Viewscapes and Cosmology in the Prehistoric Temples of Malta

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Abstract

The first known Maltese Neolithic islanders arrived from Sicily by around 6,000 BCE. In the early fifth millennium, there could have been a decline in human presence on the archipelago. A new influx of colonization from Sicily appears to have happened around 3,800 BCE, accompanied by the emergence of an original megalithic temple architecture, not known to exist anywhere else in the contemporary world. This was the start of the unique Maltese Temple Period lasting about 1,500 years, before its sudden decline around 2,400 BCE.

The present thesis examines some aspects of the worldviews of this extraordinary culture. More specifically, it investigates the following question: what do viewscapes and visual relationships tell us about the cosmology of the prehistoric temple builders in Malta? This is explored through three subsidiary research questions, namely: 1) whether the builders of the megalithic temples purposely located them to be conspicuous in the landscape and have intervisibility to other temples?, 2) whether there were any preferences for open or restricted vistas and visual relationships with specific topographic features or celestial bodies on the apparent horizon?, and 3) whether temples were orientated in such a way that specific celestial objects could be seen rising or setting through their entrance frames?

Each of these subsidiary questions requires a different, though complementary, methodology. Firstly, Geographical Information Systems (GIS) were deployed to perform viewshed, cumulative viewshed, total viewshed, and line-of-sight analysis, taking into consideration human acuity with respect to target's distance and visible height. Secondly, 360° panoramas of the apparent horizon around the temples were virtually reconstructed from a Digital Elevation Model, ground-truthed through field measurements, and used to assess preferences for specific vistas as well as visual relationships to topographic features and the rising and setting of celestial objects. Thirdly, theodolite measurements of the orientation and entrance frame of the temples, in combination with astronomical software, are used to assess and identify celestial objects rising or setting in alignment with the temples’ entrances. At each step, statistical testing was conducted to assess the significance and potential intentionality of identified patterns.

Based on the evidence obtained, new and interpretative empirical models are presented. It is demonstrated that temples had a high level of visibility and intervisibility, and that their locations were *not* chosen at random. Furthermore, it is determined that the majority of the temples were placed in the more inherently visible part of the landscape, with an open vista towards the southern horizon, and a restricted view to the north. Finally, it was found that Maltese temple entrances were preferentially aligned for observations of two bright stars, Gacrux and Avior.

Integrating all the different research areas in this study, it is shown that the design, location, and orientation of temples was informed by an interest in these visual relationships. It is argued that these considerations of the viewscape were connected to a holistic cosmology, embedded in a correlation between the nested scales of the inner structure of the temples, temple locations in the landscape, and their relationships with the celestial sphere.

DEDICATION

I dedicate this Ph.D. thesis to my late parents, Sigrun and Birger.

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Chapters

List of Abbreviations

Alt	Altitude
Az	Azimuth
ArcGIS	Esri GIS software
ArcMap	Main component of ArcGIS
CVS	Cumulative viewshed
Dec	Declination
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EQSR	Equinox sunrise
EQSS	Equinox sunset
H0	Null hypothesis
GIS	Geographical Information System
GPS	Global Positioning System
km	Kilometres
LoS	Line-of-sight
MEPA	Malta Environment & Planning Authority
Met Office	National meteorological service, Luqua Airport, Malta
m	Metres
mm	Millimetres
MjLX	Major lunar extreme
MnLX	Minor lunar extreme
nMjLXR	Northern major lunar extreme rising
nMjLXS	Northern minor lunar extreme setting
ML	Maximum likelihood
p-value	Probability value
QGIS	A Free and Open Source Geographic Information System
SDOM	Standard deviation of mean
RA	Right ascension
SSSR	Summer solstice sunrise

SSSS	Summer solstice sunset
sMjLXR	Southern major lunar extreme rising
sMjLXS	Southern major lunar extreme setting
sMnLXR	Southern minor lunar extreme rising
sMnLXS	Southern minor lunar extreme setting
ST	Significance Test
SVA	Single viewshed analysis
TotS	Total Station
TVS	Total viewshed
UTM	Universal Transverse Mercator
VS	Viewshed
VSA	Viewshed analysis
VSQ	Viewshed analysis applying QGIS
WGS84	World Geodetic System of 1984
WSSR	Winter solstice sunrise
WSSS	Winter solstice sunset

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1 General Introduction

The core research question of this study is: what do viewscape and visual relationships tell us about the cosmology of the prehistoric temple builders in Malta? This research addresses a gap of knowledge regarding to what extent the positioning and visual relationships of Maltese prehistoric temples were influenced by a belief system, worldview, or a cosmology. Although such a relationship had been hinted at in the existing literature, it had not until now been addressed in a systematic and rigorous way. What follows will introduce the prehistoric Maltese Temple Period, as well as the theory behind cosmology and viewscapes, before directly addressing the research framework and the structure of the thesis. Figure 1.1 shows the geographical position of the archipelago of Malta in relation to Sicily, indicating Maltese prehistoric megalithic temple sites.

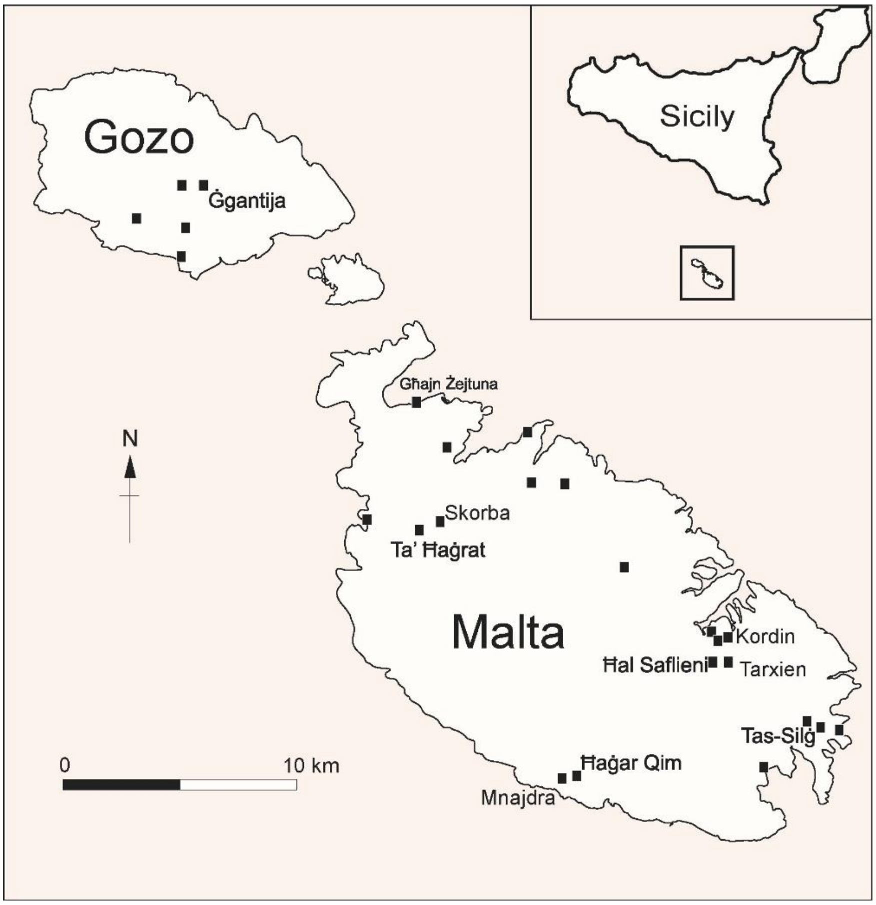


Figure 1.1. Map of the Maltese archipelago, after Grima (2016b: 28).
The map indicates prehistoric sites on the archipelago.

1.1 Maltese Temple Period

The chronological span of this study is the millennium and a half known as the Maltese Temple Period. According to Bonanno (2008: 59) the beginning and the end of this period reveals itself with a specific cultural narrative consisting of three areas, which are megalithic temples, hypogea for mass burials, and a talented art associating both. This research is concerned with researching the first of these three areas, the megalithic temples, examining their visual positioning in the landscape, their locations in relation to their apparent horizon, and celestial bodies in the heavenly sphere. But firstly, the history of conceptualisations of the Maltese Temples shall be introduced.

1.2 Conceptualisations of the Maltese Temples

The earliest mention of prehistoric monuments in Malta goes back to the 16th century, when the Frenchman Jean Quintin's (1536: 20-25) publication, *Melitae Insulae Descriptio*, connected them to Roman deities. Over a 100 years later, the Maltese scholar Abela (1647: 145) claimed that the megalithic structures were built by a race of giants and also mentioned some marked artefacts found at *Hagiar el Kim* (Ħaġar Qim), and the islet *Folfola* (Filfla) relating it to be a religious place. Jean Houël, a painter and engraver under the patronage of the King of France, visited Malta in 1770 and 1777, and promoted international antiquarian interest in the temples by including them (Houël 1787) in his four-volume illustrated description of Sicily and Malta, attributing them to the Phoenicians.

The possibility of a connection between temples and astronomical phenomena was first suggested by Vance (1842: 231-233). Vance excavated Ħaġar Qim and Mnajdra, suggesting that the high north-eastern vertical pillar at Ħaġar Qim was erected with the desire to follow the movements of celestial bodies with greater efficiency, and this was a justification for why the temples were not roofed. Zammit (1929b: 13) also related the temples to the sky, explaining that the circular holes cut into a horizontal slab close to the entry of Tarxien Temple served as an illustration of the stars of Crux (Southern Cross), a constellation clearly conspicuous in the southern sky from Malta. Ugolini (1934: 128, 138) also mentions a possible affiliation of celestial bodies and orientations of temples, suggesting that the Tal-Qadi Stone was possibly a Neolithic 'lastra astrologica'. Cutajar (1937) proposes that the Tarxien Temple site was used as a yearly almanac for observing the sun setting on specific landscape features on the western coastline, on churches or on megalithic sites.

This was also the era the Maltese megalithic monuments were frequently referred to as sanctuaries, temples or sites for religious performance by excavators and scholars (Ashby *et al.* 1913, Bradley 1912, Caruana 1882, Mayr 1901). Dating the monuments to a pre-Phoenician, prehistoric culture was first done by Mayr (1901: 86), followed by attributions to a specifically Neolithic culture by Tagliaferro (1911) and Zammit (1910, 1916). From the 1950s onwards Maltese prehistoric studies were largely led by two British archaeologists, John D. Evans (1959, 1971) and his successor David Trump (1961, 1966a, 1972). Since the late 20th century, several archaeological and archaeoastronomical studies have been completed on the Maltese temples and shall be referred to throughout this thesis.

According to Magli (2009: 49), calling the prehistoric Maltese megalithic buildings 'temples' is circumstantial as there is no written evidence for such a claim. On the other hand, there are several scholars who refer to a time period of Maltese prehistory as the 'Temple Period', and who largely accept that its monumental buildings were tied to some form of belief system (Anderson and Stoddart 2007, Bonanno 1986b, 1999b, 2008, 2017, Grima 2007, 2008, Lomsdalen 2014a, 2014b, Malone and Stoddart 2009, 2011, 2013, Robb 2007, Skeates 2007, 2010, Stoddart *et al.* 1993, Stroud 2007, 2019, Tilley 2004, Trump 1972, Zammit 1929a). The term 'temple' will be used throughout the thesis as a label for all Maltese prehistoric megalithic monuments built above the ground.

1.2.1 Chronology

Recent results from the *FRAGSUS Project* (McLaughlin *et al.* 2020a) have reassessed the chronology of Maltese prehistory and pushed the date of the first known Neolithic settlements arriving from Sicily back to around 6,000 BCE. There may have been a decline in human presence during much of the fifth millennium BCE. A new influx of colonization seems to have happened at the start of the Żebbuġ Phase at 3,800 BCE, followed by another abandonment of Malta in the late third millennium, which could be connected to climate abnormality in the Mediterranean (McLaughlin *et al.* 2020a: 33, 38), and an increasingly drought-prone landscape unable to support arable farming (Grima *et al.* 2020: 234).

When this research program initiated, the chronology of Mata's prehistory was based on Trump's (2004: 230) timeline. When the *FRAGSUS Project* published their work towards the end of 2020 (McLaughlin *et al.* 2020a), this present author compared the dating of Maltese prehistory from the *FRAGSUS Project* with the one originally used by Trump (2004: 230) and the *FRAGSUS Project* (McLaughlin *et al.* 2020a: 38) as presented in Table 1.1.

	Trump chronology		FRAGSUS chronology	
Temple Period	Start	End	Start	End
Żebbuġ	4,100 BCE	3,800 BCE	3,800 BCE	3,600 BCE
Mġarr	3,700 BCE	3,600 BCE	3,600 BCE	3,400 BCE
Ġgantija	3,500 BCE	3,300 BCE	3,400 BCE	3,100 BCE
Saflieni	3,200 BCE	3,100 BCE	3,100 BCE	2,800 BCE
Tarxien	3,000 BCE	2,500 BCE	2,800 BCE	2,400 BCE

Table 1.1. Temple Period chronology.
This table illustrates the differences in chronology of the Temple Period established by Trump and the *FRAGSUS Project*.

McLaughlin *et al.* (2020a: 38) concludes that their project has brought the chronology of Maltese prehistory into sharper focus but 'It is, perhaps, inevitable that many questions remain about the details of the cultural sequence of the Maltese Islands.' The *FRAGSUS Project*'s Bayesian data model for the various phases of the Temple Period can have a variation up to several hundred years both for the beginning and the end of each period

(McLaughlin *et al.* 2020a: 32). Furthermore, the Mġarr Phase is classified as transitional Ġgantija Phase.

This study is referring to and concerned about the two main Maltese Temple Period, Ġgantija Phase and Tarxien Phase, and not a detailed timeline of Malta’s prehistory, therefore, this research was not impacted by the variations in the core Temple Period chronology. This study will refer to the chronology as revised by the *FRAGSUS Project,* as listed in Table 1.1.

1.2.2 Development of megalithic architecture in Malta

Evans (1959: 84-97) connects the origin of the Neolithic Maltese temples to the island’s first kidney-shaped rock-cut tombs, a mortuary custom the first colonizers seem to bring with them from Sicily. Another model of the temples’ origin is offered by Tilley (2004: 99) relating it to the sea caves and arches created by fluidity of the movements of the sea along the Maltese shore land. Trump (2002: 87-88) suggests the lobed form of the temples originated from the combination of two religious structures, shrines and ancestral tombs. As illustrated in Figure 1.2 the main diversity of the typical temple structure lies in the number of curved apses that varies from two to six, where most temples had an altar similar structure against the innermost back wall (Trump 2002: 72, 74).

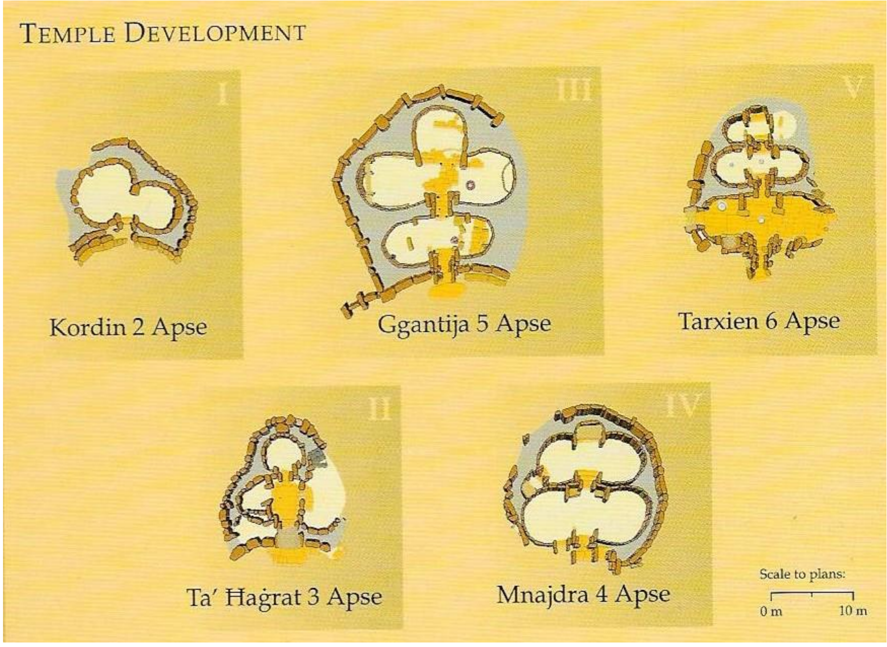


Figure 1.2. Temple development, after Trump (2002: 89).
This plan shows temple development from two to six apses.

Renfrew (1973: 161) suggests that the '…temples are the earliest free-standing monuments of stone in the world.' According to Trump (2010) Renfrew's claim is still valid, even after that Göbekli Tepe (about 10,000 BCE), located in the south-eastern part of Turkey, was discovered in the 1990's by Schmidt (2008). Trump's argument was founded on the suggestion that Göbekli Tepe is not a free-standing structure, a claim that this author can affirm by visiting Göbekli Tepe in January 2012.

Regardless of origin, the temples are *not* tombs as no burials have ever been found inside them (except in the Tarxien Temple with a result of a reuse of the building for cremation by later people) and the mortuary culture continued to use rock-cut tombs, natural caves, and the underground hypogea (Evans 1959: 85). Neither are there any indications that the temples were used as dwellings or domiciling sites (Malone and Stoddart 2013: 69), but there are examples confirming that sites were used for dwellings before temple constructions (Grima *et al.* 2020: 234, McLaughlin *et al.* 2020a: 32). The excavation of the Xagħra Circle (1987-94) in Gozo unearthed a rock-cut tomb indicating the hypogeum's continue use for about 1,500 years, from the early start of the Temple Period, the Żebbuġ Phase, until its end in the later part of the Tarxien Phase (Malone *et al.* 2009). According to Malone and Stoddart (2011: 768):

> The funerary megalithic structures located below ground belonged to the world of the dead in the lowest cosmological level. The temples located above ground belonged to the world of the living in the middle cosmological level. The sky, the location of stars and ancestors (in distant Sicily), formed the uppermost cosmological level.

This quote from Malone and Stoddard indicates that the dead were both physically and metaphorically excluded from the living (Malone and Stoddart 2009: 374, Stoddart *et al.* 1993: 15, Stoddart and Malone 2008: 19). But that there were symbolical affinities between temples and hypogea is further substantiated by Bonanno's (1990: 202) statement: 'The temples and burial places provide a seemingly unified contrast'. Robb (2001: 191) suggests that the temples represented a combination of '…two systems of cosmological distinctions: mediating the above-ground living world and the below-ground ancestral world…'. Based on the excavation of the Skorba Temple site, Trump (1966a: 10) claims there are indications of shrine ceremonies and religious rituals preceding the Temple Period. The body was central to prehistoric liturgical belief in Malta, where the intervened movements of the individual body through temples and landscape surrendered its life cycle to an ancestral unity through continuity beyond individual memory (Stoddart and Malone 2008: 19, 22).

As argued elsewhere by the present author (Lomsdalen 2017: 109) 'The Maltese temples do not appear as isolated monuments but are frequently found in groups, often paired or even clumped together', an hypothesis that will be further examined and discussed in the GIS Chapter 2 of this thesis. According to Renfrew (1973: 170-172) the buildings and the regional distribution of temple sites could have been based on a regional hierarchical chiefdom class, an argument Renfrew (2007: 12) later reconsidered that the initiating power to construct temples probably were more someone aligned to rituals, but not necessarily religiously inclined. Cazzella and Recchia (2015: 106) on the other hand argue that the organisational body of the temples were more 'ritual specialists' with ample power, but not a religious one, as retrieved artefacts do not indicate a Temple Period elite class. Evans (1971: 222, 1977: 24) on the other hand suggests that there existed a ‘privileged priesthood’ and bases it on an elaborated structure of the temples, and that ‘…some of the terracotta figures from Tarxien do look like portraits of priests’, and furthermore that human remains from the Xemxija rock-cut tombs indicate that burials were reserved for a privileged category. Anderson and Stoddart (2007: 43) propose that the sophisticated temple structure facilitated ‘hidden’ areas from where priests carrying items could appear in front of a congregation waiting in the more common areas. Clark (2004: 377) suggests that building temples was well within the population’s capacities and resources, and did not impose much great strain to the builders, however Clark would find it more intriguing to disclose how the society was organized to achieve such massive results.

Malone *et al.* (1993: 22) point out that there may have been a priestly superior class as highly detailed and artistic elaborated small stone idols representing human figures probably used by them or by other ‘specialists’ in burial rituals, while other figurines were more fanciful and individualised as animals or phallic imagery. Malone *et al.* (1993: 22) suggest that the reason for so many numerous temples on a small island could have been that ‘…they were built by perhaps half a dozen rival clans or tribes, each competing for land and water’, and there was a fixation on religious, cult, social influence and control over the population. A vast amount of resources were spent to build colossal, non-productive temples which were prioritized at the expense of developing villages, domestic structures and farming methods (Malone *et al.* 1993: 22).

Due to increasingly technical building ability and also a change in ritual needs, the temples became bigger and more elaborate, but also a visual and structural separation between ‘public’, ‘private’ and ‘hidden’ areas was emphasised (Anderson and Stoddart 2007: 43, Malone and Stoddart 2013: 74, Trump 2002: 87-88). The Mnajdra Temple is one example of this separation with elevated areas with portholes having rope holes used for closing off doorways (Lomsdalen 2014a: 50). Several temples have separated areas with so-called ‘oracle chambers’, which may also be an indication of a priestly ruling hierarchy, though the actual use of these rooms is not known (Barrowclough 2007: 50-51, Lomsdalen 2014a: 128-129, 2016, Malone and Stoddart 2013: 75, Trump 2002: 110-111). A debate of socioeconomic and hierarchal structure of the Temple Period Malta society is often

related to ritualised temple practices (Anderson and Stoddart 2007, Bonanno 1986b, Grima 2007, 2008, Lomsdalen 2014a, 2014b, Malone and Stoddart 2009, 2013, Robb 2007, Skeates 2007, 2010, Stoddart *et al.* 1993, Trump 2002: 234-237). Many temples were also directly or indirectly concerned with the sky on a cosmological level. Chapter 4 examines temple alignments to celestial bodies through the Temple Period. As will be further analysed in Chapters 3 and 4, several authors have studied various aspects of temple orientation to the celestial sphere. Quoting Trump (2002: 239) on Maltese temple culture which is marked by a '…complete absence of evidence in any form for warfare, whether weapons, defensive sites, wounds on skeletons, or any other', as fortifications and slaughter by invaders came into existence at a post-Temple Period.
Nor are there any indications of violence in the Maltese Temple Period (Evans 1959: 157-158, 1977: 24).

1.2.3 Culmination and collapse

The emergence as well as the decline and collapse of the temple culture is still very enigmatic (Bonanno 1993, 1999b, Bonanno *et al.* 1990, Malone *et al.* 1993, Malone and Stoddart 2013, Stoddart *et al.* 1993, Trump 2002, Vella 1999). During the early period of the third millennium the temple culture hit a blooming climax, when around 2,500 BCE it went into an abrupt, and probably not expected culmination (Malone and Stoddart 2013). Models from the *FRAGSUS Project* suggest a phase of human abandonment in Malta at around late third millennium, but may not have happened at exactly the same time as the transition into the Bronze Age at 2,400 BCE, which could have been influenced by a Mediterranean climate change (McLaughlin *et al.* 2020a: 33). After the following end of The Temple Period, it appears that Malta people from a new Bronze Age culture immigrated to Malta, which according to Magli (2009: 48-49) had metals but lacked '…masonry and architectural prowess of their predecessors'. That was also the area with the much simpler megalithic architecture of 'dolmens' (Bonanno *et al.* 1990: 203, Evans 1956: 87, Malone and Stoddart 2011: 771, Pasztor and Roslund 1997). Even though the usage of the dolmens and their construction periods remain uncertain, most likely they started in late Temple Period or early Bronze Age (Evans 1971: 193-198, Sciberras 1999:

106). According to Stoddart and Malone (2008: 27) the dolmens were used for temporarily displaying the dead.

1.3 Cosmology and viewscape

The concepts of cosmology and viewscape shall be approached here from the perspective of how they are applied in archaeology. As the usage is not always consistent in the literature, this part will give a more clearly defined perspective of the meanings intended here, and each chapter shall cite the literature relevant to the respective topic under examination. This thesis is devoted to how the Temple Period people experienced, perceived, detected and recognised their temples both in the landscape and in relation to events in the sky through the perception of seeing, view, vista, visibility, intervisibility, and observation. The underlying premise of the thesis is that the viewscape may reflect a core component of their cosmology. This is an area that, according to the awareness of the present author, the level of complexity and details as presented in this study has not been previously considered.

1.3.1 Cosmology

Cosmology has been defined by Darvill (2008a: 111) as: 'The world view and belief system of a community based upon their understanding of order in the universe'. Parker Pearson and Richards (1994: 10-15) have also noted that the importance of cosmology is based on '…an ordering of morality, social relations, space, time and the cosmos', where acts of the human body are '…one of the most important generators'. Richards (1996: 193), referring to the monuments of Neolithic Orkney, suggests that architecture constitutes a collective process by '..imposing a particular order on the context of daily life'. People's perception of sacred sites in the landscape influences their belief system, and as Bradly (2000: 11) maintains, this would constitute an understanding of '…how the world was formed and of their place within it.'

Mobile and foraging people who move along landmarks according to seasonal cycles often associate landscape features with particular cosmological events sometimes as spirits, deities, and abstract occurrence and the landscape is a fundamental reference point where beliefs and worldviews are anchored (Thomas 1999: 35, Tilley 1994: 40). Bradley (1998: 17-18) proposes that it was not until the European Neolithic with the new architectural formula of monumentality that people could enunciate a continuing liaison between the dead and the living, and that different forms of monuments were rooted in a shared cosmology. Tilley (1996) in his ethnoarchaeology study of Neolithic Southern Scandinavia, does not use the word cosmology *per se*, but studied how a society's material culture embedded in retrieved artefacts, cult houses, death and body symbolism, could configure a view of the world they lived in. In a volume edited by Nash and Townsend (2016) on European Neolithic islandscapes, several authors explored the concept of cosmology in connection with insularity and monumentality (Lomsdalen 2018).

