Volume 59, pp. 313-7.

Rizzo, F., 2003. Le misure delle coste di Sicilia secondo i geografi antichi. In: G. Fiorentini, M. Caltabiano & A. Calderone, eds. *Archeologia del Mediterraneo: studi in onore di Ernesto De Miro.* Roma: "L'Erma" di Bretschneider, pp. 591-7.

Ruschenbusch, E., 1985. Die Zahl der griechischen Staaten und Arealgrösse und Bürgerzahl der 'Normalpolis'. *Zeitschrift für Papyrologie und Epigraphik,* Volume 59, pp. 253-263.

Sabbione, C., 1986. La colonizzazione greca: Matauros e Mylai. *Atti del venticinquesimo convegno di studi sulla Magna Grecia, Taranto,* Volume 26, pp. 221-36.

Salinas, A., 1897. Palazzolo Acreide (provincia di Siracusa). Scoperte di un tesoretto di monete antiche di argento. *Notizie degli Scavi di Antichità,* pp. 436-7.

Salmon, J., 1984. *Wealthy Corinth: A history of the city to 338 BC.* Oxford: Clarendon Press.

Salmon, J., 1999. The Economic Role of the Greek City. *Greece & Rome,* Volume 46, pp. 147-67.

Salmon, J., 2001. Temples the measure of men: Public building in the Greek economy. In: D. Mattingly & J. Salmon, eds. *Economies beyond agriculture in the classical world.* London: Routledge, pp. 195-208.

Salzman, L., 1967. *Building in England down to 1540: a documentary history.* Oxford: Clarendon Press.

Samuel, E., 1969. Comparison of sequential rules for estimation of the size of a population. *Biometrics,* Volume 25, pp. 517-27.

Scheidel, W., 2003. The Greek Demographic Expansion: Models and Comparisons. *The Journal of Hellenic Studies,* Volume 123, pp. 120-40.

Scheidel, W., 2004. Demographic and Economic Development in the Ancient Mediterranean World. *Journal of Institutional and Theoretical Economics,* pp. 743-57.

Scheidel, W., 2005. Human Mobility in Roman Italy, II: The Slave Population. *Journal of Roman Studies,* Volume 95, pp. 64-79.

Scheidel, W., 2009a. Demography and Sociology. In: G. Boys-Stones, B. Graziosi & P. Vasunia, eds. *The Oxford Handbook of Hellenic Studies.* Oxford: Oxford University Press, pp. 665-677.

Scheidel, W., 2009b. Population and Demography. In: A. Erskine, ed. *A Companion to Ancient History.* Oxford: Blackwell Publishing, pp. 134-45.

Schmiedt, G., 1972. *Il livello antico del mar Tirreno: testimonianze dei resti archeologici.* Firenze: Leo. S. Olschki.

Schmincke, H.-U., Behncke, B., Grasso, M. & Raffi, S., 1997. Evolution of the northwestern Iblean Mountains, Sicily: uplift, Plicocene/Pleistocene sea-level changes, paleoenvironment, and volcanism. *Geologische Rundschau,* Volume 86, pp. 637-669.

Scott, M., 2016. Prestige in Greek Sanctuaries: Delphi. In: M. Miles, ed. *A Companion to Greek Architecture.* Chichester, West Sussex: John Wiley & Sons, Inc., pp. 135-46.

Scranton, R., 1960. Greek architectural inscriptions as documents. *Harvard Library Bulletin,* Volume 14, pp. 159-82.

Shennan, S., 2004. *Quantifying archaeology.* 2nd ed. Edinburgh: Edinburgh University Press.

Shepherd, G., 2009. Greek "Colonisation" in Sicily and the West. Some Problems of Evidence and Interpretation Twenty-Five Years On. *Pallas,* Volume 79, pp. 15-25.

Sjöqvist, E., 1973. *Sicily and the Greeks.* Ann Arbor: University of Michigan Press.

Skafida, E., 1994. Κατασκευαστικά υλικά, τεχνική και τεχνολογία των πλίνθινων σπιτιών στη νεολιθική Θεσσαλία: μια εθνοαρχαιολογική προσέγγιση. In: R. Misdrahi-Kapon, ed. *La Thessalie: quinze années de recherches archéologiques, 1975-1990: bilans et perspectives. Actes du colloque international, Lyon 17-22 avril 1990, vol. A.* Athens: Ministre de la culture, pp. 177-88.

Snodgrass, A., 1993. The Rise of a Polis. The Archaeological Evidence. In: M. Hansen, ed. *The Ancient Greek City-State. Symposium on the occasion of the 250th Anniversary of The Danish Academy of Sciences and Letters. July 1-4 1992. Historisk-filosofiske Meddelelser, 67.* Copenhagen: Commissioner: Munksgaard, pp. 30-40.