Kerns (2016: 39) argues that every cultural landscape creates some level of visual experience and spatial interrelationships imbedded in social and cosmological meaning. Van den Beld (2017: 13) maintains that cosmology implies more than a ritualized attitude to life and landscape, where it can be appreciated the way people or societies perceived their environment as symbolic appearance of basic values and cosmological ideas. According to Campion (2012b: 5) cosmology is not only a question of researching into the far universe, but '…recognizing that we are an integral part of it…' as much as our living surroundings, our habitat, our belief systems and the sky and stars. Sims (2009a: 4) states that 'Every culture has a 'cosmology'…', and proposes that it is a theory consolidating the sum of all undertakings in the known worlds. Mathews (1991: 3-4) claims that 'The domain of cosmology is the *actual* world…', but cosmologies may also include '…forces, fields, minds, spirits, even deities…' since they can transcendent an absolute world that may exist. Within Mathew's framework, cosmology and ontology may be an analogue description of a society's perceived or projected realistic and essential worldviews where meaning and matter are not separate elements (Barad 2007: 3, 353, David and Thomas 2008: 38, Holbraad and Perdersen 2017: 8, Viveiros de Castro 2015). On a more general archaeological affiliation, Renfrew (2007: 12) suggests that the topics of cult and religion are often associated with cosmology and a total worldview, which should also include the Sun, Moon, and celestial bodies.

Several scholars have explored the Maltese archaeological record in search of evidence of the belief system, worldview, or cosmology of the temple builders. Grima (2001: 56, 2005: 246-253, 2007: 40) suggests that the cosmological frame of temple ritual and activity was not simply expressed in the geographical context of the building itself, but also through the performative engagement with the iconographic representations of land and sea inside the temples, '…perhaps the two most inevitable components of an islander's cosmology'. Malone and Stoddart (2009: 376, 2011: 770) bring in a three-levelled cosmology, and as previously mentioned, the temples above ground are for the living, temples under the ground for the dead, and where the sky and celestial bodies are connected to the ancestors. Malone (2007) also brings in a cosmological combination of a dualistic layout and the hemispherical orientation of the temples, and further concludes that aspects of prehistoric cosmology, cult, ritual traditions, and religion may be reconstructed as long as archaeological evidence from a secure context is available. Tilley (2004: 135) connects the landscape context of prehistoric temples on Malta to cosmology through visible presence of movements and change from the outer to inner world.

1.3.2 Viewscape

Burcher (2005: 2) defines viewscape as a 'A *viewscape* is a visual connection that occurs between a person and the spatial arrangement of urban and landscape features', and consists of three elements, a view subject, a vantage point and visual corridor. Burcher further describes viewscape as the visible 3D-portion of a landscape seen from the eyes of the observer in a sense of reasoning, rational, and logical observations, like buildings of either side along the street frame a view as the observer's eyes automatically leads to the object at the end of the street. According to Kostof (2010: 3), the experience of architecture is meant to be a walking tour in a material theatre of human activity, bringing truth in its usage to the eyes that see, by being present in public places.

The word viewscape is mainly used in environmental and urban planning (Burcher 2005, Lothian 2005, Vukomanovica *et al.* 2018: 169), though some variations, affiliations, and a wider conceptualisation of the word can be found in GIS, landscape archaeology and anthropology (Fitzjohn 2007, Garcia-Moreno 2013, Gibson 1950, Ingold 2000). Llobera (2006) uses the word *visualscape* in GIS suggesting that the *visual weight* of each monument could be used to the rank monuments which could be checked against archaeological information, allowing some insight into the significance of the monuments and their social, political or symbolic role in the landscape. The visibility of temples play a symbolic role in the Maltese landscape, and based on the archaeological record, they could give us more and new informaltion about viewscape. On the other hand, in this study viewscape is not dedicated to temples only, but also to significance of other specific target objects. These are stars in the sky, celestial bodies or features on an apparent horizon, similar to Kostof's proposal, which constitute a form of 'truth' to the eyes that see an object.

Turnbull (2002: 132) uses the world viewscapes in association with soundscapes and taskscapes as integral to the Maltese prehistoric temples' setting. Though Turnbull does not define or contextualise the word viewscapes any further, his work invites further study of the relationships between the temples and their viewscape, which this thesis shall do. Though Burcher's observation of framing a view is based on urban architectural logistics, it nevertheless inspired this author to broaden this perception into a more phenomenological, anthropological, ideological, and cosmological sense of the word viewscape, researching relevant literature (Geertz 1983, Gibson 1986, Heidegger 1978, Ingold 2011, 2013, 2016, Jonas 1966, Merleau-Ponty 1962, 1964, Reed 1988, Thomas 1999, Tilley 1994, Wadell 1995).

1.4 Research framework

In order to explore the relationship between viewscape and cosmology in prehistoric Malta, five specific aspects of viewscapes will be researched. A key aspect that is important to any imposing structure is whether they *can be seen* from a wide region (visibility, see Chapter 2). Then moving to the sites where temples were built, one aspect of their viewscape is whether one would be able *to see* other temples from a given observer site (intervisibility, see Chapter 2). Another aspect is whether one would have an open or restricted view of the landscape and whether those correlate with any specific direction (vista, see Chapter 3). Looking upwards, one other aspect is whether, from the temple sites, one would see the Sun or the Moon rise or set above specific topographic features on the apparent horizon (horizon astronomy, see Chapter 3). And finally, moving inside the temple, it will be examined whether any potentially significant celestial objects could be seen rising or setting through the temple entrance frame (celestial alignment, see Chapter 4). Each of these subsidiary research questions is explored in detail in the chapters referenced above, using methodologies covering both landscape and skyscape archaeology.

The conceptual framework of the research is to bring new understanding to these mentioned areas by introducing original evidence-based results on Maltese prehistoric temples, while applying the concept of viewscape to bridge the gap between the empirical results obtained and their possible implications for prehistoric cosmology. This goal shall be attained by building on and expanding existing scholarly research, including published works by the present author. The intention is to develop new interpretations through the application of original methodologies, empirically testing previous theories against the evidence obtained in this study. This will form the basis for a discussion and conclusion where new data, knowledge, and insight on the Maltese Temple Period may be presented.

Another purpose behind this study is to bridge a research gap between archaeology and archaeoastronomy. Silva's (2014a: 24) statement that due to divergent epistemologies, 'The orientations of European prehistoric structures have been studied independently by landscape archaeologists and archaeoastronomers.' Nevertheless, this statement of Silva was an underlying additional motivational factor to conduct the present research, to contribute to a further epistemological integration of the two academic fields by exploiting the concept of *cosmology* as a common arena. This shall then be done based on the archaeological record, studying how prehistoric societies, and in this case the Maltese one, related their material culture and their affiliation with the sky.

This present author suggests that, to have a cosmology a society needs a material culture, and that this material culture is constructed around the society's worldview. In other words, culture and cosmology are two interdependent phenomena, where the one does not exist without the other. Campion (2010: 1) proposes that the *study of cosmology in culture* is how, 'human beings relate their cultures to their notions of the nature, order, function or meaning of the cosmos.' In order to examine the research question at hand, further consideration was given not only to what kind of organisational body stood behind temple constructions, but also the cultural and ideological structure of the prehistoric Maltese society.

In a personal correspondence between this author and Malville (2010), Malville proposed that the challenge we have today when studying prehistory is 'to see the cosmos through the eyes of a person living in prehistory'. In other words, not to let our modern mindset unduly influence our analysis of prehistoric society's lifestyle and ideological behaviour. Van den Beld (2017: 13) claims that, 'archaeologists can reconstruct past human behaviour and thoughts by looking at patterns in the material evidence of past activities.' What van den Beld here suggests is to reconstruct past human cosmological systems based on the archaeological record, which is a core methodology to this study. However, to give it legitimacy it is essential to substantiate every step of the investigation with replicable statistical calculations for each of the three research areas identified above. The archaeological record shall be the fundamental building block for all analyses, whether this stems from landscape archaeology, skyscape archaeology, archaeoastronomy, or astronomy.

The thesis shall proceed from a wider to a more focused investigation. Firstly, it looks at temple visibility and intervisibility in the wider landscape using Geographical Information Systems (GIS), then examines temple locations in relation to apparent horizon in a combination of landscape features and sky events, and finally narrows it down to which celestial bodies are observable through the entrance frame of a temple. A rigid methodology integrates the results of about 200 field visits (ref. Appendix 7.1) statistical applications and ground truthing of the obtained results from these three research paths, to gain new knowledge about Maltese Temple Period cosmology.

1.5 Usage of Maltese fonts

The rendering of Maltese toponyms and site names may vary considerably across different sources in the literature. Here the modern Maltese spelling and characters are used throughout the body text, except when directly quoting a source that uses a different spelling. In the maps, tables, and diagrams generated in software other than Word, which allows less facility for the use of special characters, no Maltese fonts are used.

1.6 Significance of research

The significance of the present research is threefold. Firstly, it will permit new insights into the worldviews of the extraordinary Temple Period culture that flourished on the remote archipelago of Malta during the Late Neolithic. Secondly, it will inform the wider debate on prehistoric cosmology and worldviews, and how these may be expressed and articulated in monumental appropriations of the landscape. Thirdly, the present research makes a significant methodological contribution by applying and merging a range of powerful digital tools that together allow an exploration of visual astronomical relationships in a landscape setting, moving from landscape archaeology to horizon astronomy, and on to skyscape archaeology.

1.7 Structure of thesis

In order to answer the main research question, concerning the title of this thesis, Viewscapes and Cosmology in the Prehistoric Temples of Malta, the research strategy that has been adopted was to consider three subsidiary questions in turn, within a common narrative relevant to the concept of cosmology. The research proceeds from a macroscale examination of the wider temple locations in the landscape, to the micro-scale examination of the orientations of temple doorways in relation to celestial bodies.

Chapter 2 addresses the question to what extent the prehistoric temples in Malta were located in the landscape in a way that allowed for visibility and intervisibility. To address this question, a rigorous methodology was established applying GIS which gives the possibility to research and analyse the visual interrelation between temple sites and the physical landscape that separate them, including the topographical formations of a site location within the landscape of the archipelago.

Chapter 3 examines whether the Maltese prehistoric builders were influenced by specific horizon features and visible sky objects on the apparent horizon when selecting the location for a temple site in the landscape. A distinct methodology was established, applying a 360° circumference 3D-rendering of the horizon of each of the 35 temples sites involved in the study.

Chapter 4 employs a methodology not hitherto recorded in the archaeoastronomical literature. The approach was based on previous related studies, but developed its own specific method of measuring alignments to celestial targets, through its entrance. This study is not concerned with temple locations as such, but intends to find results and answers to why the builders oriented their temples the way they did. It examines if temple orientations could be associated with archaeological chronology of temple phases, reflected in alignments to specific celestial bodies and how these may have shifted over time.

Each of the above three chapters may be considered on its own from introduction to conclusion. When considered collectively, the respective results of the three chapters allow further insight into the preferences of the temple builders, and their cosmological implications based on viewscapes. These strands are brought together in Chapter 5, General Discussion and Conclusion.

2 Were temple sites built on locations that allowed for intervisibility?

This chapter investigates the following research question:
Were Temple Sites built on locations that allowed for intervisibility?
The research methodology and the obtained results shall be fully discussed, and the chapter will conclude with a discussion of some possible implications.

2.1 Introduction

This chapter investigates to what extent the prehistoric temples in Malta were located in the landscape in a way that allowed for visibility and intervisibility. Geographical Information System (GIS) was applied since it provides the possibility to explore and analyse the visual interrelation between temple sites.

Since the 1980s, landscape archaeology has developed an increasing interest in the way cultural factors may influence spatial aspects (Darvill 2008b: 60). Since then, visibility, and intervisibility have become an important element in landscape archaeology, and particularly prehistoric monumentality, where GIS offers a formal methodology for analysing visibility through viewshed calculations (Chapman 2006: 83-90, Conolly and Lake 2006: 41-43, Wheatley and Gillings 2002: 202-205).

In a chronological and geographical context, GIS has frequently been applied for studying locations of historical monuments and visibility in their cultural landscape (Bongers *et al.* 2012, Čučković 2014, Fisher *et al.* 1997, Garcia-Moreno 2013, Llobera 2001, 2007, Ogburn 2006, Scianna and Villa 2011, Wheatley 1995, Zamora 2005). When it comes to Maltese prehistory with its unique and predominant megalithic monumental structure, the application of GIS is still in its infancy. This relative absence of applying GIS to Maltese archaeology opens up for a wide and interesting field for future research. When it comes to temple intervisibility and GIS, this study is the most comprehensive one to date. GIS can be a powerful tool for exploring new archaeological ideas, increases the possibility of data capture to improve statistical analysis and quantitatively authenticates both physical and cultural landscape formations (Wheatley and Gillings 2002).

A combination of these two mentioned approaches has been at the core of the methodology of this research program. It has fundamentally used GIS both as science and system not only to establish, but also to statistically quantify the intervisibility of Maltese temples' spatial structuring through viewshed analysis. This was complemented by first hand observations in the landscape.

When researching temple intervisibility, chronology is an essential element to consider. This study has primarily based temple chronology on the two main classical sources on typological considerations and stratigraphic evidences (Evans 1971, Trump 1966a). Updated chronological data from the *FRAGSUS Project* (McLaughlin *et al.* 2020a) has also been acknowledged.

Considerations of intervisibility as a possible influence on site location cannot be considered in isolation, but should be understood in tandem with other possible influencing factors, such as that temples are located in natural corridors between embarkation point shores and areas more suitable for agriculture, and in locations with easy access to natural agricultural resources and spring water (Grima 2002, 2005, 2008, Grima and Farrugia 2019, Grima *et al.* 2009).

2.2 Literature review

This section reviews some of the key literature on Geographical Information System (GIS) and its various applications and purposes in archaeology and especially spatial data in landscape archaeology, as well as the role of GIS and how it stands in the context of worldviews and cosmological perceptions.

2.2.1 GIS and landscape archaeology

Bender (1993: 2-3) proposes that landscape has to be contextualised as it is never passive, as people anywhere and everywhere, do rework, appreciate, or contest it reflecting historical conditions and the way people apprehend the world they lived in. As discussed elsewhere by the present author (Lomsdalen 2017: 122-123):

> However, it was not until the 1980s that landscape archaeology was widely cited in the archaeological literature, and its focus was mainly on human impact on the landscape. From then on landscape archaeology emerged in its own right, parallel with the post-processual evolution in archaeology, embedded in the idea that human activity, societies and culture have a spatial dimension [(Darvill 2008b: 60, David and Thomas 2008: 27)].

Bahn (1992: 364-365) proposes landscape archaeology as the distribution of materials across the landscape modified by humans. Chapman (2006: 11) describes landscape archaeology as the research and analysis of the interrelation between a site and the physical space that separates them, considering the landscape as distinct from the site itself.

According to Kvamme (2006: 4) the ‘First Age of Modelling’ in archaeology began in the United States in the early 1980s. However, it was from 1990 that GIS started to have a notable impact in archaeology through the study of spatial organisation, viewshed, and landscape analysis (Fisher 1999: 5, Gillings and Mattingly 1999: 1, Wheatley and Gillings 2002: 18). Due to its highly visual access to spatial information of both analysis and communication, it was rapidly accepted as an attractive tool in archaeology and landscape archaeology (Chapman 2006: 9, Gillings *et al.* 1999: 1-2). On the other hand, Wheatley and Gillings (2002: 1) claim that it was unfortunate that regardless of the growth and availability of GIS software at the turn of the millennium, archaeologists did not take advantage and use GIS knowledge and applications resulting in ‘at best, analysis that fails to live up to expectations and, at worst, flawed data-sets, poorly documented resources and misleading conclusions’. Chapman (2006: 39-40) claims that space at first glance seems very obvious as *landscape* by definition would imply space, however from the perspective of landscape archaeology the concept of space can be divided between practical and theoretical approaches. The practical path is mainly concerned with identification of archaeological sites, distribution maps and territorial sequencing, while the theoretical approach to space is concerned with cultural aspects of the way that landscape is inhabited, and the awareness that a cultural landscape exists besides a purely pragmatic one (Chapman 2006: 40).

GIS has been criticised as inadequate to examine social, political, perceptual, somatic, or phenomenological aspects rather than purely physical ones. It is questionable if the analytic power of a spatial data software can or will replace ‘the human witness of a landscape’, namely the personal experience of being in or a part of a landscape (Belcher *et al.* 1999: 100, Cummings 2008: 288, Thomas 1993, Tilley 1994: 14-17, Witcher 1999: 16-18). On the other hand, GIS increases the ability of data capture and improves a statistical and quantitative verification and precision of both physical and cultural landscapes (Conolly and Lake 2006, Rogerson 2001, Shennan 1997). Kerns (2016: 40) however, maintains that the spatial structure using viewshed limits the ability to examine the landscape as a part of an overall visual experience. According to Susmann (2020: 15), there is a wide gap between pixels and people, and a combination of digital geospatial analysis and phenomenology is needed for examining cultural landscape behaviour. Viewshed analysis in archaeology has expanded to include studies of how ancient cultures perceived their cultural landscape and the environment they lived in (Lake 2007).

The ecological psychologist Gibson (1986) introduced the term ‘*affordance*’. Llobera (1996: 614) applied the concept of *affordance* to GIS and archaeology describing it as the material evidences of a landscape observed from an individual at a location, though Llobera (1996: 612) emphasises that archaeological studies of human space in ancient societies also requires a firm empirical methodology. The underlying intention of adopting affordance and GIS is to apply GIScience framework to close the gap between theory and method by capturing and examining visual experiences, how an individual perceives and experiences surroundings, nevertheless taking all nuances into consideration (Gillings 1998, 2009). Quoting Gillings (2012), 'GIS-based research has a crucial role to play in experiential landscape research', however the gap between the practitioners and advocates of GIS and landscape theorists is still there, and therefore suggests that GIS should develop the concept of affordance as a *framing-device* in experimental landscape research. A more recent GIS study where affordance seems to be used as a framing-device is investigating affordance of walking and visual experience within the environment of a colonial town in highland Peru (Wernke *et al.* 2017). In a study of the architectural features of kiva towers of the Ancient Puebloan landscape in the US Southwest, Kantner and Hobgood (2016: 1305) investigate whether the kivas were built with the expectation of what could be seen from the towers, or, conversely, of who could see them in their landscape settings.

Visibility and landscape

According to Wheatley and Gillings (2002: 201), for most people the experience of a location or a special feature in the landscape can impact many senses, such as the sensation of cold or heat, smells, and sounds. For landscape archaeologists information and analysis of visuality, visibility and intervisibility of prehistoric monumentality have been an important study (Bongers *et al.* 2012, Čučković 2014, Fisher *et al.* 1997, Garcia-Moreno 2013, Llobera 2001, 2003, 2007, Llobera *et al.* 2004, Ogburn 2006, Wheatley 1995).

GIS and landscape archaeology in Malta

In Malta, Grima (2004, 2005, 2007, 2008) appears to be the first to use GIS and multivariate analysis in an attempt to understand the reasoning behind why the builders located their temples the way they did in the cultural landscape. Anderson and Stoddard (2007: 42) conducted a temple access analysis and applied GIS to generate a 'visibility map' of areas of high or low visibility inside the temple. Grima and Mallia (2011: 231) use GIS to compare terrestrial connectivity between two temple sites, Tas-Silġ and Borġ in-Nadur. Alberti *et al.* (2018) conducted a more contemporary GIS-based 'Logistic Regression' model on agricultural suitability in the nineteenth century. During the research of this thesis, Caruana and Stroud (2020) published a preliminary GIS-based study on how the Maltese monumental sites were organized in relation to views and vistas, though they also referred to the present author (Caruana and Stroud 2020: 448, 355).

Location and social organization of temples in Malta

Renfrew (1973: 170-172) proposed the idea of a regional hierarchical chiefdom society in Temple Period Malta, where the chiefs besides having an economic and social role, also could appear as a priesthood class being specialised in the ceremonies and rituals that took place on the island. In a later publication, Renfrew (2007: 12) distanced himself from this hierarchic model, though retaining that the temples of Malta were a designed place where rituals must have taken place, but which were not necessarily religious in nature. Cazzella and Recchia (2015) debate Renfrew's argument of the emergence of a chiefdom or elite class that built the Maltese megalithic temples despite lack of evidences in the archaeological record related to funerary sites, lack of structures, artefacts related to food distribution, and anthropomorphic figurines. A debate of socio-economic and hierarchal structure of the Temple Period Malta society is often related to ritualised temple practices (Anderson and Stoddart 2007, Bonanno 1986b, Grima 2007, 2008, Lomsdalen 2014a, 2014b, Malone and Stoddart 2009, 2013, Robb 2007, Skeates 2007, 2010, Stoddart *et al.* 1993, Trump 2002: 234-237).

2.2.2 GIS, viewscapes and cosmology

Whether or not landscape archaeologists wish to take a more holistic view of how past societies experienced the world, the use of GIS has allowed a broader understanding of landscape archaeology (Chapman 2006: 40). When it comes to a more holistic view of landscape archaeology and GIS, van den Beld (2017), from a study on Funnel Beaker Culture in Northern Europe, suggests that the selection of monumental locations and spatial relationship between different sites could be influenced by basic values of cosmological ideas and belief systems of past societies.

Fitzjohn (2007: 36), in a study in Sicily combining archaeology, anthropology, ethnography, and historical geography, claims that ‘Geographical Information Systems (GIS) are increasingly used to appreciate how past people experienced their world.’ Llobera (1996) combined archaeology and anthropology in a GIS study of Late Bronze Age Wessex, UK, suggesting that affordance was associated with the organization of power and dominance, and that spaces are no longer passive media, but active agents in the reproduction and transformation of social relations.

Vukomanovica *et al.* (2018: 169) in a GIS study of urban planning in Boulder, Colorado, USA, is referring to (Burcher, 2005) when describing ‘Viewscapes are the visible portions of a landscape that create a visual connection between a human observer and their 3-dimensional surroundings’. Viewscape is useful in comprehending how humans experience the visual enhancement of a landscapes, whereas in rural areas it inspires environmental developers where to locate habitats and constructions (Burcher 2005, Vukomanovica *et al.* 2018). Llobera (2003) introduces a similar concept, namely ‘*visualscapes*’, based on a practical perspective describing a visual configuration of structure, space, and property in the terrain, visualised by GIS. Llobera (2006) elaborates further on the concept of visualscapes by incorporating it with cumulative viewshed to test how likely it is that a pattern appears by pure chance.

According to Wheatley and Gillings (2002: 202), visual characteristics of one or more objects, or the intervisibility between them in the wider landscape, could be based on local natural geological features or connected to the wider universe, and if the object is not accidently placed, it could be related to a part of a society’s belief system, worldview or cosmology. Based on a GIS study on temporal and spatial distribution and intervisibility between monuments and settlements in the Orcadian Neolithic, Kern (2016: 49) concludes that cultural landscapes bring about a visual and structural involvement associating social memories and cosmological meanings through long-term historical development. Jelly (2016: 123) also employs GIS viewshed analysis to better understand patterning of placement, intervisibility and sea view of Neolithic megalithic sites and natural features in the landscape of Guernsey in the Channel Islands, and underlines the importance of considering these elements to elucidate past human considerations of landscape and belief.

When it comes to cosmological related topics and GIS in Malta, Grima (2007: 40) has considered ritual practise and cosmology within the frame of positioning the temples on different variables in the landscape and, ‘It is not a merely a series of images to be looked at, but a scenographic system that needs to be enacted’. Anderson and Stoddart (2007) do not use the word ‘cosmology’ as such, but with the help of GIS they examined the visible space inside various temples and suggested a practice of worship inside the temples. Further than that the integration of GIS and cosmology has remained largely unexplored in Maltese prehistoric studies. Turnbull (2002: 132) mentions ‘viewscapes’ in the context on Maltese megaliths in the landscape, but does not elaborate it any further apart from that he connects it with soundscapes and taskscapes.

2.3 Methodology

The research question examined in this chapter is whether temples were built on locations that allowed for intervisibility. To address the research question, the methodology is based on field survey and data collection, followed by post field data processing, by applying various tools of spatial analysis offered by Geographical Information Systems (GIS). By employing different scientific analytical tools and programs the results shall be examined and discussed based on both quantitative and qualitative methods.

The method is based on two different GIS platforms: ArcMap 10.8 (Esri 2020) and QGIS 3.14 (GRASS 2020), each of which offered specific tools (also called plug-ins or extensions) that were suited for the different analytical requirements of this study. For general GIS usage and analysis, ArcGIS with the tool ArcMap was primary applied (Kennedy 2013, Zhu 2016). QGIS was used for more specific tool functions which are not provided by ArcMap, and QGIS shall be referred to whenever directly applied (Graser 2013).

As stated by Burrough and McDonnel (1998a: 19) ‘Geographical phenomena require two descriptors to represent the real world; what is present, and where it is’. This has been an inspirational source for the present methodology, applying GIS both as system and science. Susmann’s (2020: 15) suggests that a consolidation between digital geospatial analysis and phenomenology offers a reflexive methodology for examining a cultural landscape. In addition, the results obtained from GIS whenever physically possible were verified by personal presence on sites.

2.3.1 Field survey and data collection

The purpose for field survey and data collection was to register geographical coordinates of locations of all temple sites that potentially could be used for data capture to GIS. To obtain data, two types of methodologies were applied. One consisted of field surveying all sites where a geographical site location could be established. The other was to use site location coordinates from the archaeological record (Cilia 2004, Evans 1971, Grima 2005). The temple sites involved in this study are shown in Figure 2.1, and an Excel spreadsheet with all the geographical temple coordinates is listed in Appendix 7.3.

The question of which sites to include and which to omit from the analysis is a thorny one, and has been approached in different ways. For example, Grima (2005: Appendix 2) focussed his analysis on 28 megalithic sites which may be considered with a high level of confidence to represent examples of the architectural form referred as a ‘temple’ in the literature. Grima (2005: Appendix 7) separately listed 12 other sites where megaliths have been recorded, but the site typology is less clear, and did not include these sites in the principal analysis. In the present work, a slightly more inclusive approach has been taken. In addition to the 28 sites listed by Grima, one newly discovered temple site (Triq ix-Xabbata) has been included, and six others of the less clearly identified megalithic sites. While this admittedly introduces a further element of uncertainty in the results, it has allowed a more thorough exploration of possible visual relationships between these sites. It should also be noted that the inclusion of these less clearly identified sites does not change any of the results obtained for the better documented sites, and does not impact the overall patterns and results obtained.

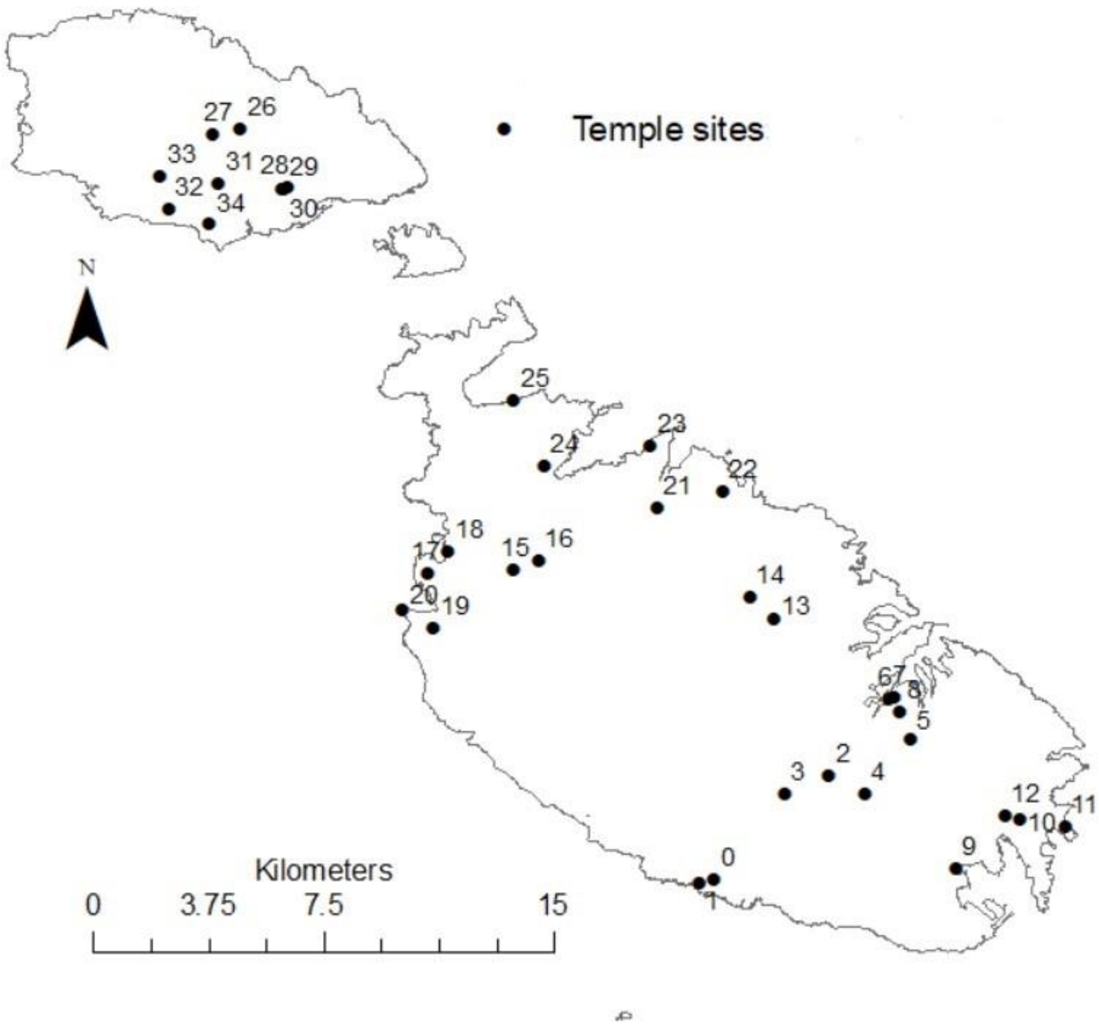


Figure 2.1. Temple site locations.
The 35 Maltese prehistoric temple sites locations are listed in numeric order from 0 to 34:
0. Ħaġar Qim, 1. Mnajdra, 2. It-Tumbata, 3. Id-Debdieba, 4. Ħal Resqun, 5. Tarxien, 6. Kordin I, 7. Kordin II, 8. Kordin III, 9. Borġ in-Nadur, 10. Tas-Silġ, 11. Xrobb l-Għaġin, 12. Ħal Ġinwi, 13. Tar-Raddiena, 14. L-Iklin, 15. Ta' Ħaġrat, 16. Skorba, 17. Ras il-Pellegrin, 18. Tal-Lippija, 19. Kunċizzjoni, 20. Ras ir-Raħeb, 21. Tal-Qadi, 22. Ta' Ħammut, 23. Buġibba, 24. Xemxija, 25. Għajn Żejtuna, 26. Ġgantija, 27. Santa Verna, 28. Borġ Għarib South, 29. Borġ Għarib North, 30. L-Imrejsbiet, 31. Xewkija, 32. Triq ix-Xabbata, 33. Ta' Marżiena, 34. Borġ L-Imramma.

Geographical coordinates (latitude and longitude) of a temple location were recorded in the field using a hand-held Global Positioning System (GPS) Garmin eTrex 30 (2012). The data from this device was verified against orthophotos from the Maltese Planning Authority (2016) and a ground-truthing verification method was applied to this study (see Table 3.1 page 186). To establish a consistent ground position inside the temple where to take the GPS reading was challenging, as early excavations were not carried out with the same precise methodology as applied in today's archaeological standards (Evans 1971: 34, Grima 2008: 35). Besides that, several axes under consideration are not perfectly linear. Successive doorways along an axis were not always precisely aligned on the same plane of direction.

One objective of this research was to have a first hand GPS reading of the geographic location of each site. Whenever possible, the GPS reading was taken at the back-apse. The reasoning behind this decision was that the main structure of a temple was originally built along this axis, starting from the back (Bonanno 1999b: 105-106, Torpiano 2004: 360, Trump 1981b: 129-130). When the back-apse could not be established, the GPS reading was taken next to the remains of the prehistoric megalithic temple structures.

To register the locations of temple sites that were no longer preserved (ref. Appendix 7.2) the site locations were copied from archaeological records which used a projected coordinate system of Universal Transverse Mercator (UTM) 1950 Zone 33N (Cilia 2004: 442, Grima 2005: 266-276). An initial informational source for metric data was Evans (1971: 229-234) who lists six digitals, whereas this study applies the modern 10 digital UTM metric system. UTM metric data was converted into geographic coordinates to identify the site location by its latitude and longitude (*x,y*) where the World Geodetic System of 1984 (WGS84) was applied (Kennedy 2013: 12-18, Longley *et al.* 2011: 132-142), to be consistent with and comparable to the field survey data (Heywood *et al.* 2006: 63-64). For the part of transforming the metric projection into geodetic coordinates, open source tools were used (MyGeodata Cloud 2020, TWCC 2020).

2.3.2 Spatial Data Models and Applications

For the more general ArcMap spatial data applications such as modelling, data input, data manipulation, and applications, this study has followed Kennedy (2013) and Zhu (2016). For GIS applications related to archaeology and specialised landscape archaeology, the methodology used here was informed by the relevant archaeological literature (Chapman 2006, Conolly and Lake 2006, Llobera 2007, Wheatley and Gillings 2002).

The methodology is based on two spatial data models, *vector* and *raster*.

Vector data model

Vector data model stores spatial data in a mathematical term and refers to an objective view of a geographical space in the real world. It is represented by feature classes with geometrical types as points, lines, or polygons (Conolly and Lake 2006: 25, de Smith *et al.* 2007: 20, Heywood *et al.* 2006: 81-83, Kennedy 2013: 234, Wheatley and Gillings 2002: 33, Zhu 2016: 59).

Raster data model

Raster data model allows to store information about a given variable for a geographical area by dividing it into grid of cells (pixels), each one storing a numeric value eg the elevation of the terrain. The smaller the cells the larger the information they provide to the entire model (Kennedy 2013: 232, Longley *et al.* 2011: 67, Zhu 2016: 96-100). In landscape archaeology, raster dataset called *Digital Elevation Model* (DEM) are routinely used given the relevance of altitudinal information to any GIS-based landscape analysis (Conolly and Lake 2006: 27-28, Kennedy 2013: 101, Longley *et al.* 2011: 241-242). A variation of the DEM is a *Digital Terrain Model* (DTM), which is a digital representation of the elevation of bare earth surface, excluding vegetation and man-made buildings (de Smith *et al.* 2007: 16).

This study applied a 5 m DTM which has been derived by Dr Gianmarco Alberti, University of Malta, from LIDAR data made available through an agreement signed between the University of Malta and the Malta Environment and Planning Authority in 2013 (ERDF LIDAR data, 2012, ERDF156 Developing National Environmental Monitoring Infrastructure and Capacity, Malta Environment and Planning Authority). The same DTM format has also been used in other Maltese GIS publications (Alberti *et al.* 2020, Alberti *et al.* 2018).

Data capture

The site locations were listed in a Microsoft Excel spreadsheet as pairs of *x* and *y* coordinates (ref. Appendix 7.3). The list was imported into ArcMap in order to create a GIS vector point layer (*shapefile* format) based on the WGS 1984 coordinate system. Before any subsequent data analysis, the layer has been re-projected to ED1950 UTM33N to match the coordinate system used for by the DTM representing the Maltese Islands (Longley *et al.* 2011: 132-139, Zhu 2016: 43-55).

The latter dataset is the raster data model for the terrain elevation of the Maltese Islands, featuring a resolution of 5 m (i.e., each raster cell is 25 m^2 in area). To put this cell size into the perspective of the Maltese terrain of 316 km^2 (Gauci and Schembri 2019: 1) or 316.000.000 m^2, this implies that Malta was divided into 12.640.000 cells for the purpose of the present GIS calculations. In an earlier explorative stage of the present research, a 1m DTM has also been tested. It was not eventually used because it proved too computationally demanding, exceeding the computer capacity applied for this study.

Analysis and modelling

According to Schuurman (2004: 88) GIS is a valuable tool for geodatabase management and displaying maps, but the real power of GIS is when it comes to analysing spatial data relationships. Spatial analysis is a means to transform geographical data into useful information (Longley *et al.* 2015: 290). Relating to this methodology, analysing and modelling is an intermediate step to combine GISystem as a data management tool to bring it to a level of GIScience, and relevant literature has been a source of information (Conolly and Lake 2006: 6-7, Longley *et al.* 2015: 11, Zhu 2016: 4). This consists of analysing various inferential statistical significances of the original geodatabase grounded on consistent theoretical proposals to try to answer this chapter's research question.

An intermediate step in the methodology is to examine possible intervisibility between temple sites, as further elaborated in the following section 2.3.3. This is to apply the GIS systems of spatial analysis and modelling to investigate and explore any pattern of geographical formations. This work is based on the relevant GIS literature (Graser 2013: Ch. 4, Kennedy 2013: Ch. 8, Longley *et al.* 2015: Ch. 13, Zhu 2016: Ch. 8), as well as the more specialised archaeological literature on landscape and visibility (Chapman 2006: Ch. 6, Conolly and Lake 2006: Ch. 8, Wheatley and Gillings 2002: Ch. 10).

2.3.3 Visibility and intervisibility

This and the following subsections explain the two core methods used to answer the research question of this chapter. The first one is *Temple Visibility and Landscape* and the other is *Temples and Intervisibility*.

For this part two GIS methods were used. One was a cumulative viewshed (CVS) and the other a total viewshed (TVS). The purpose was not only to investigate to what extent there may be intervisibility between the temples, but also if temples were positioned *to see* other temples or positioned *to be seen* from other temple sites and in the general landscape, applying advanced visibility analysis.

To better inform an overall understanding of temple positioning in the topographical landscape, an additional study, *Temples and Topography*, was conducted to examine temple locations related to elevation, slope, and aspect. This is presented first, to give a more general background perspective to temple positioning in the landscape.

Visibility and intervisibility have long been an important element in archaeology with a particular attention to prehistoric monumentality, and ArcMap offers a formal methodology for analysing visibility through viewshed calculations generated by data layers from raster modelling (Chapman 2006: 83-90, Wheatley and Gillings 2002: 202-205). According to Conolly and Lake (2006: 228), given the perfect data, GIS provides an important computational ability to calculate theoretical intervisibility accurately. The question of visibility from a given observation point is based on classifying the DEM/DTM into a binary raster model with cell values of either 1 = visible, or 0 = not visible (Kennedy 2013: 351, Zhu 2016: 163-164).

Human visual acuity

A fundamental consideration in any study of visibility is that of visual acuity, i.e. what apparent size of an object can actually be discerned by the naked eye taking the distance into consideration. A considerable amount of literature on vision science examines how the retinal image is encoded by visual pathways (Higuchi 1983, Miller and Burns 2004: Ch. 4, Miller and Magnante 2004: Ch. 9, Wadell 1995, Yanoff and Duker 2004). According to Wandell (1995: 3) ‘perception is an interpretation, not a description’. The human eye is not capable to make assumptions from a retinal vison, only inferences as to colour, motion, and shape of objects. What is paramount for this project is to take into consideration potential human visual acuity under optimal atmospheric condition in the context of viewshed analysis, and also to consider the relation between the target object’s size, distance from the observer, and the limits of human visual acuity, when evaluating what is visible or not from a given location. To calculate human visual acuity the ‘vislim’ function out of the GmAMisc R package has been used (R Core Team 2019) by Alberti (2020). The function calculates apparent angular size of an object by taking into account the visible size of the target and the distance between observer and the target.

Figure 2.2 shows an example of the distance an observer can theoretically see an object target taking human visual acuity into account. The vertical line (y-axis) is the angular size of a target object (temple heights) and the horizontal line (X-axis) is the distance the object can be seen from the observer point with a decrease in distance (Alberti 2020). The horizontal dotted line is the limit of visualization and the black dot indicates the visible limit. The top left illustration shows the visual distance for 3 m high target with a visible distance just about 10 km, the top right for 5 m target and about 17 km, the bottom left 6 m target and distance about 20 km, and the bottom right a 7.5 m object and a distance of about 25.8 km.

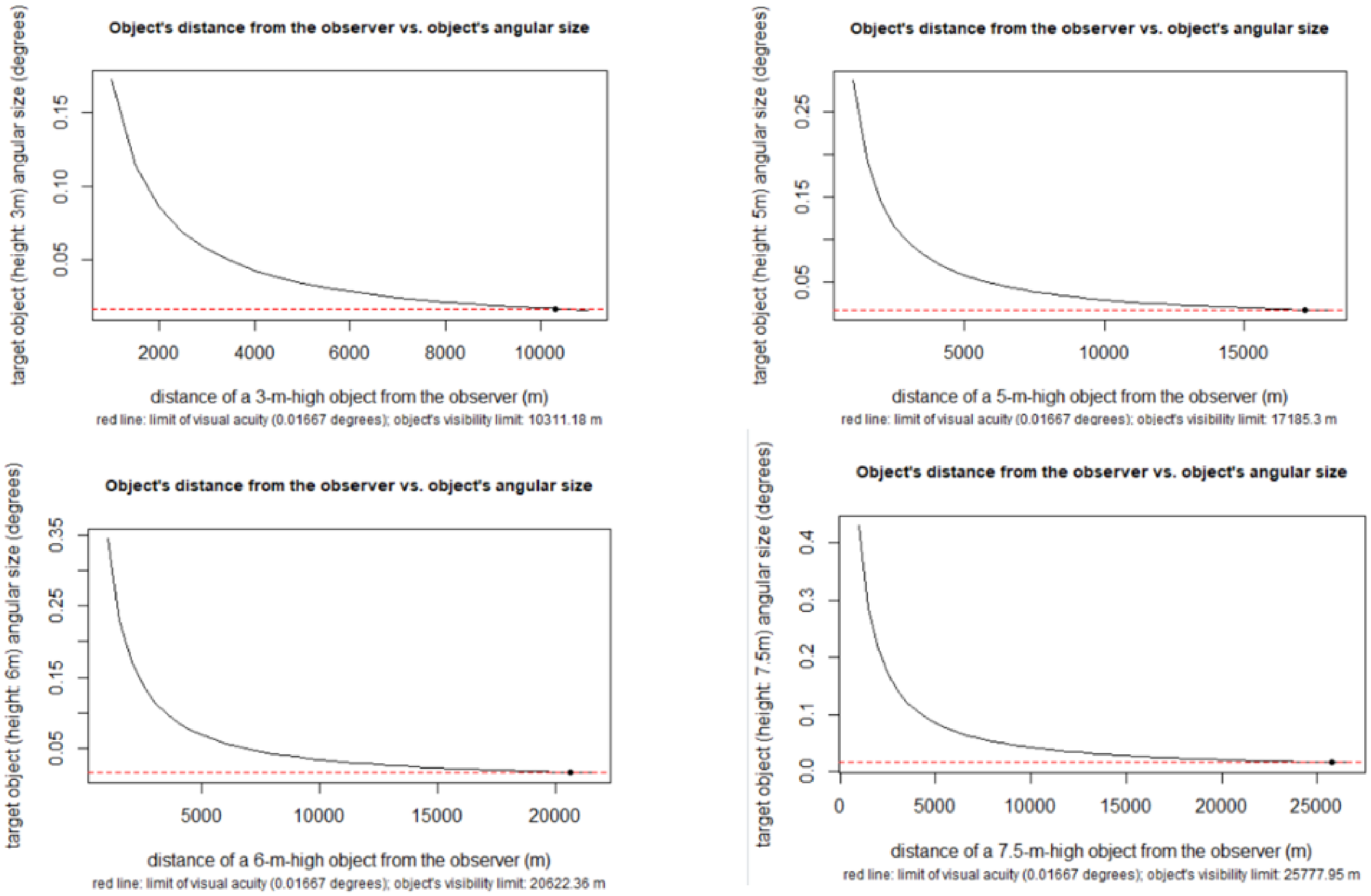
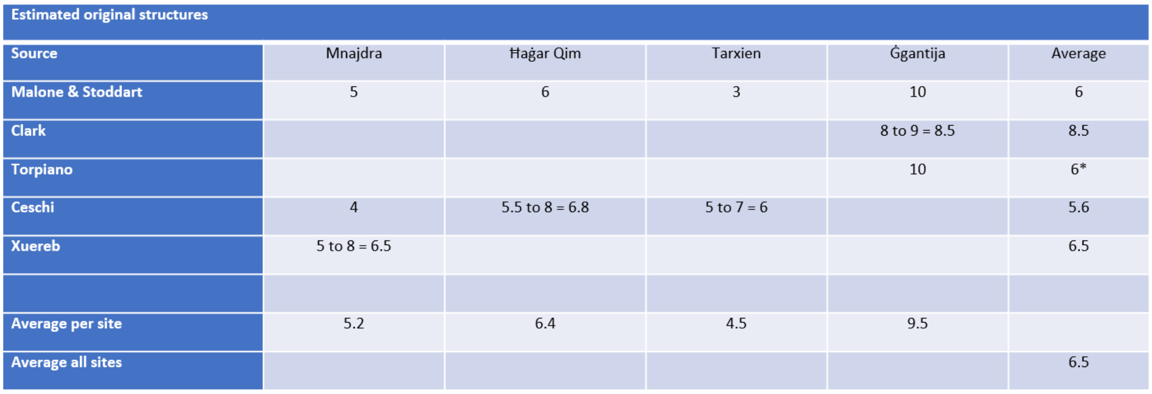


Figure 2.2. Target objects and angular size.
The figure shows the decay of the angular size of the target heights high of an object in function of the distance from the observer.

Temple heights

To answer the research question of intervisibility between prehistoric temples, a vexing question is that of the original heights of these buildings. The present study has considered the contributions by various scholars on this subject, to arrive at some tenable assumptions (see Table 2.1).



Estimated original structures

Source	Mnajdra	Ħaġar Qim	Tarxien	Ġgantija	Average
Malone & Stoddart	5	6	3	10	6
Clark				8 to 9 = 8.5	8.5
Torpiano				10	6*
Ceschi	4	5.5 to 8 = 6.8	5 to 7 = 6		5.6
Xuereb	5 to 8 = 6.5				6.5
Average per site	5.2	6.4	4.5	9.5	
Average all sites					6.5

Measured remaining structures

Source	Mnajdra	Ħaġar Qim	Tarxien	Ta' Ħaġrat	Skorba	Ġgantija	Average
Evans	4.3	5.2	3	4		7.5	4.8
Trump					3.9		3.9
Average all sites							4.4

Table 2.1. Temple heights in meters.
The top table shows the temple height estimates by various scholars (Ceschi 1939: 57-58, Clark 2004: 370, Evans 1971: 96, 87, 30, 133, 179, Malone and Stoddart 2011: 7, Torpiano 2004: 354-356, Trump 1966a: 5, Xuereb 1999: 146-151). The asterisk (*) in Torpiano's average column represents his estimate of a general temple height of 6 m. The bottom table shows factual field survey measurements of the surviving height of various temple ruins by Evans (1971) and Trump (1966a).

The studies cited above suggest that a height of around 6.5 m is a plausible average, albeit based on limited evidence. The initial viewshed analysis was conducted in ArcMap, which has the limitation that its results only indicate if a target is theoretically visible or not, without taking into account whether enough of the target is theoretically visible for it to be actually visible in practice. In order to allow for the limitations of visual acuity, a conservative arbitrary decision was taken to use a height of 3 m, meaning that for a 6 m target to be detected as visible, at least 3 m of it needed to be visible. A second iteration of the analysis was conducted in QGIS because this software allows the calculation of the visible or non-visible portion of a target of any given height. This shall be further explained in the following subsections.

2.3.4 Visibility and GIS

Visibility analysis determines what is visible or not from one or more locations, taking into account the shape of intervening terrain surfaces (Zhu 2016: 306). Chapman (2006: 83-87) notes that visual analysis with a DTM which is preferentially applied in landscape archaeology, can be used in two ways. One is the application of line-of-sight (LoS), a binary calculation of whether two points are mutual intervisible, while the other is that a directional or non-directional viewshed is calculated from a given point. The present study has examined two levels of monument visibility and intervisibility, following De Floriani and Magillo (2003: 709). Firstly, it has investigated which geographical areas have a maximum number of single viewsheds where temple sites have a common interconnecting viewshed, and secondly, which temple sites are visibly and/or intervisibly connected. According to Fisher (1993: 333) ‘Unlike some other GIS functions the viewshed is not actually verifiable in the field nor can it be logically validated’. This notwithstanding, whenever physically possible, this research has tried to ground truth results through firsthand field observation, and secondly by to complement the GIS-based viewshed work. The visibility analysis is based on methodologies described down below.

Line-of-sight (LoS)

Line-of-sight analysis is used to map visible areas (Petrasova *et al.* 2015: 78). A line-of-sight does not automatically involve reciprocity of visibility, i.e. intervisibility, between two points. The topography of the terrain could block the line-of-sight from one vantage point to the other, based on differences in altitude of the observer and the target point, as illustrated in Figure 2.3. The figure illustrates the disparity between the observer and the target point represented by the view point and target point *X*. As the topography of the terrain blocks the view of the target for the observer on the left, visibility of the two targets is not reciprocal. The larger the offset (height) disparity between the observer and the target, the larger is the possibility of non-reciprocity (Conolly and Lake 2006: 228-230, Wheatley and Gillings 2002: 210-211, Zhu 2016: 308-308).

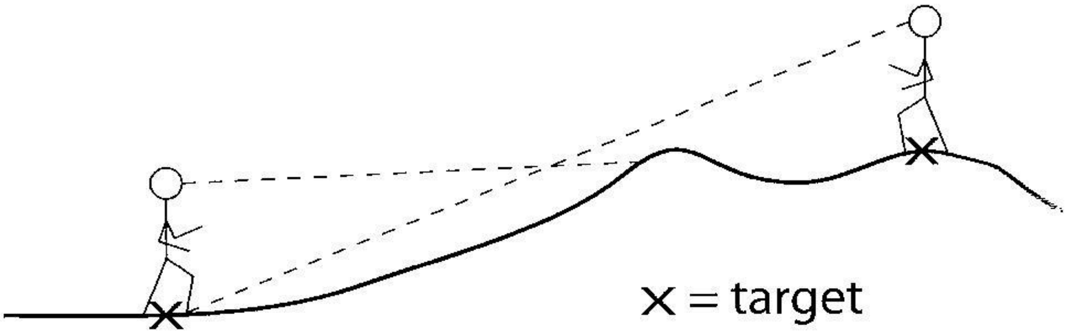


Figure 2.3. Line-of-sight, after Conolly and Lake (2006: 230, Fig. 10.17).
The LoS connects two points in the terrain resolving if a predetermined target is visible from a given observer point.

Viewshed analysis (VSA)

A viewshed analysis is basically constructed and expanded from a line-of-sight analysis, as a viewshed covers every line-of-sight to every possible target point within a given geographical area (Zhu 2016: 306-309). According to Conolly and Lake (2006: 226) the elementary result from a VSA is a binary map indicating which target cells are visible or not visible from a given observation point. A viewshed is a binary model where target cells in a raster are defined as either as visible or non-visible from a given vantage point (Chapman 2006: 105, Conolly and Lake 2006: 226, Lake *et al.* 1998: 27, Wheatley and Gillings 2002: 204). The visible area from a given observation point *is* the viewshed, and through the viewshed it is possible to analyse if a target is visible from the selected point of observation Zhu (2016: 307). A VSA is generated by an algorithm estimation of the raster data model elevation of the intermediate pixels in a DEM/DTM between observer and target points (De Floriani and Magillo 2003, Fisher 1993, Kim *et al.* 2004, Zhu 2016).

The methodological procedure to calculate the viewshed was to import the first thematic layer of a DTM5m of Malta into ArcMap. The second thematic layer to be imported was the geodatabase file of all 35 temple sites transformed into an ED1950 vector feature class which establish the vantage points in the VSA. The observer height of a prehistoric person was given an offset (OFFSETA) of 1.60 m. This observer height is based on retrieved remains of a prehistoric Maltese person estimating the stature of an adult person to be from 1.52 m to 1.8 m (Stoddart *et al.* 2009: 325), which gives a calculated average of 1.66 m. Taking the difference in height between eye level and the full height of a person, which is about 10 cm, observer height has been adjusted and rounded to 1.6 m for the purposes of the present research program.

The temple height was set to 3 m using the ArcMap option OFFSETB, as previously explained. A third option in ArcMap is the radius of the terrain to be covered by the VSA. As previously explained, for this study the radius is based on the calculations of human acuity of a visible temple height of at least 3 m, and consequently option RADIUS2 was set to 10 km. ArcMap further offers a standard option to use corrections of curvature of the earth and refraction, both of which were utilised.

Cumulative viewshed (CVS)

Wheatley (1995: 173), who launched the term *cumulative viewshed*, describes it as the sum of two or more individual viewsheds using map algebra technology to construct one single viewshed map. The CVS is an overlay of the single viewsheds of two or more given locations creating integer cell values ranging from zero to maximum number of viewpoints, and lists the number of viewpoints that are visible in the CVS (Conolly and Lake 2006: 227-228).

CVS has been used, following literature (Chapman 2006: 135, Gillings 2009: 340, Wheatley 1995, Wright *et al.* 2014), to address two (partially intertwined) questions. Firstly, to empirically assess which part of the Maltese landscape is visible from more observer points (i.e. temple sites). Secondly, to identify areas that overlap within the view from a given temple site to establish how many temple sites are visually connected. CVS entails first calculating individual binary viewsheds from each temple site in turn, and then adding them up through ArcMap's Raster Calculator tool. In the cumulative viewshed raster, overlapping visible cells will store a value ranging from one to the number of sites from which the location represented by the cells proves visible. According to Wheatley and Gillings (2002: 209) CVS analysis are prone to edge effect errors underestimating the borderlines of the viewshed. Based on this mentioned potential problem of viewshed borderline and edge effects, this study intends to examine if the obtained results would indicate that this could be an issue for temple intervisibility. If so, a more focused investigation shall be conducted applying a more detailed study of human acuity based on target distances.