Snodgrass, A., 2002. A Paradigm Shift in Classical Archaeology?. *Cambridge Archaeological Journal,* Volume 12, pp. 179-194.

Solomonik, E. & Nikolaenko, G., 1990. O zemel'nych ucastkach Chersonesa v nacale IIIv. do n.e. (IOSPE I², 403). *Vestnick drevnej istorii,* Volume 2, pp. 79-99.

Spawforth, T., 2006. *The Complete Greek Temples.* London: Thames and Hudson.

Spencer, C., 1998. A Mathematical Model of Primary State Formation. *Cultural Dynamics,* Volume 10, pp. 5-20.

Stanier, R., 1953. The Cost of the Parthenon. *The Journal of Hellenic Studies,* Volume 73, pp. 68-76.

Stika, H.-P., Heiss, A. & Zach, B., 2008. Plant remains from the early Iron Age in western Sicily: differences in subsistence strategies of Greek and Elymian sites. *Vegetation History and Archaeobotany,* Volume 17 (Suppl. 1), pp. 139-48.

Stone, P. & Planel, P., 1999. *Constructed Past: Experimental Archaeology, Education and the Public.* London: Routledge.

Thomas, G., 2012. *Experimental Archaeology.* London: Routledge.

Tréziny, H., 1999. Les fortifications grecques en Occident à l'époque classique (491-322 av. J.-C.). *Pallas, revue d'études antiques,* Volume 51, pp. 241-82.

Tréziny, H., 2002. Urbanisme et voirie dans les colonies grecques archaïques de Sicile. *Pallas,* Volume 58, pp. 267-282.

Trigger, B., 2003. *Understanding Early Civilizations: A Comparative Study.* Cambridge: Cambridge University Press.

Tsakirgis, B., 2016. The Architecture of Greek Houses. In: M. Miles, ed. *A Companion to Greek Architecture.* Chichester, West Sussex: John Wily & Sons, Inc., pp. 273-87.

Tsetkhladze, G., ed., 2006. *Greek Colonisation: An Account of Greek Colonies and Other Settlements Overseas.* Leiden: Brill.

Vallet, G., 1968. La cité et son territoire dans le colonies grecques d'occident. In: P. Romanelli, ed. *La città e il suo territorio: Atti del settimo convengo di studi sulla Magna Grecia, Taranto 8-12 ottobre 1967.* Napoli: L'Arte Tipografica, pp. 67-142.

Vallet, G., Villard, F. & Auberson, P., 1976. *Mégara Hyblaea. 1: Le quartier de l'agora archaïque.* Rome: École française de Rome.

van Dommelen, P., 2012. Colonialism and Migration in the Ancient Mediterranean. *The Annual Review of Anthropology,* Volume 41, pp. 393-409.

Vander Poppen, R., 2008. *Rural Change and Continuity in Etruria: A Study of Village Communities from the 7th Century B.C. to the 1st Century A.D.* University of North Carolina: Ph.D. thesis.

Vassallo, S., 1997. Indagini in un quartiere della città bassa di Himera. In: H. Isler, ed. *Wohnbauforschung in Zentral- und Westsizilien. Sicilia occidentale e centro-meridionale: ricerche archeologiche nell'abitato.* Zürich: Archäologisches Institut der Universität, pp. 81-90.

Villard, F., 1982. La céramique géométrique importée de Mégara Hyblaea. In: *La céramique grecqué ou de tradition grecque au VIIIᵉ siècle en Italie centrale et méridionale.* Naples: Institut français de Naples, pp. 181-5.

Vita Finzi, C. & Higgs, E., 1970. Prehistoric economy in the Mt. Carmel area of Palestine: site catchment analysis. *Proceedings of the Prehistoric Society,* Volume 36, pp. 1-37.

Voza, G., 1968-1969. Intervento di G. Voza (Siracusa). *Kokalos,* Volume 14-15, pp. 357-64.

Voza, G., 1970. Eloro. In: *Enciclopedia dell'arte antica, classica e orientale, Supplemento 1970.* Roma: Istituto della Enciclopedia Italiana, pp. 297-301.

Voza, G., 1971. Akrai. In: G. Voza, ed. *Un quinquennio di attività archeologica nella provincia di Siracusa.* Siracusa: Ente Provinciale per il Turismo, pp. 72-4.

Voza, G., 1972-1973. Intervento di G. Voza (Siracusa). *Kokalos,* Volume 18-19, pp. 186-92.

Voza, G., 1973. Akrai. In: P. Pelagatti & G. Voza, eds. *Archaeologia nella Sicilia sud-orientale.* Napoli: Centre Jean Bérard, pp. 127-8.