2.3.5 Temples and topography

The main objective to this section is to study if temples are built on locations which favoured intervisibility. Nevertheless, to give a broader picture of the distribution of temple site locations within the wider landscape, this section shall employ GIS modelling to investigate temple locations within the topographic characteristics of the landscape, such as elevation, slope, and aspect. Elements like why the builders chose these locations based on affordance and affiliation to the surrounding region as portrayed in a Site Catchment Analysis (Chisholm 1968) shall not be considered; neither is analysis like least cost paths (Alberti 2019), sources of building material, availability of fresh water, vegetation and agricultural land, or dwelling sites a part of this methodology (Bonanno 2017, Grima 2002, 2005, 2008, 2016b, Grima and Farrugia 2019, Grima and Vassallo 2008). The aim of this part of the study is not a detailed and generic investigation into temple sites and locations in the topographic cultural landscape, but it is more to give a general background of the temples' landscape settings, to set the stage for a more detailed GIS analysis of temple visibility and intervisibility.

Using GIS to investigate where and how prehistoric temple sites are located in the Maltese landscape has mainly been inspired and motivated by studies of Grima (2004, 2005) and Alberti *et al.* (2018). For GIS modelling of elevation, slope, and aspect of the Maltese landscape, other archaeological relevant sources have also been used (Chapman 2006: 103-111, Conolly and Lake 2006: :187-197, Wheatley and Gillings 2002: 12-124). The use of ArcMap applications of modelling terrain attributes has been informed by Zhu (2016: 282-294). Attending a study unit (ARC5016: GIS for Archaeologists) 2020 lectured by Dr Gianmarco Alberti, University of Malta, has also been a valuable resource. For elevation, slope, and aspect, the curvature layers were obtained from the DTM5m by using the appropriate ArcMap tools for Spatial Analysis. For inferential statistical analysis from the obtained GIS models, the R Core (2019), further adapted for GIS implementation by Alberti (2015) with the application GaAMisc version 1.1.0 was used (Alberti 2020).

The Maltese archipelago

Malta consists of two main islands, Malta and Gozo, and several islets. According to the archaeological record only the islands of Malta and Gozo have prehistoric temple remains (Evans 1971, Trump 2010). The archipelago covers an area of 316 km^2 with a maximum height of little over 250 m in Malta and about 190 m (ta' Dbiegi) in Gozo, and contrary to the country's relative small size, it has a great variation of relief and landforms (Gauci and Scerri 2019). According to Gauci and Scerri (2019: 49) 'The landscapes of the Maltese Islands owe much of their distinctive nature to their gentle dip to the NE.' Though Gozo is only about one third the size of the main island, the territory is more diversified than Malta, and as Gauci and Scerri (2019: 57-58) suggest 'is characterised by a gentle regional dip to the north…', with '…vertical cliffs over 120 m high along the south-west coast falling to just over 20 m above sea level on the northern coast.' Further to Gauci and Scerri (2019: 57-58), drainage is mainly north-east in Malta, while in Gozo rather wide waterways drain to the north, south, and west.

Modelling elevation, slope and aspect

Applying ArcMap for modelling the elevation, slope and aspect is fairly straight-forward (Wheatley and Gillings 2002: 120, Zhu 2016: 286). After having imported 35 temple sites and DTM5m, ArcMap provides standardised tools for calculating and modelling each and one of these categories. Zhu (2016: 293) shows a practical step-by-step example how to build slope and aspect in ArcMap.

Elevation

As Zhu (2016: 286) explains obtaining elevations value (altitude above sea level) of certain locations is based on a digital terrain model and as in this case, the DTM5m of Malta represents elevation data (see Figure 2.4).

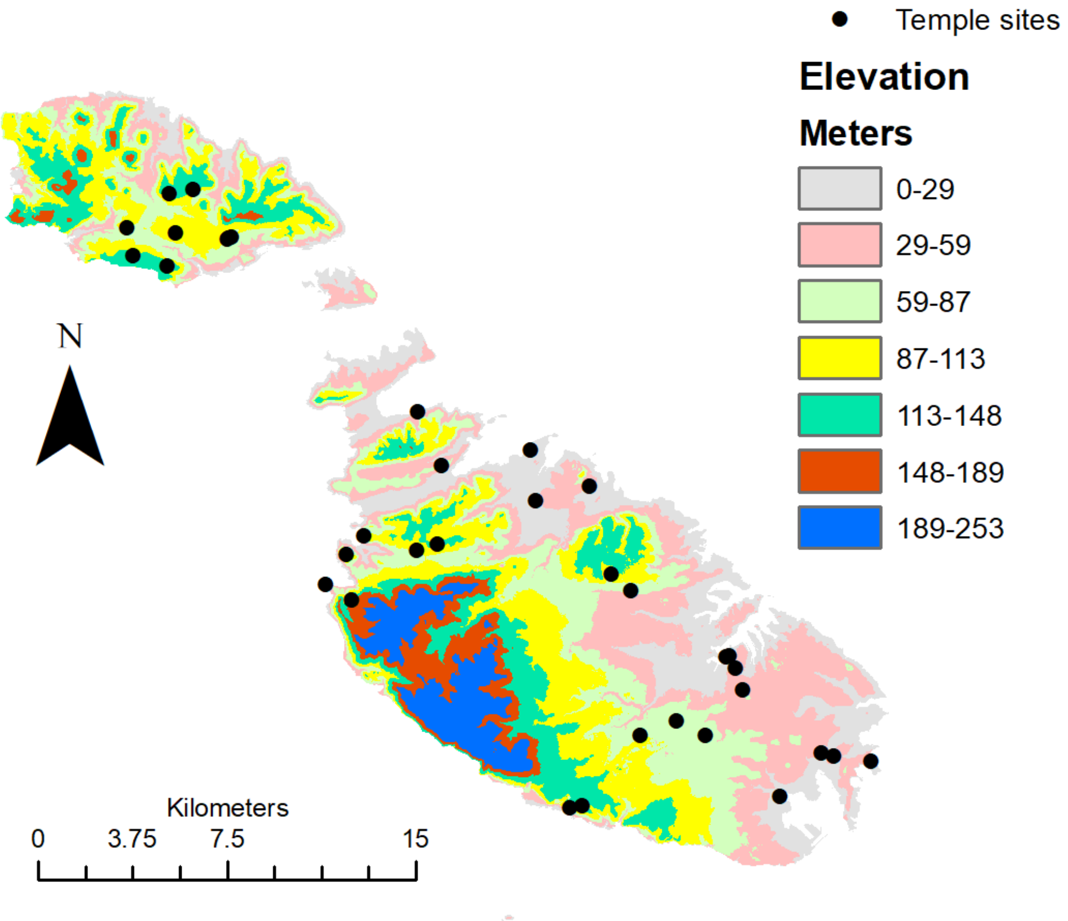


Figure 2.4. Malta elevation map.
Temple locations are represented by a black dot. The variation of the elevation of the landscape is illustrated by the colour scale in metres.

Slope

A slope indicates the angle of terrain by measuring the rate of change of elevation of a location. For this study the slope shall be calculated in terms of degrees based on DTM5m's cell value from 0 and 90°, (Chapman 2006: 105, Wheatley and Gillings 2002: 120, Zhu 2016: 286-289). The slope in degrees of the Archipelago landscape is presented in Figure 2.5.

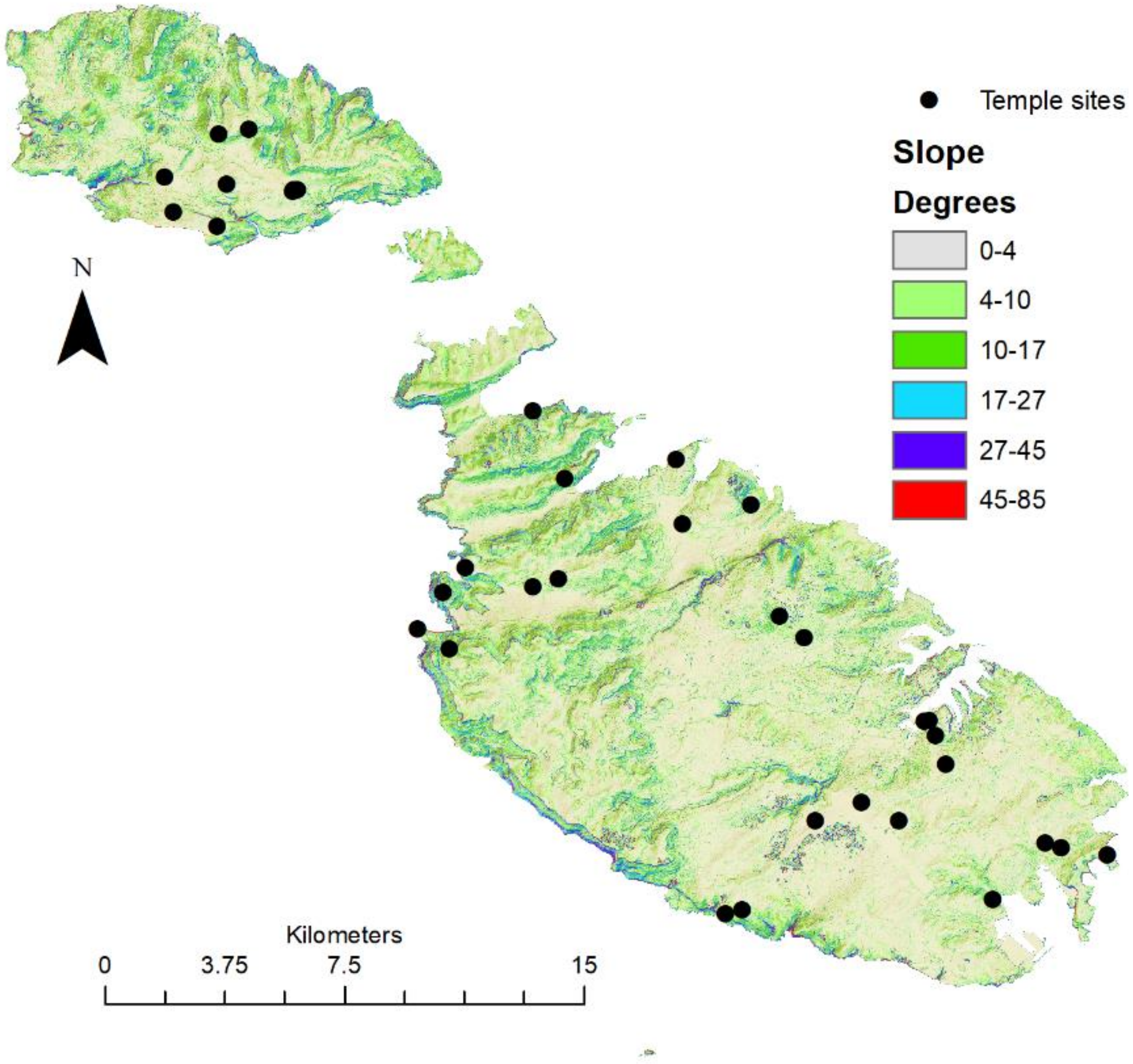


Figure 2.5. Malta slope map.
The temple locations are indicated with the black dot. Further, the legend is listed by a colour scheme representing the slope of the landscape in degrees.

Aspect

As slope is the rate of change in elevation of a given location, the aspect is the compass bearing (azimuth) of the downhill direction (Chapman 2006: 105, Conolly and Lake 2006: 190-191). Figure 2.6 illustrates the aspect of temple locations.

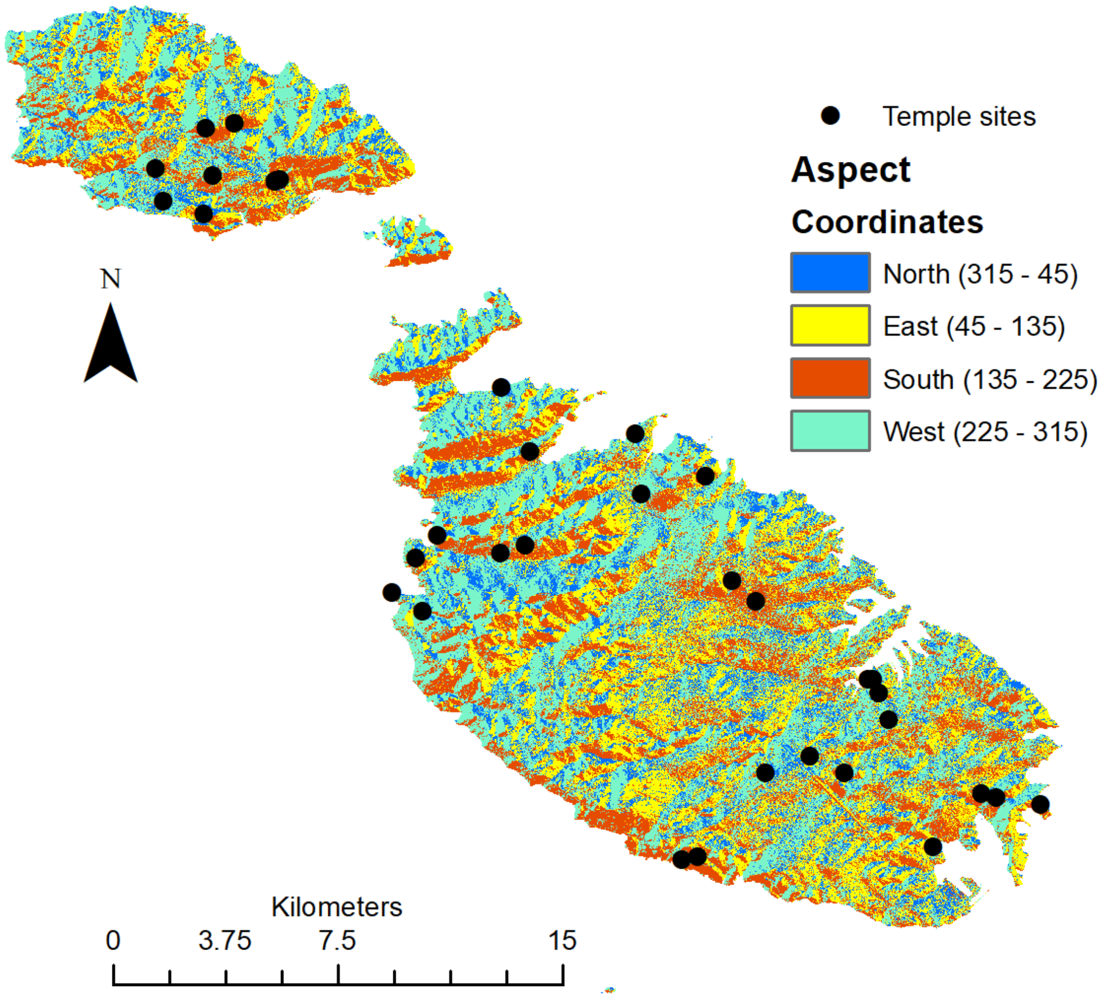


Figure 2.6. Malta aspect map.
The figure shows the aspect (simplified to the four cardinal directions) of temple locations.

2.3.6 Temple visibility and landscape.

The methodology of this section is based on two components, but these are different in approaching the investigation of temple visibility in the landscape. The first one is based on a cumulative viewshed (CVS) which examines temple sites and maximum intervisibility in the landscape. The other uses a total viewshed (TVS) as a means to explore whether the temples prove to be positioned in more inherently visible locations in the Maltese landscape. In order to try to bring credibility to temple positioning in a landscape setting, statistical analysis shall be applied inferring to what extent temples are randomly located.

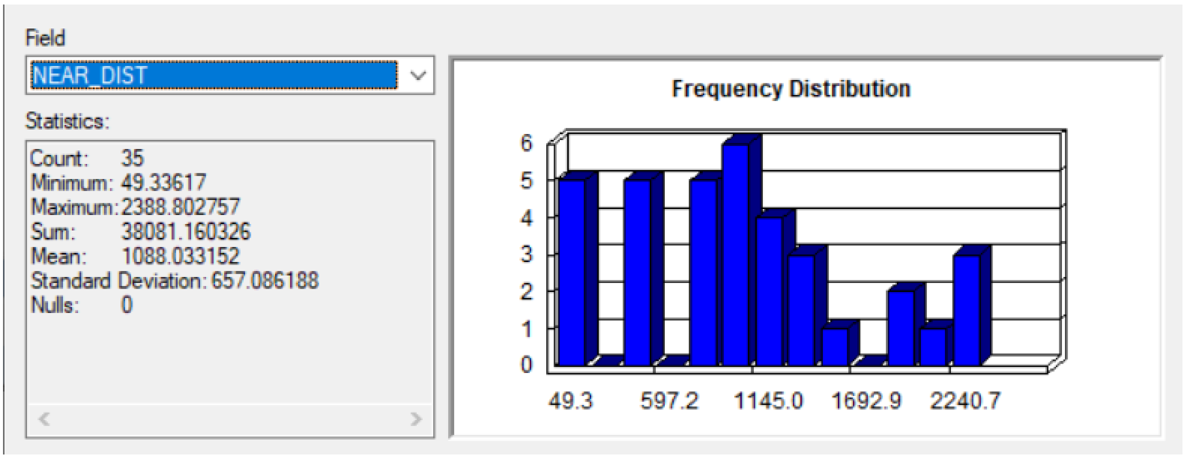
In addition, matrix excel spreadsheets shall also be compiled to establish which temple sites do have or do not have a visual interconnection.

Cumulative viewshed (CVS) and random locations

Conolly and Lake (2006: 226) define *intervisibility* as a GIS visibility analysis deciding whether any given par of cells (points) are intervisible. This section confronts if temple sites were likely to have been located in places that maximise intervisibility, using the relevant literature (Chapman 2006: 135-138, Conolly and Lake 2006: 225-233, Garcia-Moreno 2013, Kantner and Hobgood 2016, Lake 2007, Wheatley and Gillings 2002: 201-216).

A CVS of the 35 temple sites on the Maltese archipelago was generated from DTM5m. The CVS thus obtained was confronted with a CVS generated on the basis of 35 random locations as a control for the first result. As previously explained, the CVS indicates from how many other places each cell of the raster is visible. As all 35 sites are a part of the CVS raster, each site is associated to a CVS value and measured against the CVS values of random locations. The aim of this exercise is to discern if there is a difference between temple sites and random locations, to examine whether sites are located in places that are more inter-visible than the random sites.

The first step was to produce in ArcMap a CVS for the 35 temple sites based on a 3 m temple height. In order to have a consistency in reproducing random site points, the minimum distance between the randomly computed sites has been set to the mean distance observed between the 35 temple sites (1,088 m) as illustrated in Figure 2.7.



Field: NEAR_DIST

Statistics:

Count: 35
Minimum: 49.33617
Maximum: 2388.802757
Sum: 38081.160326
Mean: 1088.033152
Standard Deviation: 657.086188
Nulls: 0

Figure 2.7. Distance between temples in metres.
The box on the left lists the statistical distribution values of 35 temple sites in meters of two regional temple sites, including the mean value of 1088.03152 which has been applied for this study. The box on the right shows the Frequency Distribution in meters represented by the horizontal line, and the vertical line illustrates number of sites within that frequency distribution range.

The next step in the analysis was then to generate CVS random points for 35 site locations using the ArcMap tools *Create Random Points and Extract Multi Values to Points*. The geographical locations of the CVS of 35 temple sites and 35 random points is shown in Figure 2.8 below.

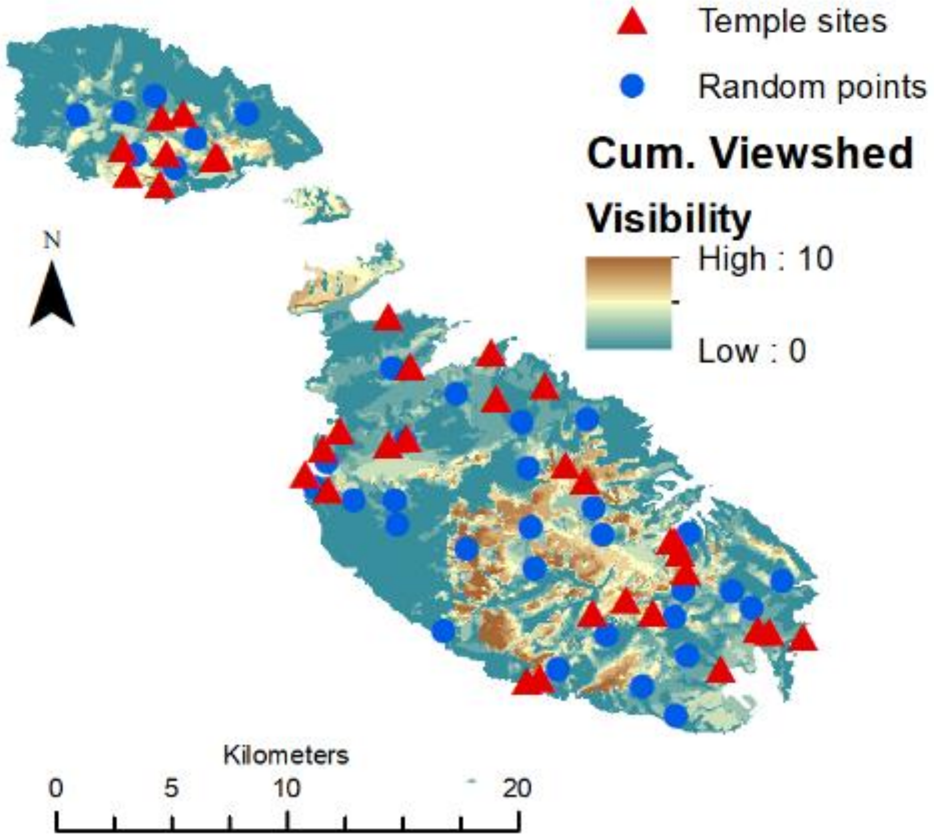


Figure 2.8. Cumulative viewshed and random points.
This shows the location of 35 temple sites and 35 random points across the archipelago, plotted against the CVS. The high visibility of ten indicates that from those cells ten sites can be seen, while from the areas with the lowest value of zero, no sites besides itself can be seen.

The final part of this exercise consisted of two steps. The first step was to import from ArcMap the two shape file layers of the CVS of the 35 temple sites and the CVS of the 35 random points (sites) into the free scientific data software PAST (2020) for computing statistical testing, in order to explore to what extent the choice of the temple locations may have been influenced by considerations of visibility. The second step consisted of establishing which sites have a potential or theoretical intervisibility between them, as well as which sites have a visual reciprocity. This part was based on data from CVS and Extract Multi Values to points creating a line-of-sight (LOS) by compiling a matrix in an Excel spreadsheet. The results from these two exercises are presented in 2.4.2 page 59.

Total viewshed (TVS) and random locations

According to Llobera (2003: 33) and Llobera *et al*. (2004: 146) a TVS map is created in the same way as a CVS except that it includes a viewshed for every single cell in the landscape, and can be a mean to retrieve new information as 'visual prominence'. TVS affords a portrayal of the most inherent visual plots in a landscape based on its topography, but is rarely explored in archaeology due to its lengthy computing time and creating a limited set of hypothesis (Brughmans *et al.* 2018: 14).

A CVS/TVS may be generated by using one of two methods. The first method records each cell as a single viewshed and calculates the sum of each viewshed as a CVS of every possible viewpoint. The second method uses dedicated programs like QGIS which calculates the viewshed from every single map cell by counting the number of cells in the viewshed and recording them as the viewpoint (Conolly and Lake 2006: 228). According to Lee and Stucky (1998: 893-894) 'Two matrices are not equal because the number of cells visible from a cell does not always equal the number of cells to which that cell is visible.' TVS and CVS are both conditioned to the same restrictions as single viewsheds, as points and positions close to the borderlines suffer from an edge effect (Llobera *et al.* 2004: 146, Wheatley and Gillings 2002: 209).

Following Conolly and Lake (2006: 228), the present study has chosen the method of QGIS (Čučković 2014) as a tool for the calculation of the TVS. The method consists of constructing a total viewshed raster by calculating a binary viewshed using each cell of a DTM as observer point (Čučković 2016a). As the area of Malta covers 316 km^2 (Gauci and Schembri 2019: 1) a DTM of resolution 20 m was applied, consisting of 790,000 cells. Each cell of the resulting raster features a value corresponding to the number of cells from which that specific cell proves visible. For this computationally-intensive exercise, a Dell Precision 7740 computer with an Intel Xeon e-2276M CPU was used. A DTM20m resolution was applied as the computer could not handle an attempted computation of a DTM10m. The processing time for the DTM20m still lasted several days. As already mentioned, the rationale of using a TVS raster was to examine if the 35 temple sites had a tendency to be situated in places with a higher inherent visibility. The TVS map is shown in Figure 2.9, and the statistical outcome of this exercise is in 2.4.2 page 59.

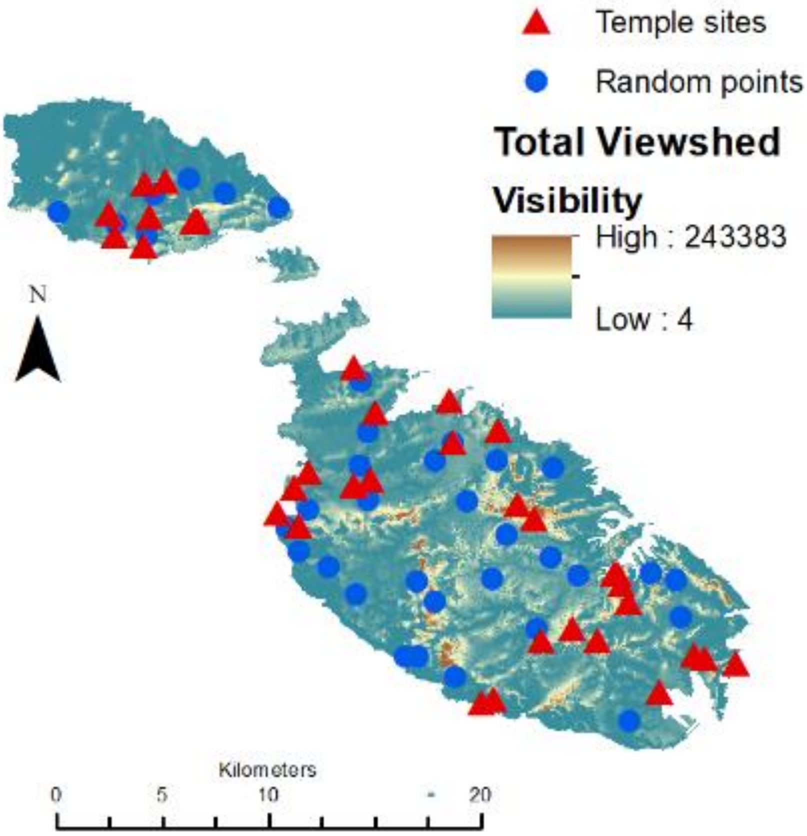


Figure 2.9. Total Viewshed and random points.
Location of 35 temple sites and 35 generated random point (site) locations plotted against TVS. The high value of 243383 indicates the highest number of other cells from which that location is visible, while the lowest value indicates that four other cells may make the corresponding observation for that location.

2.3.7 Temple intervisibility

The purpose of this exercise is the spatial modelling of a limited and specific number of target points relating to each other in a network of intervisibility throughout the Maltese Archipelago. In order to avoid any potential misunderstanding, it is relevant to emphasise that this temple intervisibility study is *not* a CVS analysis as explained and adopted in the previous section (ref. 2.3.6). As described in detail below, it is a single viewshed (SVA) application similar to a line-of-sight (LoS).

To obtain a result of network intervisibility the following three outcomes shall be represented:

1. A map of interconnecting lines between temples based on 3 m and 6 m target heights.
2. Present temple intervisibility in pivot tables based on temple heights.
3. A temple source site listing the height of the visible part in metres of a temple target. This is done be taking the distance between the source and the target site, and establish how much of the target site is actually visible by taking the human acuity into consideration.
4. Establish how many sites and which would be intervisible within a given target height of 3 m and 6 m.

As the actual height of the Maltese prehistoric temples is not only hard, but could probably be considered impossible to retrieve correctly based on present archaeological knowledge, this third part of the methodology is specially aimed to establish how much of a temple is distinguishable given a target height and a visual radius conditioned by human acuity.

Conolly and Lake (2006: 226) were an inspiration for applying intervisibility using single viewshed, which describes a VSA being a binary map marking target cells as visible or not visible from a specific observation point. ArcMap does not provide the ability to calculate the visual height of a target, therefore an alternative GIS was chosen, namely QGIS (2017) software with the binary plug-in, *Viewshed analysis*, developed by Čučković (2016b), which does provide these kind of calculations. What this single viewshed analysis (SVA) actually creates is a line-of-sight (LoS) between theoretical visible and intervisible temple sites which consequently are filtered out into non-visible (FALSE) and visible (TRUE) interconnecting lines between the sites and shall be named and shall be referred to as VSQ, a short form for viewshed analysis applying QGIS.

The QGIS (QGIS 2017) is particularly suitable for multiple viewshed calculations from a set of fixed points in the landscape. Čučković (2014) was an inspiration in an attempt to build a structured approach for investigating the intervisibility network of 35 Maltese prehistoric temple sites, similar to Čučković's analysis of 480 Bronze and Iron Age hillfort sites in Istria (Croatia and Slovenia).

The main reason for applying Čučković's (2014: 470) QGIS plug-in for this project was its ability to use a viewshed algorithms to verify predetermined target points over a given distance, using a specific and limited number of target points of interest. A distinct advantage of this tool is that it does not only tell if a target is visible (TRUE) or non-visual (FALSE), but also gives the height of the part of a target that is visible from a given source point. It also tells how much taller a non-visual target needs to be to become visible (see Appendix 7.6). For this exercise OFFSETA, the height of an observer was again set to 1.60 m, while OFFSETB was set to 6 m temple height which establishes a visual radius of 20.6 km based on human acuity (ref. Figure 2.2 page 33). The reasoning behind choosing 6 m as a base-line value for temple height was based on the average estimate of temple heights (ref. Table 2.1 page 34). For this exercise an older version (v. 2.18.15, Las Palmas) of QGIS (2017) was preferred, as the newer version (v. 3.4, Madeira) does not provide this specific advanced viewshed analysis (QGIS 2020).

The methodology consists of the following steps. Firstly, the raster DTM5m of Malta and the ArcMap shapefile of the 35 temple sites were imported as layers into QGIS, though converted into an QGIS shapefile. This shapefile of the 35 temple sites in its new format becomes both the *Observation points* and the *Target Points* for the calculation of intervisibility in the Advanced Viewshed Analysis plug-in tool. Then based on the established offsets and radius, the plug-in tool calculates 900 interconnecting temple site lines, flagging them either as TRUE (visible) or FALSE (not visible) as listed in Appendix 7.6. The next step was to import this visibility shapefile into ArcMap to filter out the FALSE temple sites, remaining with 151 TRUE interconnecting lines, as listed in Appendix 7.5. The last step was to create two pivot tables of temple intervisibility based on the TRUE sites listing temples as both a source and a target. The reason for this exercise was to establish which sites do or do not have a visual connection between them (see Table 2.4 page 68) and also to establish which temples have a visual reciprocity between them (see Table 2.5 page 69). This methodology is the fundamental step for both calculating and illustrating temple intervisibility.

2.3.8 Statistical analysis

This section outlines the various statistical methods applied to the GIS data to answer the research question of this chapter. The probability tests are based on the free open statistical software PAST (2020) and R (R Core Team 2019). Alberti (2015, 2017, 2019, 2020, Alberti *et al.* 2018) has been the main source informing this methodology through using GIS and ArcMap not only as a tool and a system, but also as a scientific stepping stone for inferential statistical applications of spatial analysis, modelling and patterning related to potential visibility of temple settings in the landscape. Other relevant literature has also been a contributing source (Camizuli and Carranza 2018, Carlson 2012, Carrero-Pazos 2018, Conolly and Lake 2006, Conroy 2012, Drennan 2009, Grima 2004, Shennan 1997, 2006, VanPool and Leonard 2011).

Probability and hypothesis testing

According to Fisher (1922: 311-312) *probabilit*y is the most elementary of statistical concepts. The essential part in probability theory is that the model involves randomness and is based on a nondetermined outcome (Fisher 1950: 269, Linde 2016: 1). Neyman and Pearson (1933: 290-291) propose that hypothesis testing is a method that compares two opposing hypothesis where one is excluded to the advantage of the other. According to Silva (2020: 2) probability testing is to measure the evidence against a single hypothesis which is the *null hypothesis*(H0), and the result of the test is the *p-value* (probability value). The p-value estimates how strong the statistical evidences against the H0 are. A traditionally accepted threshold of a p-value is 0.05, and describes the observed data in regard to a defined hypothetical explanation, however as Wasserstein and Lazar (2016: 7-9) suggest, the p-value is not a description about the explanation itself, and does not automatically become true on one side and false on the other. A H0 can be rejected with a p-value less than 0.05, indicating a confidence level of 95% that the H0 is not true. Maintaining a level of 5% unpredictability could be in line with Taylor’s (1997: 3) proposal that uncertainty in measurements in science are not necessarily mistakes or blunders that can be eliminated, but that even carefully-taken measurements cannot be completely free of uncertainties.

When it comes to the hypothesis tests used throughout this dissertation to analyse the spatial distribution of temple site locations and their relationship with a number of topographic variables (e.g., elevation, slope, aspect; see details provided later on), it is important to clarify that they rest on the Null Hypothesis of Complete Spatial Randomness (hereafter CRS). In other words, as Boots and Getis (1988)put it, statistics computed using the observed data are "evaluated in terms of the likelihood of their occurrence under the assumptions of the null hypothesis" of CSR (Boots and Getis 1988: 12). It must be acknowledged that, while rejecting the Null Hypothesis of CSR may not be extremely informative, it may prove important nevertheless (O'Sullivan and Unwin 2010: 159). As matter of fact, if the Null Hypothesis of CSR in not rejected, any further formal analysis and/or substantive conclusions and interpretations are not warranted (Boots and Getis 1988: 12).

Temples and intervisibility

There are two similar probability tests that shall be conducted for this part of the study. One is the *Cumulative Viewshed and random locations*, and the other is the *Total Viewshed and random locations*. The methodological reasoning behind these statistical analyses has been articulated in 2.3.6 page 42. For both statistical assessments the *Mann-Whitney* test has been applied (Mann and Whitney 1947). Conroy (2012: 182) maintains that the Mann-Whitney test is 'very useful' to measure effect size and particularly of two-group comparison of ordinal and arbitrary scale units. However, other literature relevant for a two-group testing has also been sourced (Camizuli and Carranza 2018, Drennan 2009, VanPool and Leonard 2011). According to Hammer (PAST 2020), the inventor and creator of the free statistical software package PAST, the two-tailed Mann-Whitney Univariate Test, can be used to test '…whether the medians of two independent samples are different'. This is a comparable analogy for the particular test of this study as it shall compare a two-grouped hypothesis.

The initial methodological step for a probability test was to transmute the obtained two-grouped ArcMap data of CVS and TVS temple sites and the random site data into PAST, and then to process a Mann-Whitney compilation using the PAST applications Univariate and Two-sample test. The PAST Barchart/Boxplot application was also utilised for turning the distribution of the two-group values into a visual data summary indicating any asymmetry in the main sampling of the observations (Shennan 1997: 45-46). According to VanPool and Leonard (2011: 57) a box plot shows the median and the interquartile range and the box itself mirrors the distribution of the middle of the 50% of the data, which is the ‘body’ of the data. In statistics the *mean* is the same as the average value of a data set, while the *median* is the central number of a data set, and the *interquartile range* describes the midspread of a batch and the variations towards the centre of a distribution (Drennan 2009: 17, 19, 28, VanPool and Leonard 2011: 47-58).

The value of each cell in a CVS is the number of visible cells from other sites. The higher the CVS value is, the higher is the number of sites from which this cell can be seen. The motivation behind testing intervisibility using TVS and random locations (sites) is the same as for the CVS, however the raster modelling of the TVS is slightly different from the CVS one. The TVS raster analysis examines the inherent visibility of the landscape, without the addition of the height of a building or other target. In a CVS the observer point is the cell where the site is located, while in TVS the observer points are *all* cells of a DTM. The CVS used here discloses which cells can be seen from other cells, while the TVS was designed the other way around, revealing how many other cells can see that cell.

For this study the null hypothesis (H0) is CVS and TVS do not feature higher values for temple sites than for random locations. In plainer terms, the null hypothesis is that the builders did not have any preference to locate their temples in places which were intrinsically more visible, or which enjoyed higher intervisibility with other sites. As already explained the confidence level is set at 0.05. The results of these statistical tests are shown in 2.4.2 page 59.

Temples and topography

For the statistical analysis of the topography regarding elevation, slope, and aspect, the same test was used for all three variables. The function *pointsCovarCum*, from the GmAMisc R package (Alberti 2020), has been used to ‘test if there is a significant dependence of the input point pattern on an underlying spatial numeric covariate (first-order effect)’.

The same statistical test was applied for all three topographical variables, however aspect was divided into two test components, cosine-sine transformation data, based on trigonometric functions of an angle applying exponential distribution as baseline (Chesneau *et al.* 2017, Jenness 2007, Qiu *et al.* 2001). As explained by Alberti *et al*. (2018) the aspect-cosine and aspect-sine transformation test produces values from positive 1 (+1) to negative 1 (-1), giving north-facing slopes an aspect-cosine value closer to +1, while south-facing slopes tend to be -1, whereas east-facing slopes have aspect-sine tending to be +1, and west-facing slopes values around -1.

The objective behind the analysis was to retrieve any possible topographical pattering of temple site locations related to elevation, slope, or aspect. If the results observed for temple site locations is no different from a set of random locations, that implies that there is no particular preference for locating temples in sites with a specific range of that variable. If the p-value is lower than the established threshold of 0.05, that concludes that the observed distribution is unlikely if there was no particular preference, entailing that temple sites are not randomly chosen by their builders. The null hypothesis (H0) for this test shows that there is no relation between temple site locations and any particular values of the three variables under consideration. The results of all these statistical tests are presented in 2.4.1 page 56.

2.3.9 Limitations and uncertainties

This section shall look at limitations and uncertainties encountered in applying GIS for data capture analysing Maltese prehistoric temple locations in respect to visibility in the landscape and intervisibility between temple sites.

According to Longley *et al.* (2015: 99) uncertainty in geographic representation is basically inevitable as almost all portrayal of the world is incomplete, and in addition the way users perceive the world, measure, resent, and analyse it, is also subject to personal variations. De Floriani and Magillo (2003: 727) suggest that visibility data is sensitive to errors and propose that a probabilistic approach to a site being visible is more advisable than directly classifying a location as visible or not visible. Silva (2020) argues that inferring patterns in measurements can only be done by statistical inference that takes the uncertainty into account. Kantner and Hobgood (2016: 1307) suggest that the most significant challenge in using viewshed analysis is to reconstruct the past landscape that correlates with the inhabitants' visual experience.

Fisher (1992, 1993) proposes problems that unrealistic binary outputs do not represent the reality, however, Chapman (2006: 83) states that these problems have been addressed since the 1990s by implementing new methods in GIS proving a more sophisticated representation of the topological reality. Nevertheless Chapman (2006: 83) maintains that viewshed analysis has been criticised on several issues, as they determine the level of correct algorithmic calculations. Wheatley and Gillings (2002: 209) address a potential interpretation problem in cumulative viewshed analysis in rejecting the null hypothesis as it 'shows *association* between monuments and areas of high visibility and does not show that one *caused* the other'. In other words, that temples located with high intervisibility in the landscape is not necessarily caused by the temple builders. As already noted, cumulative viewsheds are also inclined to *edge effects*, because the cumulative viewshed could be underestimated as in the cases where monument distribution continues outside the study area. Other possible limitations are related to the accuracy of the DTM (Wheatley and Gillings 2002: 209). The height of an observer or a target are not trivial issues and have to be evaluated as realistically as possible, and the same goes for refraction, earth curvature, and acuity of vision (Chapman 2006: 83-85, Conolly and Lake 2006: 228-233, Čučković 2014: 469, Kantner and Hobgood 2016: 1307).

The present study has addressed the sources of uncertainty noted above in the following ways. A DTM resolution of 5 m has been used to reduce edge effects and to produce an acceptable representation of the present topography of the landscape without modern buildings and vegetation. Regarding the topography of the Maltese landscape there seems to have been a degradation and erosion since the Temple Period, however there are suggestions that a steppe and open landscape existed with similarities of what Malta has today (Fenech 2007: 113-114, Gambin *et al.* 2016: 273). The observer height of a prehistoric person is based on the archaeological record (Stoddart *et al.* 2009: 322-325).

The acuity of human vison is referenced from relevant literature and based on algorithmic calculations (see 2.3.3 page 31). For refraction and earth curvature, standard inputs in ArcMap have been applied. The statistical interpretation problems raised by Wheatley and Gillings (2002) mentioned above are also taken into account, as all statistical testing in this study is based on a null hypothesis of total randomness.

Another area of uncertainty in studies of visibility and intervisibility is based on the point from which the GPS reading inside a temple compound is registered. In temples with a recognisable central axis, the GPS readings were as a standard taken from the centre of the back apse. However, for most of the temple sites this was not possible due to the poor state of preservation of the megalithic structures. In these cases, the GPS reading was taken next to the megalithic remains. An additional uncertainty in correct registration of site locations is that for sites that have been completely lost, the location could only be derived from existing records, that is primarily the site coordinates based on Evans (1971: 229-234). Evans' site catalogue was based on the projected grid reference system GSGS 3859 1954 (Evans 1971: Fig. 1) applying six digits, whereas ArcMap data input for this study is based on Universal Transverse Mercator (UTM) 1950 Zone 33N applying a ten-digit coordinate system (ref. 2.3.1 page 26). In these cases, the site location may vary by up to about 100 meters, however, only Id-Debdieba falls in this category which today lays under the Malta Airport runaway.

For other destroyed sites an eight-digit UTM grid coordinate system was used based on Grima (2005: 266, 276) and Cilia (2004: 442-443), which may produce an actual error of up to ten meters which on the other hand could also be an uncertainty level in this study for GPS registration of sites with no basic structure but only megalithic remains. Appendix 7.3 lists the position where the GPS reading was taken, or which source was used. Lastly, as mentioned in section 2.3.2 page 28, transforming WGS 1984 data into ED1950 UTM 33N coordinates, may also result in a DTM grid difference of 1 in 2.500 (Kennedy 2013: 18-19).

The limitation of not knowing the original height of each individual temple building has been addressed by conducting visibility analysis in QGIS, which does not simply indicate whether a site would have been visible or not, but also gives values of how high a building needed to be in order to be visible, which may be compared to the available archaeological evidence for that specific site, while also taking visual acuity and target distance into account.

Another area of uncertainty is related to the potential impact of vegetation, which is no longer present on the Maltese archipelago could have had on temple intervisibility. The results of palaeobotanical work conducted during the FRAGSUS project (Farrell *et al.* 2020: 110) have indicated that the Maltese Temple Period landscape '…remained extremely open…', and was characterised by *Pistacia* and *Phillyrea* bushes. This raises the question of whether the visibility relationships discussed here would have been impacted by the presence of such vegetation. It should be noted that any vegetation growing in more sheltered areas would generally be lower than the temple buildings, and would have had little impact. The problem of vegetation is arguably a circular argument; if an axis of visibility was considered significant, it would not have been difficult for the Temple Period inhabitants to keep such an axis clear of vegetation.

2.4 Results

This section presents the results from the various probability tests that have been performed according to the methodologies in 2.3.8 page 50. The results obtained are based on two means of statistical inferences. For Temples and Topography (ref. 2.3.5 page 38) RStudio (R Core Team 2019) specially adapted for GIS applications by Alberti (2020) was implemented, while for the study of Intervisibility and Random Points (ref. 2.3.6 page 42) the Mann-Whitney and PAST (2020) applications was used.

2.4.1 Temples and topography

This section presents the results (see Figure 2.10) for topographical temple site locations regarding three variables, namely elevation, slope, and aspect as explained in 2.3.8 page 50. The following plots represent the '…cumulative distribution of the values of the covariate at the locations…' of interest (Alberti 2020), being in this case the black line in the chart. The grey envelope represents the acceptance interval (with significance level equal to 0.05), which is built by calculating the cumulative distribution of the value of the covariate measured at randomly generated locations within the same study area, and keeping the middle 95% of the distributions. As proposed in Alberti's (2020) webpage 'The number of random points drawn during each of the…' iteration '…is equal to the number of features of the input point pattern' which are temple site locations in this study. 200 randomised iterations have been used. If the observed cumulative distribution curve falls inside the 'acceptance envelope', it means that the distribution of the observed values of the covariate measured at the temple locations is not significantly different from random. Conversely, if the black line falls outside or does not touch the acceptance envelope, the distribution pattern is significant. Nevertheless, it is essential to discern if the black line is above the acceptance envelope, indicating that there are more sites than expected for that indicated range, or below the acceptance envelope, showing that there are less sites than expected.

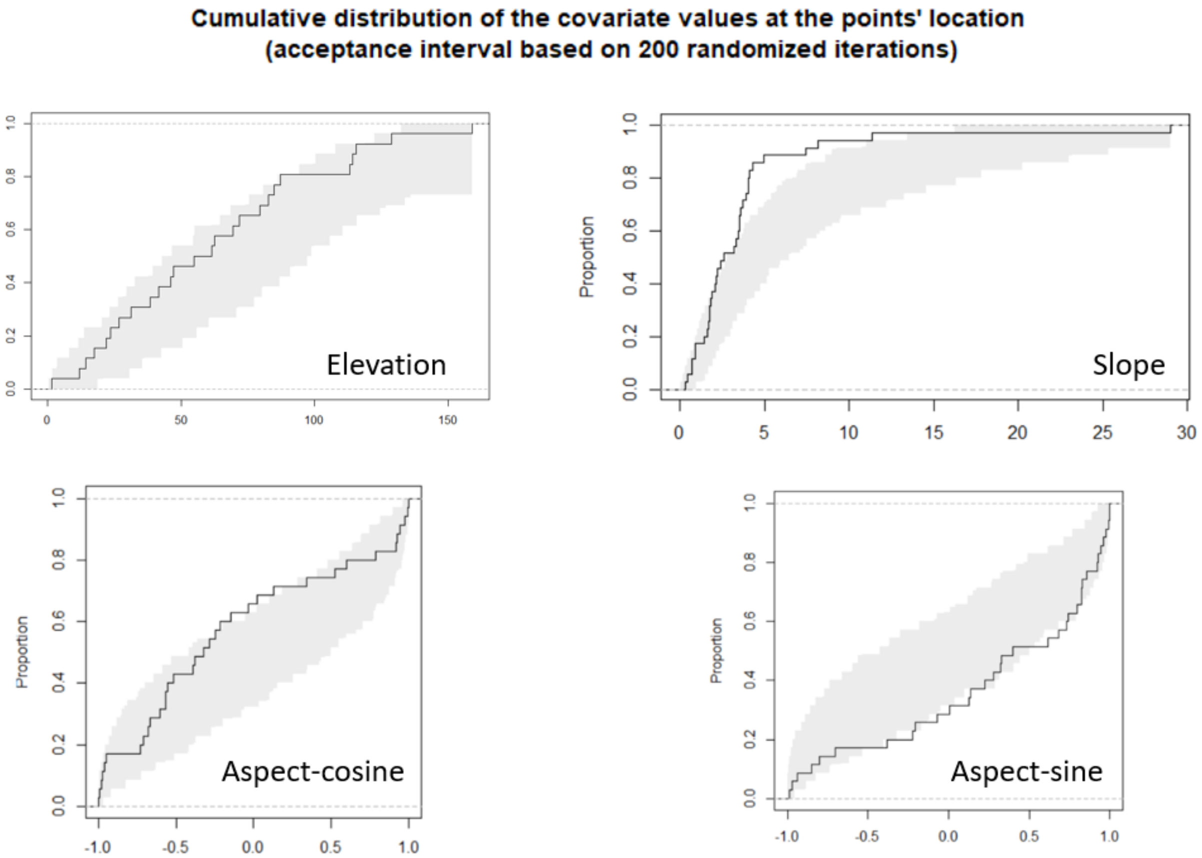


Figure 2.10. Distribution of temple sites and topography.
This figure shows the three results from the cumulative distribution of temple sites located in the topographical landscape. Aspect is divided into two components, aspect-cosine and aspect-sine. The grey area is the acceptance envelope (the null hypothesis) presenting the cumulative distribution of the DTM raster values in a random pattern. The black line is the observed cumulative distribution of the observed values of the DTM raster of the locations of temple sites. The vertical proportion line is the relative distribution of temple sites, and the horizontal line shows the respective topographical values for each study area.

Results explained for each of the three topographical variables.

Elevation:

The black line, representing the cumulative distribution of the values of the spatial covariate for temple sites, falls completely inside the acceptance envelope. This indicates that the test's result is not significant. In other words, there is no preference in low or high elevations of temple locations in the Maltese landscape.

Slope:

The black line moves outside the acceptance envelope at around 4° in slope formation and touches the envelope again at around 14°. This indicates that there is a significant distribution for slope variations between about 4° and 14°. Since the black line is higher and above the envelope, it suggests that there is a larger than expected proportion of temple sites than randomly calculated points with slope values between about 4° and 14°.

Aspect:

As shown in Figure 2.10 the aspect analysis is divided into two components, Aspect-cosine and Aspect-sine. The Aspect-cosine chart represents a north-to-south opposition where -1.0 is true south and +1.0 is true north. A small portion, from about -0.20 to +0.25 of the black line is outside and above the envelope, meaning that there is a larger-than-expected proportion of sites on slopes that generally face towards the south.

The Aspect-sine chart represents an east to west opposition where -1.0 is true west and +1.0 is true east. In this case, the black line is outside and below the envelope, showing there are less temple sites than random ones expected to be located in both west and east facing slopes. The largest part of the black line which is outside the envelope is centred around the west to east divide of 0.0, indicating that temple sites tend not to be on east or west facing slopes. However, a smaller portion of the black lines goes lower and outside the envelope from about +0.50 to +0.75, emphasising that a smaller portion of temple sites than expected, of a random distribution is located on east facing slopes.

2.4.2 Temple visibility and landscape

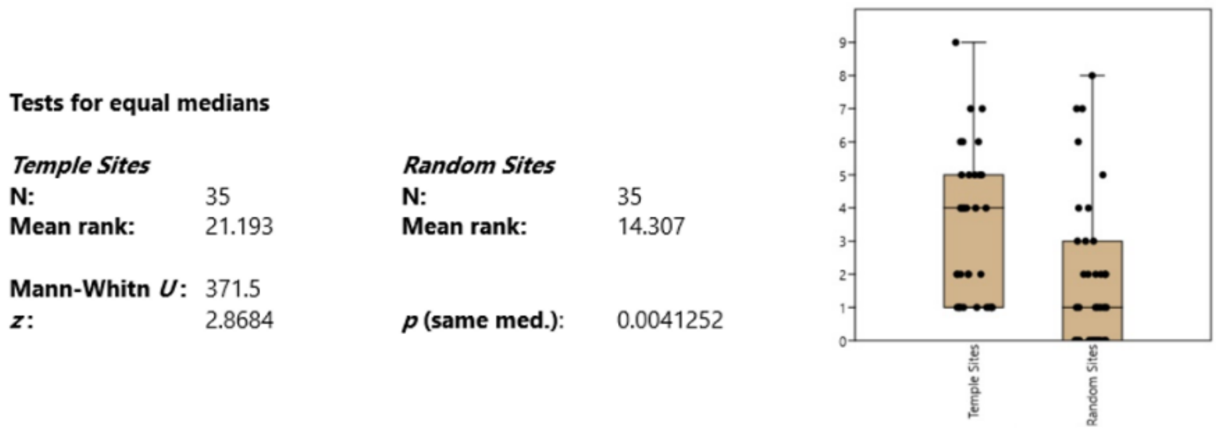
This section consists of two main components. One is results of Cumulative viewshed (CVS) and random points, while the other shows the results of Total viewshed (TVS) and random points. For both areas the statistical Mann-Whitney test is applied. All estimates in this subsection are based on 3 m temple heights (ref. 2.3.6 page 42).

As explained in 2.3.8 page 50, the two-tailed Mann-Whitney Univariate has been used to test whether the medians of two independent samples are different. This is a non-parametric test and does not infer a normal classification, however does estimate equal-shaped dispositions in both groups where the distribution value is based on a given default of 9,999 as a random permutation number (PAST 2020). Derived from ArcMap, the two-grouped distribution data applicable to Mann-Whitney test for both the CVS and TVS random points (sites) test. In addition, the results from the two excel spreadsheets showing temple sites and intervisibility are also listed after the statistical results of the CVS and random sites.

Cumulative viewshed (CVS) and random sites

The reasoning behind this test was to investigate if known temple sites have different CVS values to random site locations. The null hypothesis (H0) was defined as ‘the distribution of temple sites and random sites for CVS feature higher values than the random locations. Figure 2.11 shows that the p-value obtained from the Mann-Whitney test is 0.0041252. This implies that this result is statistically significant, and the null hypothesis can consequently be rejected.

The result also shows that the temple sites have a tendency to have larger CVS values than the random sites, as shown in the boxplot to the right of the figure. In other words, temples appear to be located at points in the landscape that are visible from more of the other temple site than the random sites.