Voza, G., 1973a. Eloro. In: P. Pelagatti & G. Voza, eds. *Archeologia nella Sicilia sud-orientale.* Napoli: Centre Jean Bérard, pp. 117-9.

Voza, G., 1973b. Eloro. In: *Enciclopedia dell'arte antica, classica e orientale: supplemento 1970.* Roma: Istituto della Enciclopedia italiana, pp. 297-301.

Voza, G., 1973c. Kasmenai (Monte Casale). In: P. Pelagatti & G. Voza, eds. *Archeologia nella Sicilia sud-orientale.* Napoli: Centre Jean Bérard, pp. 129-30.

Voza, G., 1979. Siracusa. In: R. Romeo, ed. *Storia della Sicilia.* Napoli: Società Editrice Storia di Napoli e della Sicilia, pp. 655-92.

Voza, G., 1980-1981. Eloro. *Kokalos,* Volume 26-27, pp. 685-8.

Voza, G., 1984-1985. Attività nel territorio della Soprintendenza di Siracusa nel quadrennio 1980-1984. *Kokalos,* Volume 30-31, pp. 657-78.

Voza, G., 1989. Eloro. B. Storia della ricerca archeologica. In: G. Nenci & G. Vallet, eds. *Bibliografia Topografica della colonizzazione greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 159-63.

Voza, G., 1993-1994. Attività archeologica della Sopritendenza di Siracusa e Ragusa. *Kokalos,* Volume 39-40, II-2, pp. 1281-7.

Voza, G., 1999. *Nel segno dell'antico.* Palermo: Arnaldo Lombardi Editore.

Voza, G. & Lanza, M., 1994. Eloro. In: *Enciclopedia dell'arte antica, classica e orientale.* Roma: Istituto della Enciclopedia Italiana, pp. 462-3.

White, K., 1965. The productivity of labour in Roman agriculture. *Antiquity,* Volume 39, pp. 102-7.

White, K., 1970. *Roman Farming.* Ithaca, NY: Cornell University Press.

Whitley, J., 2001. *The Archaeology of Ancient Greece.* Cambridge: Cambridge University Press.

Wickler, S., Hoyt, D., Cogger, E. & Hirschbein, M., 2000. Preferred speed and cost of transport: the effect of incline. *The Journal of Experimental Biology,* Volume 203, pp. 2,195-200.

Wikander, Ö., 1990. Archaic Roof Tiles the First Generation. *Hesperia: The Journal of the American School of Classical Studies at Athens,* Volume 59, pp. 285-90.

Wilkinson, T., 1994. The Structure and Dynamics of Dry-Farming States in Upper Mesopotamia. *Current Anthropology,* Volume 35, pp. 483-520.

Wilson, J.-P., 1997. The nature of Greek overseas settlements in the archaic period. Emporion or apoikia?. In: L. Mitchell & P. Rhodes, eds. *The development of the polis in archaic Greece.* London: Routledge, pp. 110-4.

Wilson, R., 1987-1988. Archaeology in Sicily, 1982-87. *Archaeological Reports,* Volume 34, pp. 105-50.

Wilson, R., 1995-1996. Archaeology in Sicily 1988-1995. *Archaeological Reports,* Volume 42, pp. 59-123.

Winter, N. A., 1993. *Greek Architectural Terracottas: from the Prehistoric to the End of the Archaic Period.* Oxford: Clarendon Press.

Woodward, R., 2012. *An Architectural Investigation into the Relationship between Doric Temple Architecture and Identity in the Archaic and Classical Periods,* University of Sheffield: Ph.D. thesis.

Wright, G., 2005a. *Ancient Building Technology, II: Materials, pt. 1: Text.* Leiden: Brill.

Wright, G., 2005b. *Ancient Building Technology, II: Materials, pt. 2: Illustrations.* Leiden: Brill.

Wulff, H., 1976. *The Traditional Crafts of Persia. Their Development, Technology, and Influence on Eastern and Western Civilizations.* Cambridge, Mass.: The Massachusetts Institute of Technology Press.

Young, R., 1939. Late Geometric Graves and a Seventh Century Well in the Agora. *Hesperia Supplements,* Volume 2, pp. 1-250.

Zipf, G., 1949. *Human Behavior and the Principle of Least Effort: An Introduction to Human Ecology.* Reading, MA: Addison-Wesley.

Zirone, D., 2005. Siracusa. B. Storia della ricerca archaeologica. In: *Bibliografia Topografica della colonizzazione Greca in Italia e nelle isole tirreniche.* Pisa: Scuola Normale Superiore, pp. 145-204.