Tests for equal medians

Temple Sites		*Random Sites*	
N:	35	**N:**	35
Mean rank:	21.193	**Mean rank:**	14.307
Mann-Whitn *U*:	371.5		
***z*:**	2.8684	***p* (same med.):**	0.0041252

Figure 2.11. Two-group test for CVS.
The left side of this figure shows the p-value from Mann-Whitney test = 0.0041252 pointing at a significant difference between 35 temple sites and 35 random locations. The right side shows a boxplot illustrating a visual data summary of the distribution of the two-group values of the Temple Sites and the Random Sites. The x-axis (the left vertical line) represents the cumulative viewshed values. The dots are the individual values (the sites). The largest non-outlying values are shown by the short horizontal lines. The box itself reflects the distribution of the middle of the 50% of the data, actually the 'body' of the data whereas the horizontal line inside the box is the median. As indicated, Temple Sites box is slightly larger than the Random Sites box, and the median value of the Temple Sites shows a considerable higher value than the Random Sites, indicating a tendency for the Temple Sites to have larger values than those of Random Sites (ref. 2.3.8 page 50).

Cumulative viewshed (CVS) and intervisibility

The two excel spreadsheets presented here are how the actual line-of-sight (LoS) based on the parameters used in the CVS of a 3 m temple height and an observable radius of 10 km. For both sheets the value of zero (0), indicated by an empty field, indicates that there is no visual connection for the parameters indicated. In both sheets the x-axis 'Source', listing temples from which another temple site may be observed, while the y-axis is the Target, listing temples that *can be seen* from another site. The x-axis and y-axis of both spreadsheets are identical. However, the values shown are computed differently.

Table 2.2 below give a value of one (1) indicates a visual connection between another temple site, while zero (0) or an empty cell illustrate no visual connection, which consists of 11 Source or Target sites. There is a total of 82 visual connections for both Source and Target temple sites. The table has two additional columns. The column 'Cum. Viewshed' is the number of visible sites seen from a Source site or a Target site including itself, whereas in the column 'CVS adjusted' this site is omitted. Therefore the 'CVS adjusted' total is 82, which is 35 less than the total of Cum. Viewshed of 117. This difference reflects the fact that 35 temple sites have been included in this analysis (117 – 35 = 82). The fact that a temple can see itself is irrelevant to this study.

	Source																																					
Target	Hagar Qim	Mnajdra	It-Tumbata	Id-Debdieba	Hal Resqun	Tarxien	Kordin I	Kordin II	Kordin III	Borg in-Nadur	Tas-Silg	Xrobb l-Ghagin	Hal Ginwi	Tar-Raddiena	L-Iklin	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Tal-Qadi	Ta' Hammut	Bugibba	Xemxija	Ghajn Zejtuna	Ggantija	Santa Verna	Borg Gharib South	Borg Gharib North	L-Imrejsbiet	Xewkija	Triq ix-Xabbata	Ta' Marziena	Borg L-Imramma		Total Target sites	CVS adjusted	Cum. viewshed
Hagar Qim																																					0	0	1
Mnajdra																																					0	0	1
It-Tumbata				1		1	1	1	1		1			1	1																						8	8	9
Id-Debdieba			1											1	1																						3	3	4
Hal Resqun						1																															1	1	2
Tarxien			1		1									1	1																						4	4	5
Kordin I			1					1	1					1	1																						5	5	6
Kordin II			1				1		1					1	1																						5	5	6
Kordin III			1				1							1	1																						4	4	5
Borg in-Nadur											1																										1	1	2
Tas-Silg										1																											1	1	2
Xrobb l-Ghagin																																					0	0	1
Hal Ginwi																																					0	0	1
Tar-Raddiena				1		1	1	1	1						1																						6	6	7
L-Iklin			1	1		1	1	1	1																												6	6	7
Ta' Hagrat																		1																			1	1	2
Skorba																																					0	0	1
Ras il-Pellegrin																1																					1	1	2
Tal-Lippija																																					0	0	1
Kuncizzjoni																1		1			1																3	3	4
Ras ir-Raheb																				1																	1	1	2
Tal-Qadi																																					0	0	1
Ta' Hammut																																					0	0	1
Bugibba																																					0	0	1
Xemxija																																					0	0	1
Ghajn Zejtuna																																					0	0	1
Ggantija																																1	1	1	1		4	4	5
Santa Verna																																1	1	1			3	3	4
Borg Gharib South																														1	1				1		3	3	4
Borg Gharib North																													1		1				1		3	3	4
L-Imrejsbiet																													1	1					1		3	3	4
Xewkija																											1	1					1	1			4	4	5
Triq ix-Xabbata																											1	1				1		1			4	4	5
Ta' Marziena																											1					1	1				3	3	4
Borg L-Imramma																											1	1	1	1	1						5	5	6
Total Target sites																																					82	82	117
Total Source sites	0	0	6	3	1	4	5	4	5	1	2	0	0	6	7	2	0	2	0	1	1	0	0	0	0	0	4	3	3	3	3	4	4	4	4		82		

Table 2.2. CVS intervisibility target height set to 3 m.
The column in this table is the Source which lists temples that *can see* another temple site, while the row is the Target listing the temples that *can be seen* from another temple site.

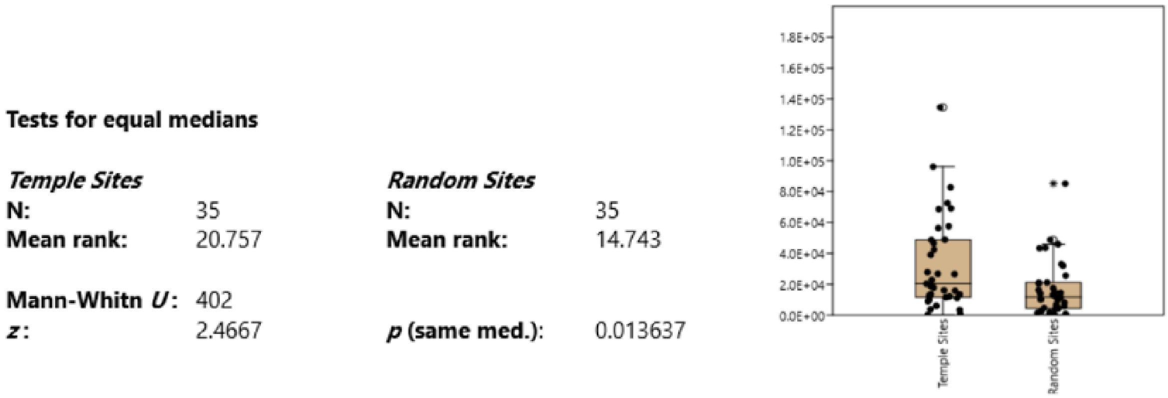
	Source																																			
Target	Hagar Qim	Mnajdra	It-Tumbata	Id-Debdieba	Hal Resqun	Tarxien	Kordin I	Kordin II	Kordin III	Borg in-Nadur	Tas-Silg	Xrobb l-Ghagin	Hal Ginwi	Tar-Raddiena	L-Iklin	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Tal-Qadi	Ta' Hammut	Bugibba	Xemxija	Ghajn Zejtuna	Ggantija	Santa Verna	Borg Gharib South	Borg Gharib North	L-Imrejsbiet	Xewkija	Triq ix-Xabbata	Ta' Marziena	Borg L-Imramma		Total Target sites
Hagar Qim																																					0
Mnajdra																																					0
It-Tumbata				1		1	1	1	1						1																						6
Id-Debdieba			1											1	1																						3
Hal Resqun						1																															1
Tarxien			1		1									1	1																						4
Kordin I			1					1	1					1	1																						5
Kordin II			1				1							1	1																						4
Kordin III			1				1							1	1																						4
Borg in-Nadur											1																										1
Tas-Silg										1																											1
Xrobb l-Ghagin																																					0
Hal Ginwi																																					0
Tar-Raddiena				1		1	1	1	1																												5
L-Iklin			1	1		1	1	1	1																												6
Ta' Hagrat																		1																			1
Skorba																																					0
Ras il-Pellegrin																1																					1
Tal-Lippija																																					0
Kuncizzjoni																					1																1
Ras ir-Raheb																				1																	1
Tal-Qadi																																					0
Ta' Hammut																																					0
Bugibba																																					0
Xemxija																																					0
Ghajn Zejtuna																																					0
Ggantija																																1	1	1	1		4
Santa Verna																																1	1				2
Borg Gharib South																														1	1				1		3
Borg Gharib North																													1		1				1		3
L-Imrejsbiet																													1	1					1		3
Xewkija																											1	1					1	1			4
Triq ix-Xabbata																											1	1				1		1			4
Ta' Marziena																											1					1	1				3
Borg L-Imramma																											1		1	1	1						4
Total Target sites																																					74
Total Source sites	0	0	6	3	1	4	5	4	4	1	1	0	0	5	6	1	0	1	0	1	1	0	0	0	0	0	4	2	3	3	3	4	4	3	4		74

Table 2.3. CVS reciprocity target height set to 3 m .
This table lists only sites which have a visual reciprocity between them. The columns show the Source which lists temples that can see another temple site. The row is the Target representing temples that can be seen from another site.

Table 2.3 above gives a value of one (1) only to temples which are reciprocally intervisible for the given parameters, resulting in a total of 74 cases (37 pairs of sites) of mutual intervisibility. The implication is that there are eight cases where, for the given parameters, there is a non-reciprocal visual relationship between sites, in other words, cases where site A is visible from Site B, but not vice-versa. The value of zero (0), indicated by an empty cell, shows there is no visual connection. The total interconnecting lines between target and source sits are 74.

Total viewshed (TVS) and random sites

The rationale behind this statistical test was to examine if temple sites tend to be located in the less or more inherently visible portions of the landscape than random sites. Figure 2.12 presents the result from Mann-Whitney test with a p-value = 0.013637. This demonstrates a significant result as the p-value is lower than the threshold of 0.05 and the H0 can be rejected. This result also displays that the TVS temple sites tend to have larger values than the TVS random sites. The Barchart/Boxplot to the right also indicates that temple sites tend to have higher TVS values than random sites.



```
Tests for equal medians

Temple Sites                     Random Sites
N:              35               N:                 35
Mean rank:      20.757           Mean rank:         14.743

Mann-Whitn U:   402
z:              2.4667           p (same med.):     0.013637
```

Figure 2.12. Two-group test for TVS.
The left side of this figure shows the p-value from Mann-Whitney test = 0.013637 pointing at a significant difference between temple sites and random locations. The right side shows boxplots illustrating a visual data summary of the distribution of the two-group values of the Temple Sites and the Random Sites. The y-axis (the left vertical line) represents the cumulative viewshed values. The dots are the individual values (the sites). The largest non-outlying values are shown by the short horizontal lines. Temple Sites have larger values than Random Sites (ref. 2.3.8 page 50).

2.4.3 Temple intervisibility

The next step in the analysis was based on the methodology (ref. 2.3.3 and 2.3.7) utilising two different GIS platforms namely, QGIS and ArcMap. This analysis shall be referred to as Viewshed QGIS (VSQ). It consists of two parts where the same methods and tools of intervisibility analysis are applied. The difference is that first part examines temple intervisibility based on 6 m temple height, while the latter investigates temples that are based on a height of 3 m. The actual height of the visible part of a building, and implications for visibility when taking human visual acuity into consideration, will also be analysed.

Temple intervisibility 6 m height

Figure 2.13 below is based on a temple height of 6 m; on the left it shows the visual result from VSQ indicating 900 interconnecting lines between all individual temple sites that fall inside the viewshed radius of 20.6 km, the maximum distance between two temple sites and the radius in this analysis was set not to exclude any visual relationship on the bases of distance, but are classified as either FALSE (not visible) or TRUE (visible), as listed in Appendix 7.6. The right side of Figure 2.13 illustrates TRUE intervisible temple sites by taking the human acuity into consideration, resulting in 151 TRUE interconnecting site lines, as listed in Appendix 7.5. The 151 TRUE interconnecting sites lines are further compiled (see also Table 2.6) and ordered into 28 temple sites that have an intervisibility with each other in way or the other. The result from this exercise is presented in Table 2.4. This table shows that out of the 35 temples in this study, 28 sites, or 80%, have a visual interconnectivity with each other. Table 2.5 shows temple sites that have a visual reciprocity between them. Of the 28 sites in the previous result, 4 (Buġibba, Ħaġar Qim, Mnajdra and Xemxija) are not reciprocally visible, meaning that 24 sites, or 68.6% of the total of 35, have visual reciprocity.

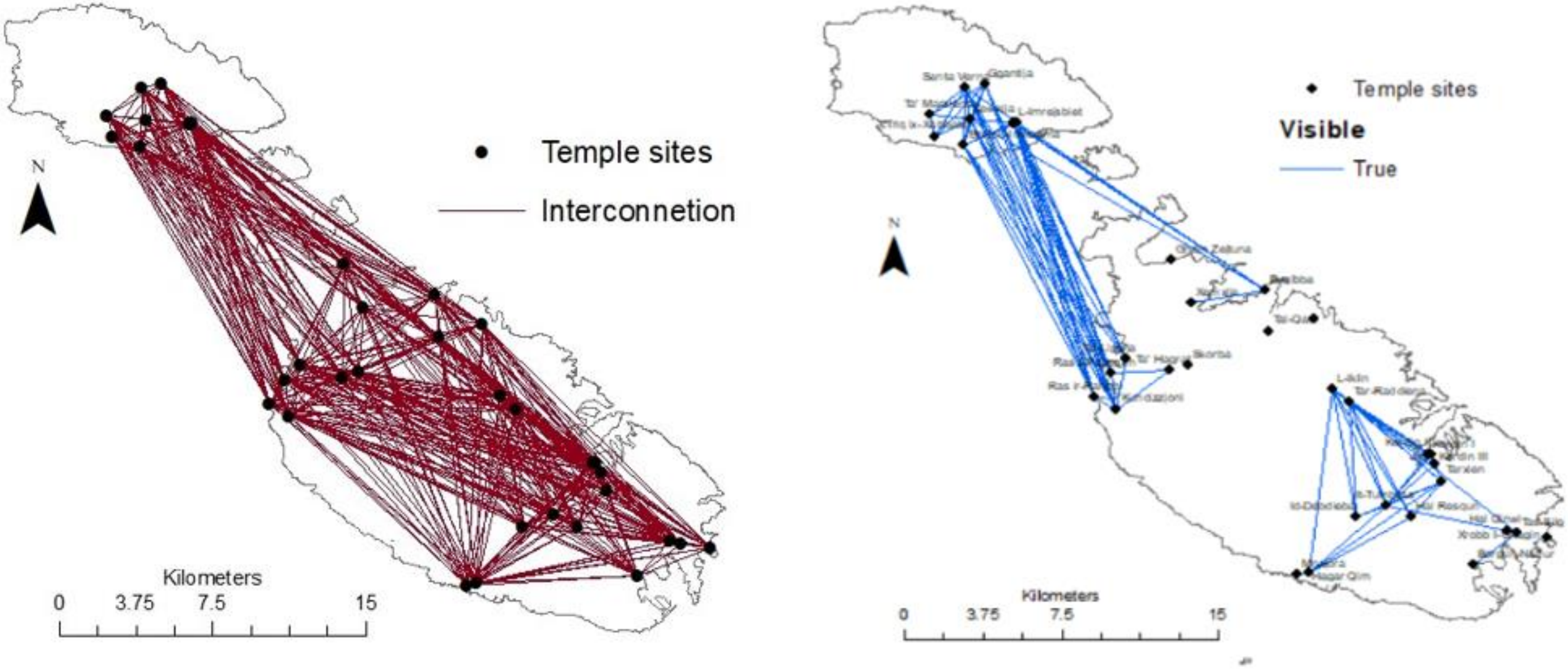


Figure 2.13. Temple intervisibility based on 6 m height.

The figure to the left shows the visual result from VSQ indicating 900 interconnecting lines (FALSE and TRUE) between all individual temple sites. On the right, it shows the visual TRUE interconnecting lines of 151 temple sites where the human acuity of observing a target of 6 m at a distance of 20.6 km is taken into consideration which is further illustrated in Table 2.4.

	Target																											
Source	Borg Gharib North	Borg Gharib South	Borg in-Nadur	Borg L-Imramma	Bugibba	Ggantija	Hagar Qim	Hal Resqun	Id-Debdieba	It-Tumbata	Kordin I	Kordin II	Kordin III	Kuncizzjoni	L-Iklin	L-Imrejsbiet	Ras il-Pellegrin	Ras ir-Raheb	Santa Verna	Ta' Hagrat	Ta' Marziena	Tal-Lippija	Tar-Raddiena	Tarxien	Tas-Silg	Triq ix-Xabbata	Xemxija	Xewkija	Grand Total
Borg Gharib North		1		1	1									1		1	1	1				1							8
Borg Gharib South	1			1	1									1		1	1	1				1							8
Borg in-Nadur																									1				1
Borg L-Imramma	1	1				1								1		1	1	1	1			1							9
Bugibba																			1								1		2
Ggantija				1										1			1	1			1					1		1	7
Hal Ginwi																									1				1
Hal Resqun							1																	1					2
Id-Debdieba										1					1								1						3
It-Tumbata							1		1		1	1	1		1									1	1				8
Kordin I										1		1	1		1								1						5
Kordin II										1	1		1		1								1	1					6
Kordin III										1	1	1			1								1						5
Kuncizzjoni	1	1		1		1										1		1	1									1	8
L-Iklin							1	1	1	1	1	1	1										1	1	1				10
L-Imrejsbiet	1	1		1	1									1			1	1				1							8
Mnajdra							1																						1
Ras il-Pellegrin														1						1									2
Ras ir-Raheb	1	1		1		1								1		1			1									1	8
Santa Verna				1										1			1	1				1				1		1	7
Ta' Hagrat														1			1												2
Ta' Marziena						1													1							1		1	4
Tal-Lippija	1	1		1										1		1			1										6
Tar-Raddiena								1	1	1	1	1	1											1					7
Tarxien							1	1	1	1					1								1						6
Tas-Silg			1							1					1														3
Triq ix-Xabbata						1													1		1							1	4
Xewkija	1			1	1	1								1			1	1	1		1					1			10
Grand Total	**7**	**6**	**1**	**9**	**4**	**6**	**5**	**3**	**4**	**8**	**5**	**5**	**5**	**11**	**7**	**6**	**8**	**8**	**8**	**1**	**3**	**5**	**6**	**5**	**4**	**4**	**1**	**6**	**151**

Table 2.4. VSQ intervisibility target height set to 6 m.
This pivot table lists the 28 sites which enjoy some form of intervisibility, in alphabetical order. The row shows the Source, or observation point. The column shows the Target, that is which temple sites *can be seen* from the respective 'Source' site. The Grand Total shows the 151 interconnecting lines.

	Target																												
Source	**Borg Gharib North**	**Borg Gharib South**	**Borg in-Nadur**	**Borg L-Imramma**	**Bugibba**	**Ggantija**	**Hagar Qim**	**Hal Resqun**	**Id-Debdieba**	**It-Tumbata**	**Kordin I**	**Kordin II**	**Kordin III**	**Kuncizzjoni**	**L-Iklin**	**L-Imrejsbiet**	**Ras il-Pellegrin**	**Ras ir-Raheb**	**Santa Verna**	**Ta' Hagrat**	**Ta' Marziena**	**Tal-Lippija**	**Tar-Raddiena**	**Tarxien**	**Tas-Silg**	**Triq ix-Xabbata**	**Xemxija**	**Xewkija**	**Grand Total**
Borg Gharib North		1		1										1		1		1				1							6
Borg Gharib South	1			1										1		1		1				1							6
Borg in-Nadur																									1				1
Borg L-Imramma	1	1				1								1		1		1	1			1							8
Bugibba																													0
Ggantija				1										1				1			1					1		1	6
Hal Ginwi																													0
Hal Resqun																								1					1
Id-Debdieba										1					1								1						3
It-Tumbata									1		1	1	1		1									1	1				7
Kordin I										1		1	1		1								1						5
Kordin II										1	1		1		1								1						5
Kordin III										1	1	1			1								1						5
Kuncizzjoni	1	1		1		1										1		1	1									1	8
L-Iklin									1	1	1	1	1											1	1				7
L-Imrejsbiet	1	1		1										1				1				1							6
Mnajdra																													0
Ras il-Pellegrin																				1									1
Ras ir-Raheb	1	1		1		1								1		1			1									1	8
Santa Verna				1										1				1				1				1		1	6
Ta' Hagrat																	1												1
Ta' Marziena						1																				1		1	3
Tal-Lippija	1	1		1												1			1										5
Tar-Raddiena									1		1	1	1											1					5
Tarxien								1		1					1								1						4
Tas-Silg			1							1					1														3
Triq ix-Xabbata						1													1		1							1	4
Xewkija						1								1				1	1		1					1			6
Grand Total	**6**	**6**	**1**	**8**	**0**	**6**	**0**	**1**	**3**	**7**	**5**	**5**	**5**	**8**	**7**	**6**	**1**	**8**	**6**	**1**	**3**	**5**	**5**	**4**	**3**	**4**	**0**	**6**	**120**

Table 2.5. VSQ reciprocity target height set to 6 m.
This pivot table lists temple sites that have visual reciprocity, meaning they are both visible from each other. The Grand Total shows the 120 interconnecting temple lines.

Metric differences in temple intervisibility based on 6 m height.

As explained in the methodology, an important step in the analysis of intervisibility consist in quantifying how much of a target site is visible. Figure 2.13 shows the result of the 900 theoretical (TRUE or FALSE) intervisibility lines listed in Appendix 7.6. Breaking further down the result from the 900 intervisibility lines to quantify the TRUE lines, gives a result of 151 TRUE intervisibility lines, listed in Appendix 7.5. A compiled result of the 151 theoretically intervisibility lines is presented in Table 2.6, consisting of 28 temple sites. The values presented in this table, obtained through QGIS, indicating the actual visible height for each pair of temples, make it possible to examine whether this would have been visible in practice, after considering the distance between observer and target, and taking visual acuity into consideration. These considerations will be further analysed in the discussion section 2.5.7 page 130.

FID	Source	Target	Visible	Target Size	Distance
838	Xewkija	Ras il-Pellegrin	TRUE	0.062	14453.84
361	L-Iklin	Hagar Qim	TRUE	0.21	9256.71
773	Borg Gharib South	Bugibba	TRUE	0.496	14550.14
894	Borg L-Imramma	Ras il-Pellegrin	TRUE	0.558	13470.63
656	Bugibba	Xemxija	TRUE	0.57	3542.91
759	Santa Verna	Ras il-Pellegrin	TRUE	0.887	15966.19
130	Tarxien	Id-Debdieba	TRUE	0.947	4453.38
819	L-Imrejsbiet	Ras il-Pellegrin	TRUE	1.062	13401.21
779	Borg Gharib South	Ras il-Pellegrin	TRUE	1.087	13405.77
799	Borg Gharib North	Ras il-Pellegrin	TRUE	1.093	13439.87
740	Ggantija	Ras il-Pellegrin	TRUE	1.155	15712.71
487	Tal-Lippija	Kuncizzjoni	TRUE	1.17	2586.83
184	Kordin II	Kordin III	TRUE	1.281	523.93
882	Borg L-Imramma	Santa Verna	TRUE	1.321	2885.85
833	Xewkija	Bugibba	TRUE	1.386	16497.02
185	Kordin II	Tarxien	TRUE	1.422	1451.35
120	Hal Resqun	Hagar Qim	TRUE	1.722	5632.42
813	L-Imrejsbiet	Bugibba	TRUE	1.742	14638.04
319	Tar-Raddiena	Hal Resqun	TRUE	1.896	6444.8
793	Borg Gharib North	Bugibba	TRUE	2.069	14655.7
832	Xewkija	Borg L-Imramma	TRUE	2.092	1339.04
145	Tarxien	Hagar Qim	TRUE	2.233	7834.55
347	L-Iklin	Hal Resqun	TRUE	2.367	7404.03
828	Xewkija	Borg Gharib North	TRUE	2.453	2096.9
70	It-Tumbata	Hagar Qim	TRUE	2.559	5023.93
72	It-Tumbata	Tas-Silg	TRUE	2.618	6385.37
45	Mnajdra	Hagar Qim	TRUE	2.728	537.45
311	Hal Ginwi	Tas-Silg	TRUE	2.955	513.08

Table 2.6. QGIS values of visible portion of a target, temple height 6 m.
This table lists the 28 temples with TRUE results based on a target height of 6 m. The FID (Field Identification Number) which identify the numerical order based on a range of 151 theoretical intervisibility lines (ref Appendix 7.5). The Target Size indicates the visible portion in metres of a 6 m target, where it shows that the visible portions are less than 3 m.

Temple intervisibility 3 m height

The next iteration was to run the analysis again, this time based on a temple height of 3 m. It should be highlighted that this VSQ analysis of intervisibility of 3 m temple height in QGIS, as explained in 2.3.7, is a different method to using CVS from ArcMap (ref. 2.3.6 page 42). Nevertheless, it should be accentuated that the results from CVS (ref. 2.4.2 page 59) and QVS are identical as shown in the following pivot tables, Table 2.7 and Table 2.8.

Figure 2.14 left side shows the result from QGIS indicating 400 interconnecting lines (ref. Appendix 7.8) between all individual temple sites that fall inside a viewshed radius of 10 km and a temple height of 3 m. The right side illustrates the TRUE temple sites by taking the human visual acuity into consideration, resulting in 82 interconnecting visible site lines (ref. Appendix 7.7).

Table 2.7 lists the 24 temple sites with 82 visual interconnections with each other in one way or the other. This illustrates that out of a total of 35 temple sites, 24, or 68.6% do have a visual connection with each other, concluding that 11 sites do not have any visual interconnection (ref. Table 2.10 page 82).

Table 2.8 based on VSQ also lists the same 24 temple sites. However, the total of interconnecting lines is not 82 but 74, because there are eight pairs of sites that do not have any visual reciprocity with each other (ref. Table 2.10 page 82). The actual number of sites that are reciprocally intervisible is 16 (45.7 % of the total 35 sites).

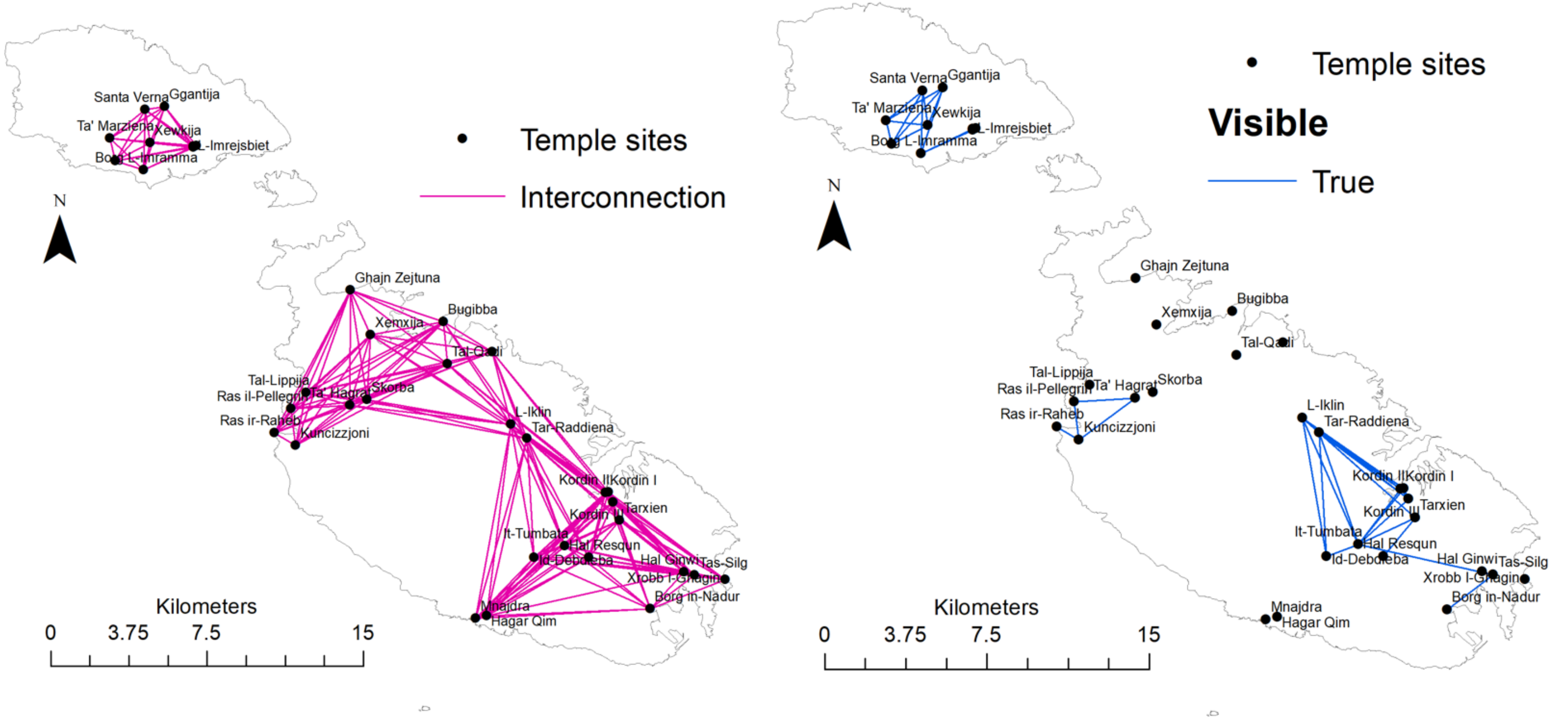


Figure 2.14. Temple intervisibility based on 3 m height.
The figure to the left shows the result from VSQ indicating 400 theoretical (TRUE or FALSE) interconnecting lines between all temple sites that fall within a radius of about 10 km. The right side displays the 82 visual TRUE interconnecting lines between 24 temple sites for which the distance between target and observer is less than 10 km.

	Target																								
Source	**Borg Gharib North**	**Borg Gharib South**	**Borg in-Nadur**	**Borg L-Imramma**	**Ggantija**	**Hal Resqun**	**Id-Debdieba**	**It-Tumbata**	**Kordin I**	**Kordin II**	**Kordin III**	**Kuncizzjoni**	**L-Iklin**	**L-Imrejsbiet**	**Ras il-Pellegrin**	**Ras ir-Raheb**	**Santa Verna**	**Ta' Hagrat**	**Ta' Marziena**	**Tar-Raddiena**	**Tarxien**	**Tas-Silg**	**Triq ix-Xabbata**	**Xewkija**	**Grand Total**
Borg Gharib North		1		1										1											3
Borg Gharib South	1			1										1											3
Borg in-Nadur																						1			1
Borg L-Imramma	1	1			1									1											4
Ggantija				1															1				1	1	4
Hal Resqun																					1				1
Id-Debdieba								1					1							1					3
It-Tumbata							1		1	1	1		1								1				6
Kordin I								1		1	1		1							1					5
Kordin II								1	1				1							1					4
Kordin III								1	1	1			1							1					5
Kuncizzjoni																1									1
L-Iklin							1	1	1	1	1									1	1				7
L-Imrejsbiet	1	1		1																					3
Ras il-Pellegrin												1						1							2
Ras ir-Raheb												1													1
Santa Verna				1																			1	1	3
Ta' Hagrat												1			1										2
Ta' Marziena					1												1						1	1	4
Tar-Raddiena							1	1	1	1	1										1				6
Tarxien						1		1					1							1					4
Tas-Silg			1					1																	2
Triq ix-Xabbata					1												1		1					1	4
Xewkija					1												1		1				1		4
Grand Total	**3**	**3**	**1**	**5**	**4**	**1**	**3**	**8**	**5**	**5**	**4**	**3**	**6**	**3**	**1**	**1**	**3**	**1**	**3**	**6**	**4**	**1**	**4**	**4**	**82**

Table 2.7. VSQ intervisibility target ehight set to 3 m.

This pivot table lists in alphabetical order, the 24 sites which showed a visibility relationship, whether reciprocal or not. The rows show the Source, indicating which temple site *can see* another site. The columns represent the Target, illustrating the sites that *can be seen* from another site. The Grand Total shows the number of interconnecting lines to be 82.

	Target																							
Source	Borg Gharib North	Borg Gharib South	Borg In-Nadur	Borg L-Imramma	Ggantija	Hal Resqun	Id-Debdieba	It-Tumbata	Kordin I	Kordin II	Kordin III	Kuncizzjoni	L-Iklin	L-Imrejsbiet	Ras il-Pellegrin	Ras ir-Raheb	Santa Verna	Ta' Hagrat	Ta' Marziena	Tar-Raddiena	Tarxien	Tas-Silg	Triq ix-Xabbata	Xewkija	Grand Total
Borg Gharib North		1		1										1											3
Borg Gharib South	1			1										1											3
Borg In Nadur																						1			1
Borg L Imramma	1	1			1									1											4
Ggantija				1															1				1	1	4
Hal Resqun																					1				1
Id Debdieba								1					1							1					3
It Tumbata							1		1	1	1		1								1				6
Kordin I								1		1	1		1							1					5
Kordin II								1	1				1							1					4
Kordin III								1	1				1							1					4
Kuncizzjoni																1									1
L Iklin							1	1	1	1	1										1				6
L Imrejsbiet	1	1		1																					3
Ras il Pellegrin																		1							1
Ras ir Raheb												1													1
Santa Verna																							1	1	2
Ta' Hagrat															1										1
Ta' Marziena					1																		1	1	3
Tar Raddiena							1		1	1	1										1				5
Tarxien						1		1					1							1					4
Tas Silg			1																						1
Triq ix Xabbata					1												1		1					1	4
Xewkija					1												1		1				1		4
Grand Total	3	3	1	4	4	1	3	6	5	4	4	1	6	3	1	1	2	1	3	5	4	1	4	4	74

Table 2.8. VSQ reciprocity target height set to 3 m.
The rows show the Source or observer. The columns show the Targets. The Grand Total is 74 interconnecting lines.

Metric differences in temple intervisibility based on 3 m height.

With reference to methodology section 2.3.3 in order to establish an outcome on how much of a 3 m high temple would be visible taking the human acuity conditioned on a radius of 10 km. The result of this investigation shows that there are theoretically 400 (TRUE or FALSE) intervisibility lines listed in Appendix 7.8, and that there are 82 theoretically (TRUE) intervisibility lines as listed in Appendix 7.7. Figure 2.14 shows the 400 theoretical visual (TRUE and FALSE) interconnecting lines as well as the 82 TRUE cases of intervisibility, whether reciprocal or not between 24 temples are presented in Table 2.7.

The 82 theoretically intervisibility lines are analysed further in Table 2.9 below. This shows nine 'TRUE' cases for which the visible target size was found to be less than 1 m of the presumed 3 m temple height. The extent to which these sites were actually visible when also taking distance and human acuity into consideration shall be further evaluated and discussed in 2.5.7 page 130.

FID	Source	Target	Visible	Target Size	Distance
176	Tar-Raddiena	It-Tumbata	TRUE	0.219	5468.02
140	Tas-Silg	It-Tumbata	TRUE	0.229	6385.37
39	Id-Debdieba	Tar-Raddiena	TRUE	0.307	5745.07
191	L-Iklin	Tar-Raddiena	TRUE	0.374	1029.42
212	Ta' Hagrat	Ras il-Pellegrin	TRUE	0.502	2809.85
210	Ta' Hagrat	Kuncizzjoni	TRUE	0.624	3239
385	Ta' Marziena	Santa Verna	TRUE	0.864	2173.16
119	Kordin III	Kordin II	TRUE	0.909	523.93
175	Tar-Raddiena	Id-Debdieba	TRUE	0.926	5745.07

Table 2.9. QGIS values of a 3 m temples with a visual portion of less than 1 m.
This table shows nine (TRUE) cases where less than 1 m of the presumed 3 m temple target height is visible at the given observer distance.

2.5 Discussion

Based on this chapter's research question which enquires whether Temple Sites were built on locations that allowed for intervisibility?, this section will draw upon the literature review (see 2.2 page 19) to offer a discussion and revision of the results obtained above. It shall compare the results of this study to earlier relevant findings, filling a gap in previous knowledge and bringing new awareness of Maltese prehistoric temples and intervisibility. The section shall be structured and follow the same order as the Methodology and Result sections, where Temples and Topography, Temple Visibility and Landscape and Temples and Intervisibility will be the main sub-sections. Firstly, an introduction on previous studies of GIS, landscape archaeology, viewscape and cosmology shall be discussed in the light of the present gap in awareness and to highlight the areas where this thesis brings new knowledge to humanity.

2.5.1 Previous studies of GIS, landscape archaeology, and cosmology

As noted in the literature review, the number of studies related to GIS and landscape archaeology in Malta is still very low when taking into consideration the impact GIS has in archaeology (Chapman 2006, Conolly and Lake 2006, Wheatley and Gillings 2002). It leaves open a significant and untouched part of Malta's archaeological history for further GIS exploration, as was the case for this Ph.D. research program. Apart from the present work, there has only been a preliminary study on visibility of Malta's megalithic temples as of today (Caruana and Stroud 2020) which was based on a DTM25m and an arbitrary temple height of 5 m, without considering the effect of human visual acuity on visibility. The present study has allowed a much more in-depth treatment of the subject.

2.5.2 Temples and topography

As explained in 2.3.5 page 38, the examination of temples and topography is not a core research area for this thesis, but more a general backdrop to how temples are topographically located in the landscape. Elements such as hydrology and availability of fresh water, distance from plain boundaries and closeness to favourable agricultural land or relationship with the sea, are not part of this study. Even as the main islands Malta and

Gozo have a great variation of relief and landforms (Gauci and Scerri 2019), this study shall treat the whole Maltese Archipelago as one single unit. The same concept has also been applied to temple intervisibility.

The results in 2.4.1 page 56 for the topographical variables of elevation, slope and aspect are here discussed in comparison with another relevant study of Grima (2004). Grima (2004: 338-341) applying GIS and Kolmogorov-Smirnov and chi-square testing, based on 28 temple sites throughout the archipelago, suggests that there is no particular preference to place a temple on high or low ground when it comes to elevation above sea level. According to Grima, the same analysis and results also apply to slope, as temples do not show any preference for locations on steeper or shallower slopes, but rather for locations near level plains.

With regard to aspect, Grima (2004: 340) maintains that the result of his study shows 'a strong predilection for locations facing south, as well as a less distinct prevalence for locations facing west'. For statistical analysis Grima applied Kolmogorov-Smirnov and chi-square testing. The following sub-sections shall examine similarities and differences between Grima's (2004: 338-340) results and the results of this study regarding elevation, slope, and aspect. Results from this study are listed in Figure 2.10 page 58, and a map illustration in 2.3.5 page 38.

Elevation

When it comes to elevation the results from Grima and this study are similar as both indicate that there seems to be no option to locate temples on higher or lower ground.

Slope

Regarding slope, there is a difference between the two studies. Grima concludes that there seems to be no priority in locating temples on steeper or shallower slopes, but there would seem to be a preference to locate sites near level plains. This study indicates that there is a larger-than-expected proportion of temple sites with slope values between 4° and 14°, with an emphasis around 7°. This indicates that there is a significant distribution of temple locations on slopes between 4° and 14° degrees, which is illustrated in Figure

2.5 page 41 where most of the temples seem to be located inside the two greenish areas of the GIS map of Malta representing a slope from 4° to 17°.

Aspect

Contrary to Grima (2004: 340), this statistical analysis of aspect is divided into two components, aspect-cosine and aspect-sine as indicated in Figure 2.10 page 58, where the site distribution is illustrated on a GIS map in 2.3.5 page 38. The aspect-cosine represents the orientation north/south, while aspect-sine illustrates east/west (ref. 2.4.1 page 56). When it comes to the aspect-cosine, the data of this study shows that there is a larger-than-expected proportion of temple sites facing a southerly direction, without specifying a south/east or south/west direction. Nevertheless, there seems to be an overall accordance with the findings of Grima, suggesting a preference of locations towards the south. It must be acknowledged that it would be interesting to explore if there is any further patterning within the south-facing locations. However, this definitely interesting research question would entail dealing with a smaller sample of 14 sites with a south aspect out of the parent dataset of 35 sites. This would in turn potentially make it more difficult to test for any statistically valid pattern.

Regarding aspect-sine, the results from this study points out that there are less temple sites than expected to be located in both west and east facing slopes. Grima (2004: 340) on the other hand suggests that there is an eminence for locations facings west, but it is less distinct than the dominance for south-facing slopes.

Reflections on findings of temples and topography

This is a topic Grima (2004) covers fully, analysing whether temple sites were chosen based on properties that were considered more suitable like distance from springs, plains and close to agricultural activity and points that gave access to the sea. When bringing new knowledge related to temple locations, the results of Grima's findings are essential information for further research, as it also was for this study. That said, this study is not primarily concerned with all possible elements as to why temples were placed on specific locations in the landscape, but mainly to answer the research question of this chapter, focusing on whether temples could have been deliberately positioned for intervisibility in its landscape setting.

There may of course have been several reasons to locate a temple at a predetermined position which we, in our modern world and with a modern mindset would not even be able to consider. Based on the results of temple intervisibility in 2.4.2 page 59 and 2.4.3 page 66, indicating a high probability that one of the factors influencing the positioning of temples in the landscape was intervisibility. Based on that, the slope degree and aspect factors may have been an influential cause of where to position the temples in the landscape.

2.5.3 Temple visibility and landscape

This section is divided into two parts as explained in methodology (ref. 2.3.6 page 42) and results (ref. 2.4.2 page 59). The first part discusses and analyses results obtained regarding temple sites and intervisibility in the landscape utilising cumulative viewshed (CVS). The second part investigates and discusses whether temples were likely to be positioned in the most inherently visible locations in the Maltese landscape, applying total viewshed (TVS).

Cumulative viewshed (CVS) and random locations

1st part, ArcMap and CVS

The first part consists of a map (see Figure 2.8 page 45) illustration of the CVS and the geographical locations of all 35 temple sites, but also applies ArcMap to incorporate 35 random points representing randomly chosen site locations. The reasoning behind this map is to give an illustrative explanation of temple visibility and the relationship between locations of temple sites and random points in a CVS presentation. In addition to this visual part, the ArcGIS calculations and numbers generated through producing this CVS in ArcMap are the groundwork and basic structure for all further analysis of temple intervisibility.

2nd part, Mann-Whitney and PAST

The importance of the statistical analysis of part two was that it has shown that locations of temple sites *do* feature higher CVS values than the locations of random points. This research then went one step further by introducing a third part to the analysis, as follows.

3rd part, intervisibility and reciprocity

The intention behind this 3rd part is to be able to give some conclusive discussion on the research question of this chapter regarding temple intervisibility, where the analysis and discussion in the above 2nd part, Mann-Whitney and PAST will be fundamental for further analysis. Based on results in 2.4.2 page 59 on cumulative viewshed and intervisibility (Table 2.2 page 63) and CVS and reciprocity (Table 2.3 page 64), this part will discuss which temples were positioned and located in the landscape allowing for intervisibility.

Table 2.2 page 63 on CVS and temple intervisibility lists 84 visible interconnecting lines between the 35 temple sites of this study. A CVS map provides a visual general impression of temple locations within regions of a landscape. Although the spreadsheet is quite detailed, the 84 visual interconnection lines only tell part of the story about temple intervisibility and do not really give rise to any concluding results besides the 84 lines. Therefore, the spreadsheet needs to be further elaborated manually, then analysed and discussed.

As mentioned above, the spreadsheet lists 84 interconnecting visible lines between a total of 35 temples indicated with a one (1). A zero (0) or an empty box represents no intervisibility whatsoever. However, without a tidy, thorough, and manual elaboration of the rows and columns with a one (1), it is very hard to detect which temples do have, or which temples do not have, a reciprocal intervisibility. The number zeros (0) in the totals of both source and target sums up to 11, indicating that there is a total of 11 sites that have no visual relationship whatsoever with another temple site. Table 2.10 lists these temples without intervisibility and the ones without visual reciprocity.

Sites without intervisibility		Eight pairs of sites without visual reciprocity
1. Ħaġar Qim		1. Kordin II and Kordin III.
2. Mnajdra		2. It-Tumbata and Tas-Silġ.
3. Xrobb l-Għaġin		3. It-Tumbata and Tar-Raddiena.
4. Ħal Ġinwi		4. Tar-Raddiena and L-Iklin.
5. Skorba		5. Kunċizzjoni and Ta' Ħaġrat.
6. Tal-Lippija		6. Kunċizzjoni and Ras il-Pellegrin.
7. Tal-Qadi		7. Borġ L-Imramma and Santa Verna.
8. Ta' Ħammut		8. Santa Verna and Ta' Marżiena.
9. Buġibba		
10. Xemxija		
11. Għajn Żejtuna		

Table 2.10. CVS non-intervisible sites.
Based on CVS analysis of 35 temple sites, the left side of the table lists 11 sites that have no visual connection with another site. The right side shows a total of eight pairs of sites without mutual visual reciprocity. This does not exclude that one of the source or target sites listed here may have a mutual visual reciprocity with other sites.

Based on the significant result from the Mann-Whitney test and illustrated in Table 2.11, that temples were not randomly located in the landscape and that more than two-thirds or 68.6% of all temples do have a visual connection to another site. This strengthens the narrative that intervisibility could have been a plausible cause where the builders wanted to locate most of their temples in the landscape. The fact that nearly half, or to be exact 45.7%, of all temples seem to have a reciprocal intervisibility between them, enhances this narrative even further. Another result from this analysis is that 11 sites or nearly one-third, (31.4%) of all sites have no visual contact with another temple as listed in Table 2.10.

CVS 3 m temple height	Intervisibility Sites	Reciprocity Sites	Difference
Total intervisible sites lines	82	74	8
- Not intervisible sites	11	11	0
= Net intervisible sites	71	63	8
Sites in the study	35	35	0
- Not intervisible sites	11	11	0
- Diff. in reciprocal sites		8	8
= Net intervisible sites	24	16	8
Net intervisible sites %	68.6	45.7	22.9

Table 2.11. CVS and Intervisible sites.
This table illustrates numeric site results from Table 2.2 in the column Intervisibility Sites (sites that have a visual connection to another site) and Table 2.3 in the column Reciprocity Sites (sites that have a reciprocal visual connection). The column Difference indicates the difference in number of pair sites between the Intervisibility Sites and Reciprocity Sites quantified to 8. The lower part of the table illustrates that from 35 sites in this study, 11 sites have no visual connection to another site. When it comes to Intervisibility Sites the result is 24 sites out of all 35 sites, or 68.6%, have a visual connection. As there are eight less Reciprocity Sites than Intervisibility Sites, resulting in the fact that out to the 35 sites, 16 sites, or 45.7%, do have a visual reciprocity between them.

Speculations as to why exactly these 11 sites (see Table 2.10) should be without visibility to another site can be many. One could be that the builders may have a predestined building program to which temples should see another temple or not. By looking at the map of Figure 2.14 page 73, the right-hand side seems to illustrate a certain priority of regional distribution to temple intervisibility. One element of uncertainty to bear in mind, which was approached in 2.3.9 page 53, is that the standardized positing of GPS registrations of a temple site would or could change the result of sites being, or not be visible. Another limiting factor as registered in the table of temple heights (see Table 2.1 page 34) is that they do have various heights and not an assumed 3 m as used here for all temples. ArcMap and CVS calculations do not concede computing individual temple heights. This limitation was addressed in the next step of the analysis by using VSQ, the QGIS *Viewshed Analysis* plug-in (ref. 2.3.7 page 47) allowing an estimation as to how much of a target is actually (TRUE) visible, taking distance and human acuity into consideration, as further discussed in 2.5.7 page 130.

Total viewshed (TVS) and random locations

This second part of Temple Visibility and Landscape shall analyse and discuss whether temples were likely to be positioned in the most inherently visible locations in the Maltese landscape, applying total viewshed (TVS), as explained in methodology 2.3.6 page 42, and results 2.4.2 page 59. The analysis and discussion consist of two parts; one based on TVS and the other on statistical analysis applying Mann-Whitney and PAST.

1st part, ArcMap and TVS

The TVS in ArcMap (see Figure 2.9 page 47) illustrates the geographical locations of the 35 temple sites, but also the 35 randomly chosen locations. The colour scale shows whether these are located in raster cells with high or low visibility in the inherent landscape. The calculations and results generated through this TVS in QGIS and ArcMap, are the groundwork for the following statistical inferential analysis.

2nd part, Mann-Whitney and PAST

As explained in 2.4.2 page 59, the results from the two-tailed Mann-Whitney Univariate statistical test shows that the TVS temple sites tend to have larger values than the TVS random sites. This means that temple sites tend to coincide with locations featuring higher TVS values than the random site locations. As indicated in Figure 2.12 page 65, the p-value from the test is 0.013637, implying that there is only a probability of 1.36% that the temples are randomly located, with a 5% margin of error. The Boxplot chart indicates that the TVS of temple sites tend to feature higher values than the TVS of random sites. These statistical results show that the probability of randomly locating the temples by their builders is extremely low and suggest that the builders probably would have had a planned schedule where to erect the temples in order to have the most inherent visibility in the wider landscape of the archipelago. In other words, they apparently placed their temples in inherently better locations so they could be more conspicuous in the landscape, probably as a part of an inherent concept of viewscape.

2.5.4 Temple visibility in Qrendi region

This section and the following two sections (2.5.4 ,2.5.5, 2.5.6) will complement the foregoing analysis by focussing on three specific regions, an exploring the visual relationships between those sites through GIS as well as ground-truthing by first-hand observations from multiple points in the landscape. The main reason behind the choice of these three specific regions was that they are still relatively unobstructed by modern building development, allowing a meaningful ground-truthing exercise.

The Qrendi region section presents the results of an additional exercise that was conducted specifically where two temples, Mnajdra and Ħaġar Qim, are located. In this region, three sets of analysis shall be done. One is related to intervisibility between Ħaġar Qim and Mnajdra. The second is regarding Ħaġar Qim's location and its intervisibility in the Qrendi region and with temples in southern part of Malta. The third is analysing an intervisibility situation on a hypothetical relocation of Ħaġar Qim, and finally a reflection on the various findings.

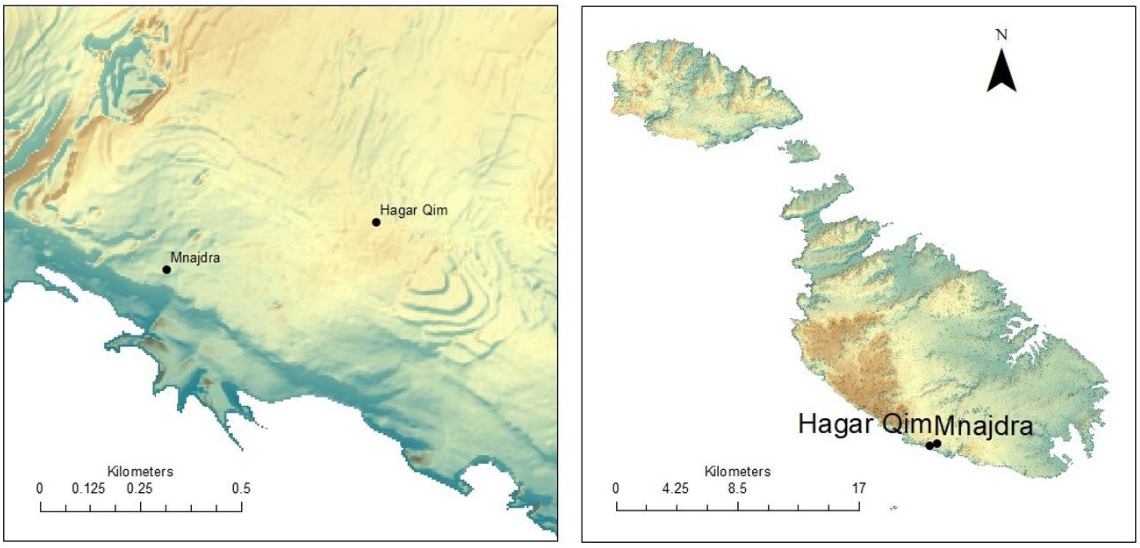


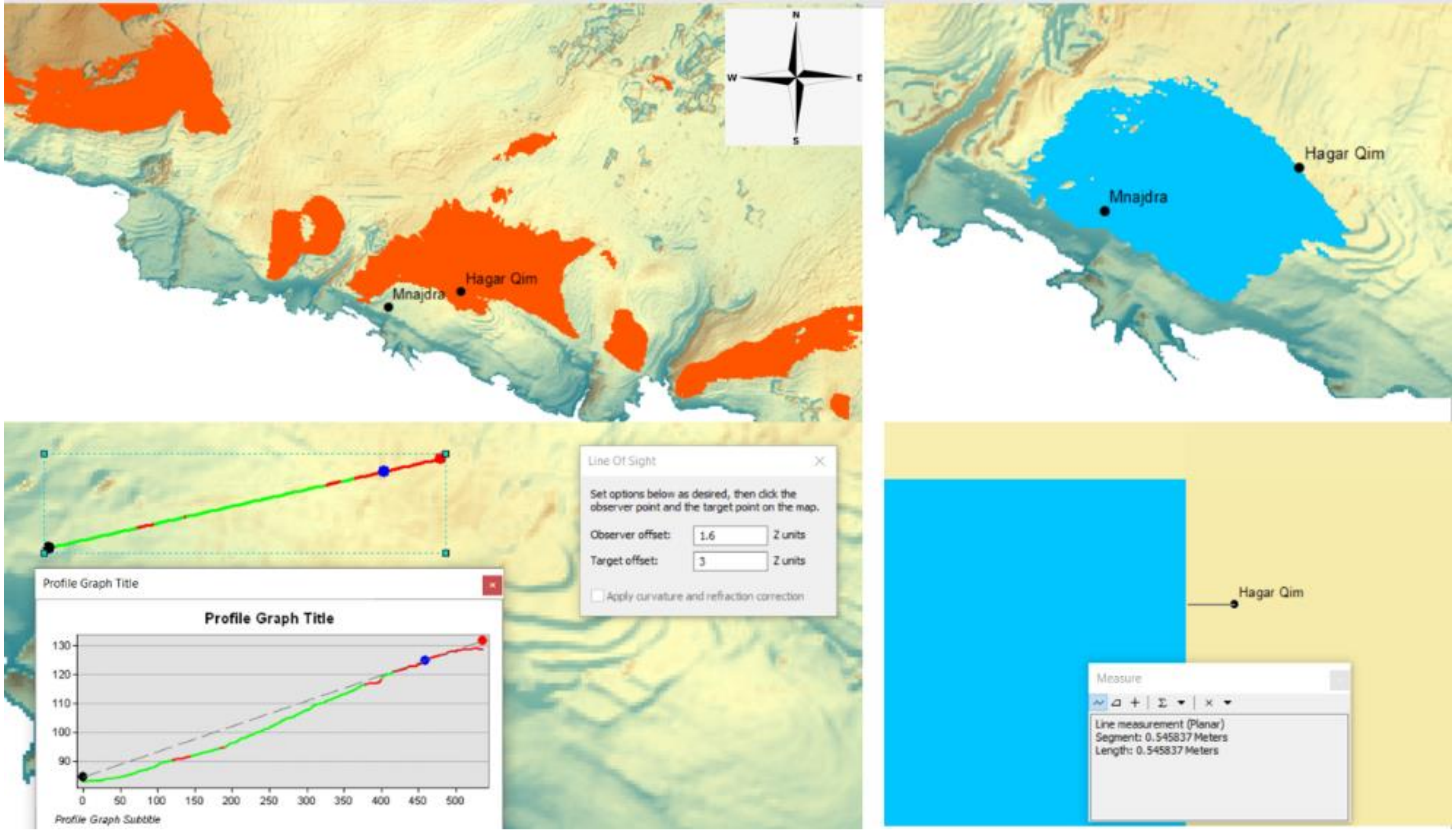
Figure 2.15. Mnajdra and Ħaġar Qim.
The left map shows the locations of Mnajdra and Ħaġar Qim in the Qrendi region. The right map shows Mnajdra and Ħaġar Qim's locations in Malta.

Mnajdra and Ħaġar Qim, intervisibility

In Table 2.10 page 82 both Mnajdra and Ħaġar Qim are listed as temples without visual connection to each other based on a CVS with 3 m temple heights but CVS in ArcMap does not allow for individual temple heights so this part of the study is applying a standard of 3 m.

Figure 2.16 below using a line of sight illustrates the intervisibility between Mnajdra and Ħaġar Qim, or rather the lack of it. It indicates that a 3 m structure at Ħaġar Qim would be just outside (by about 0.5 m) the viewshed from Mnajdra (in blue colour), and consequently would not be visible from Mnajdra. A possible scenario could be that if the GPS registration of Ħaġar Qim would have been about half a meter further to west, it may have been visible from Mnajdra. The figure also indicates that there is an interruption in the line of sight from Mnajdra to Ħaġar Qim. This could be caused by a modern rubble wall of about 1.6 m height which today marks the boundary of the visitor park. To an observer standing at Ħaġar Qim today, only the top part of the protective shelter, which has a total height of about 11 m, is clearly visible, as shown in Figure 2.17 below. These observations suggest that when the two megalithic monuments stood to their full original height, Ħaġar Qim would have been clearly visible to an observer at Mnajdra, but not necessarily the other way round, as Mnajdra falls around 130 m outside the viewshed of Ħaġar Qim (shown in red), and it would have been largely hidden to an observer standing immediately next to Ħaġar Qim.

In Figure 2.16 the top right part illustrates the viewshed of Mnajdra (in blue colour), which shows that Ħaġar Qim is actually on the border line of being visible from Mnajdra. The bottom right part is displaying a detailed edge format of the Mnajdra viewshed, showing a 3 m structure at Ħaġar Qim would be just 0.5 m outside the viewshed. The bottom left part is indicating the line of sight from Mnajdra, interrupted at around 60 m from Ħaġar Qim's GPS reading point. The top left shows the viewshed (in red) of Ħaġar Qim, revealing that a 3 m target of Mnajdra falls well outside the viewshed.



Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

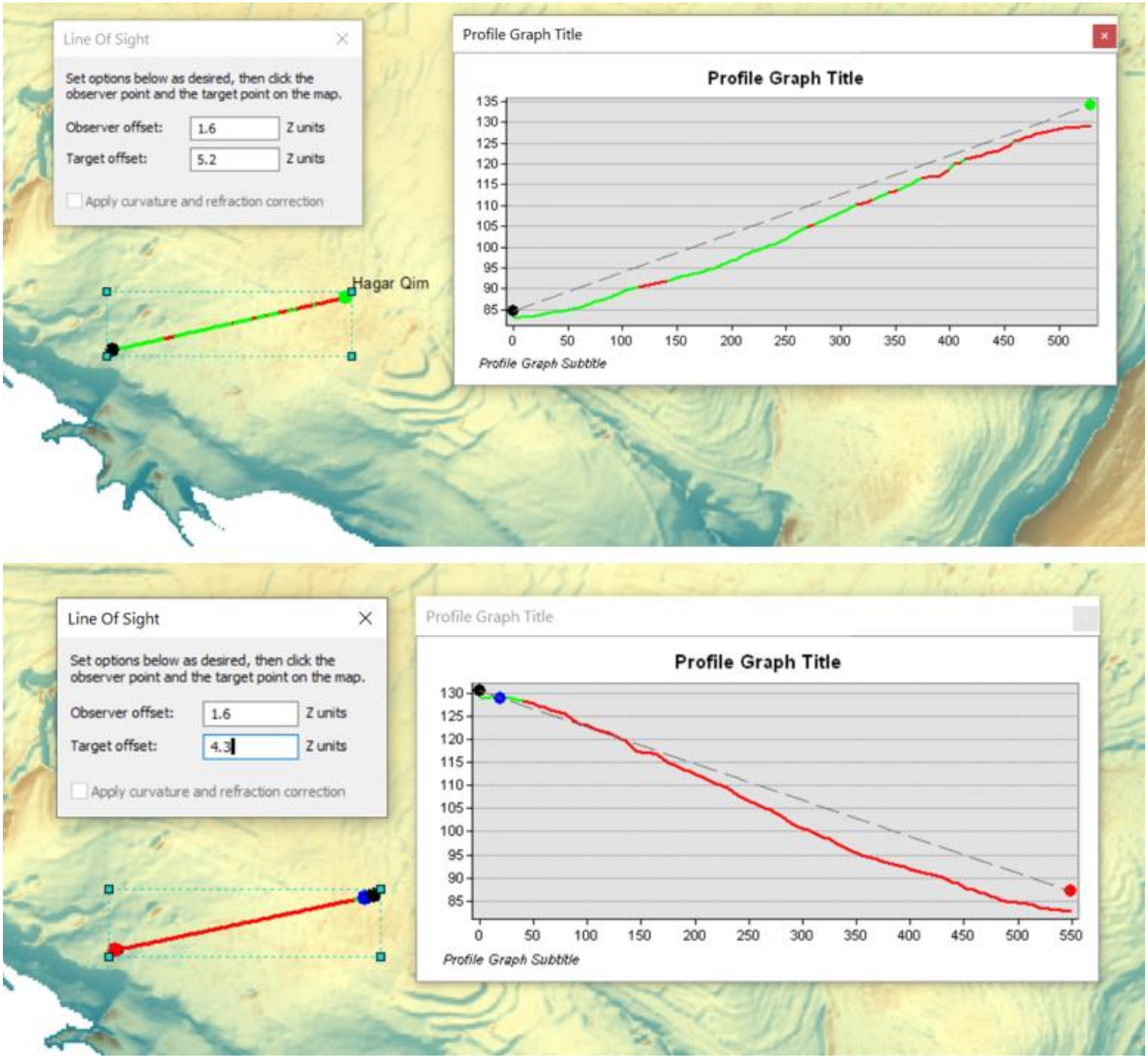
Target offset: 3 Z units

☐ Apply curvature and refraction correction

Line measurement (Planar)
Segment: 0.545837 Meters
Length: 0.545837 Meters

Figure 2.16. Mnajdra and Ħaġar Qim, intervisibility for 3 m temple height.

Figure 2.17. Mnajdra seen from Ħaġar Qim.
Photo taken from inside the compound of Ħaġar Qim. The white arrow indicates the top part of the protective cover of Mnajdra above the modern rubble wall at a distance of about 550 m with a ground level altitude of about 50 m or about 4°. Photo: Lomsdalen.



Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 5.2 Z units

☐ Apply curvature and refraction correction

Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 4.3 Z units

☐ Apply curvature and refraction correction

Figure 2.18. LoS of Mnajdra and Ħaġar Qim, actual temple heights.
Line-of-sight between the two temples based on actual present temple heights. The top graph shows that Ħaġar Qim is visible from Mnajdra (indicated by a green dot, and the green line of sight). The bottom graph shows that an observer at Ħaġar Qim cannot see the presently surviving height of Mnajdra (indicated by a red dot and the red line). Based on the actual present temple heights of Mnajdra being 4.3 m and Ħaġar Qim 5.2 m as measured by Evans (1971), the result of this exersice confirms that an observer from Mnajdra can see Ħaġar Qim, but one at Ħaġar Qim cannot see Mnajdra.

Ħaġar Qim and visibility in the landscape

Based on the 3 m temple height and a 10 km visual radius as applied in this CVS analysis, both Mnajdra and Ħaġar Qim are listed as sites without *any* intervisible connection to another site (ref. Table 2.10 page 82). As Mnajdra is located in a valley, the fact that it is not visible to other sites is not strange. But when it comes to Ħaġar Qim, since it is located at high level position of about 135 m above the sea level with a nearly 360° open landscape, gives rise to questions about its lack of intervisibility to other temples in its geographical part of Malta. Where Ħaġar Qim is located today, there is to the north/northeast a horizon of about 500-600 m away circa the same altitude as Ħaġar Qim, as shown in Figure 2.19 below. In Figure 2.16 above, the picture top left illustrates the limit of the Ħaġar Qim viewshed in a northern direction, at about 500-600 m from the site.

Figure 2.19. Ħaġar Qim and norther horizon.
This panoramic photo illustrates the north/northeast horizon about 500-600 m away from the temple site.
Photo: T. Lomsdalen

A field survey was conducted in November 2018, registering by GPS various points from public roads and areas in the Qrendi region and beyond like Mqabba and Siġġiewi prior to conducting the viewshed analysis, which eventually corroborated the first hand observations made in the field. The result concludes that a phenomenological experience of landscape observations is coherent with GIS as a scientific system. The field survey points from where a person could or would see Ħaġar Qim are represented with green dots (see Figure 2.21).

For this part of the study, the present actual temple height of Ħaġar Qim is applied and set to 5 m, with an observer height of 1.6 m which gives a visual radius of 17 km (ref. Figure 2.2 page 33). The reason behind changing the temple height from what was used in the CVS analysis of 3 m is that there was sufficient evidence that this particular building would probably have stood to an even greater height originally, so for this specific exercise, 5 m is still a conservative value.

A challenge to see Ħaġar Qim from the neighbouring landscape comes from modern vegetation. This results in that often only the top part of the about 9 m high white protective covering tent was visible (see Figure 2.22). Regarding the view of Ħaġar Qim from Qrendi, Mqabba, and Siġġiewi, the visibility was hampered by modern buildings, but they fall clearly outside the blue zone of the viewshed (ref. Figure 2.21). Ħaġar Qim's north/northeast horizon is probably causing hindrance of a wider intervisibility in the regional landscape. Ħaġar Qim's view is restricted by the topography as Figure 2.21 indicates.

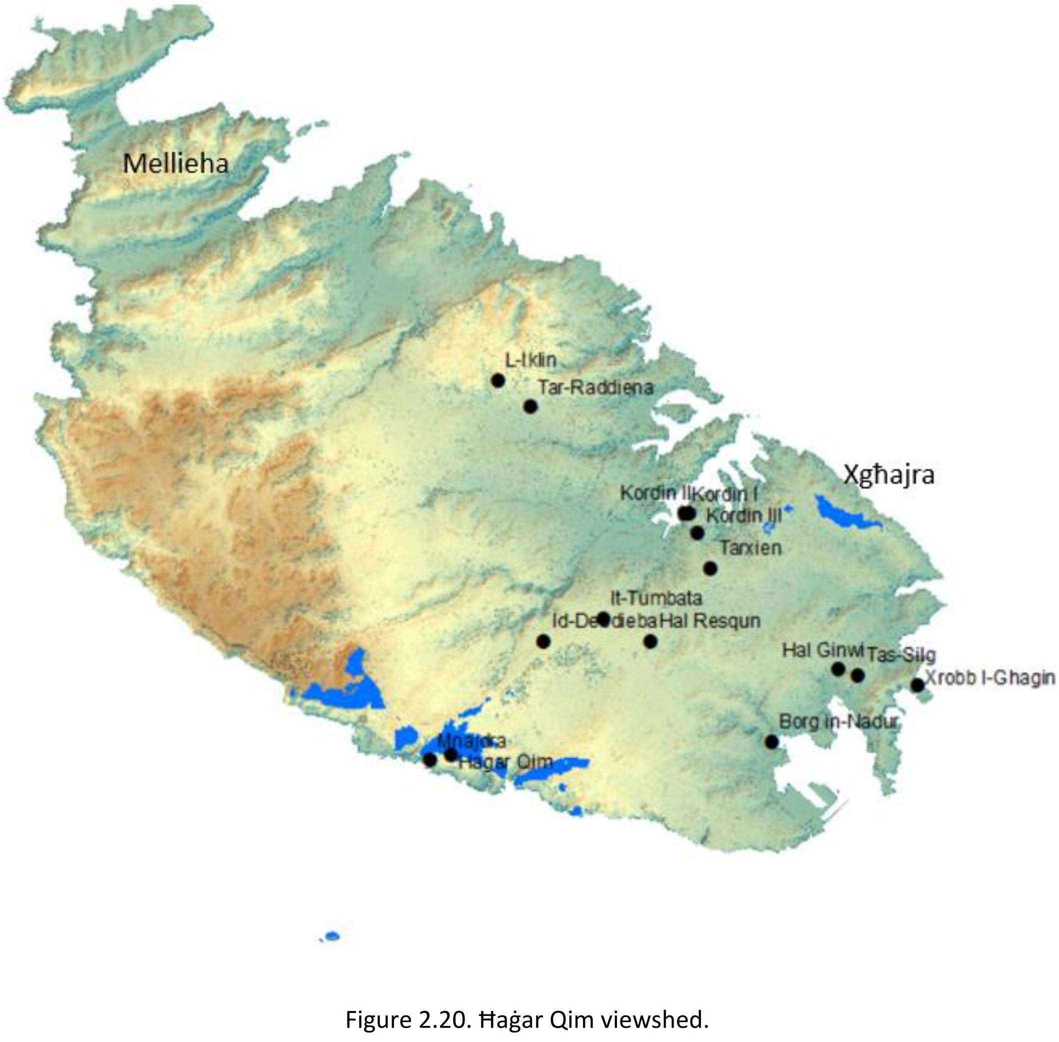


Figure 2.20. Ħaġar Qim viewshed.
This blue coloured Ħaġar Qim viewshed is based on an observer height of 1.6 m, target height of 5 m and a visual radius of 17 km. This figure clearly shows how diversified Ħaġar Qim's viewshed is. It is a locally emphasised viewshed which is largely limited within a 3 km radius. The exception is a smaller area of about 11 km away to the northeast, about 300 m wide and 1.5 km long, in the Xgħajra region where there are no prehistoric temples recorded. Filfla island is some 5 km away from Ħaġar Qim and is also within the viewshed. The maximum distance of 17 km from Ħaġar Qim reaches nearly up to the very northwest end of Malta island, namely to the Mellieħa area.

Going from a broader to a narrower depiction of Ħaġar Qim's location and intervisibility, the next part of the argument will look more closely at the observation points (green dots) inside the blue zone of the viewshed. This is done by combining analysis from Figure 2.21 and Figure 2.22 below. Figure 2.21 shows the results of an exercise to test and compare the viewshed results with first hand testing on the ground. Ten observation points from where it was established by in person vistas in the field that Ħaġar Qim can be seen. The most easterly point P1 has a distance of about 800 m and the most westerly P4 is about 500 m from the temple site, and both are about 100 m inside the main viewshed area. The non-reciprocal nature of intervisibility was indicated that P3 falls outside the viewshed by about 25 m, though Ħaġar Qim was slightly visible from the observation point. P3 is at a distance of about 1.2 km placed at the foot of a hill formation where Qrendi Water Reservoir is located. All other observation locations are near the limits of the core viewshed with about 100 m distance. Out of all ten observation points, four (P1, P3, P4 and P10) have been selected for a photographic representation based on their somehow extreme positions within the main viewshed area (see Figure 2.22).

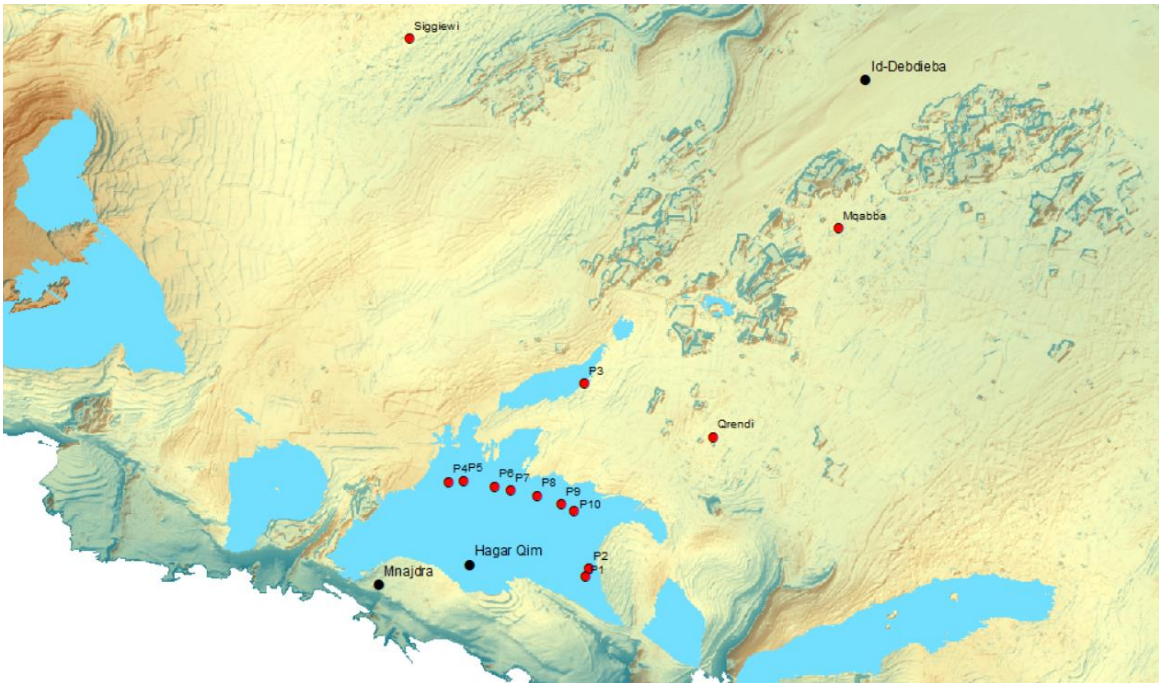


Figure 2.21. Ħaġar Qim's visibility in the landscape based on 5 m temple height.
The blue coloured areas are the single viewshed seen from Ħaġar Qim represented by a black dot. The red dots are the observation points of a potential visual connection with Ħaġar Qim. All points were GPS registered in the field. Points within the blue viewshed area are in addition photographically documented (see Figure 2.22).

Figure 2.22. Ħaġar Qim and visual points in the landscape.
Top left: Ħaġar Qim from observation point P1 about 800 m away. Top right: view from P3, at a distance of about 1.2 km. Inset: detail of the temple as seen from this viewpoint. Bottom right: the temple seen from P4 at a distance of about 500 m. Bottom left: taken from P10 at a distance of about 630 m.
Photos: Lomsdalen.

Figure 2.23. Google Earth map of Qrendi region.
This Google Earth map indicates the observation points as yellow pointers in the wider landscape.

Ħaġar Qim's 5 m and intervisibility

As Figure 2.20 illustrates, the viewshed from Ħaġar Qim does not included any other temple site when based on VSA of 3 m temple height. Table 2.2 page 63 also confirms that Ħaġar Qim *cannot see* any other temple. Based on the fact that Ħaġar Qim cannot see or be seen from any other temple in the CVS 3 m study though being located in a relatively high, open and not obstructed position in the wider landscape, a relevant investigation arises if temples could have seen Ħaġar Qim with its today's height of 5 m. Based on manually working through a single viewshed analysis of 5 m with visual radius within about 17 km (ref. Figure 2.2 page 33) covering 14 sites in the southern part of Malta that potentially *can see* Ħaġar Qim, the four following sites qualify (ref. Table 2.12 page 98), but it is prudent to clarify that Ħaġar Qim *cannot see* any of these four sites:

1. Mnajdra
2. It-Tumbata
3. Ħal-Resqun
4. Tarxien.

Temple chronology has also to be considered. Ħaġar Qim is listed in the Ġgantija Phase and so is Mnajdra South (and the small trefoil East Temple), but It-Tumbata, Ħal-Resqun, and Tarxien are all listed to the succeeding Tarxien Phase (Evans 1971). That these three temples from the Tarxien Phase were located by their builders for the reason to see Ħaġar Qim could have been an incentive, but this cannot be verified. Most probably, the deciding factors to locate these four temples were based more on local priorities and considerations, than a viewscape of Ħaġar Qim.

Ħaġar Qim 6 m and intervisibility

As noted, the present measured height of Ħaġar Qim is 5.2 m, but it can also be claimed that it could have been somewhat higher during the Temple Period as suggested in Table 2.1 page 34. Based on 2.4.3 page 66 and Table 2.4 page 68, where results from an intervisibility analysis taking into consideration TRUE visible parts of a 6 m target, shows that Ħaġar Qim cannot see any other site, but is visible from the following five sites:

1. Mnajdra
2. It-Tumbata
3. Ħal-Resqun
4. Tarxien
5. L-Iklin

That these five sites can see Ħaġar Qim is in a way TRUE, but only theoretical 'true'. They are all within the limits of the parameters (target 6 m and radius 20 km) applied in the VSA. To find the actual TRUE a manual analysis had to be compiled as explained and discussed in 2.5.7 page 130. This analysis consisting of recognising the visible portion of a 6 m target considering distance between the source and the target site related to human acuity of an object 20 km away from the source. The results of this analysis are listed in

Table 2.18 page 138 and Table 2.19 page 140, where Ħaġar Qim cannot see any other site, but where now the following three sites can see Ħaġar Qim:

1. Mnajdra
2. It-Tumbata
3. Ħal-Resqun

When distance and human visual acuity are taken into consideration, Tarxien and L-Iklin can no longer see Ħaġar Qim. The reason for this is as follows (ref. Table 2.18 page 138): Tarxien as a source site can theoretically (TRUE) see 2.2 m of Ħaġar Qim at a distance of 7.8 km, but by taking human visual acuity into account limiting the view of a 2.2 m object to 7.5 km, it is on the limit of *not* being observable, consequently physical intervisibility is excluded. Why L-Iklin can no longer see Ħaġar Qim is based on the same arithmetic.
L-Iklin as a source can theoretically (TRUE) see 0.21 cm of Ħaġar Qim as a target site, but since the distance between these two sites are 9.3 km, in practice there is no intervisibility.

According to this author, these various results of temple intervisibility seen in this case study of Ħaġar Qim is an example that general viewshed analyses are prone to so-called *edge effects,* as suggested by Wheatley and Gillings (2002: 209). In the case of Tarxien and Ħaġar Qim the edge effect was in kilometre distance, while with L-Iklin and Ħaġar Qim the edge effect was influenced by the target size. Based on a possible edge effect error, is the reason why an investigation went one step further adopting GIS applications as line of sight analysis in ArcMap and viewshed analysis in QGIS together with an algorithm considering human acuity. With all fairness, it should also be taken into consideration that the true height of prehistoric megalithic monuments is either not known or difficult to retrieve or estimate for general CVS analysis of several sites. In the case of Mnajdra and Ħaġar Qim, the archaeological record has references to applicable reliable temple heights.

Ħaġar Qim relocated

One of the characteristics of the immediate environs of Ħaġar Qim is that to the southeast, it is overlooked by a hillock, which is presently the site of a restaurant and car park. This begs the question that, if visibility was a significant consideration in the choice of the precise location for such a building, why was this elevation not used? A simple exercise was undertaken to examine how far intervisibility could be improved by locating Ħaġar Qim on this hillock, about 150 m to the southeast. Based on that, a CVS analysis was undertaken, employing the same input parameters as in the above-mentioned CVS study of Ħaġar Qim; observer height 1.6 m, temple height 5 m, and radius 17 km. (see Figure 2.24 below).

Figure 2.24. Ħaġar Qim relocated GPS position.
The photo shows the area of the car parking of the closed restaurant and the hypothetical position indicated with an arrow. Mnajdra is seen on the left and Ħaġar Qim with its covering tent is seen through the trees in the background. Photo: Lomsdalen.

Comparing the viewshed of this hypothetical alternative location (Figure 2.25) with the viewshed of Ħaġar Qim's true location (Figure 2.20 page 91), the relocated one not only opens up to a wider angle of view, but also makes the ground view in the northeast direction more detectable. Four temple sites would be intervisible with a temple located in this position, while Ħaġar Qim in its true location cannot see any other temples, as illustrated in Table 2.12, which shows that by relocating Ħaġar Qim, temple sites that can see Ħaġar Qim increases from four to seven, or 75%. The fact that this opportunity significantly increases the visibility and intervisibility of Ħaġar Qim, by shifting the site by only a short distance was not exploited, suggests that to be positioned on the top of a hill for intervisibility, may not have been an important consideration. A possible explanation is that the builders may have been more concerned with the visual relationship with the local environment than a wider intervisibility across the island of Malta.

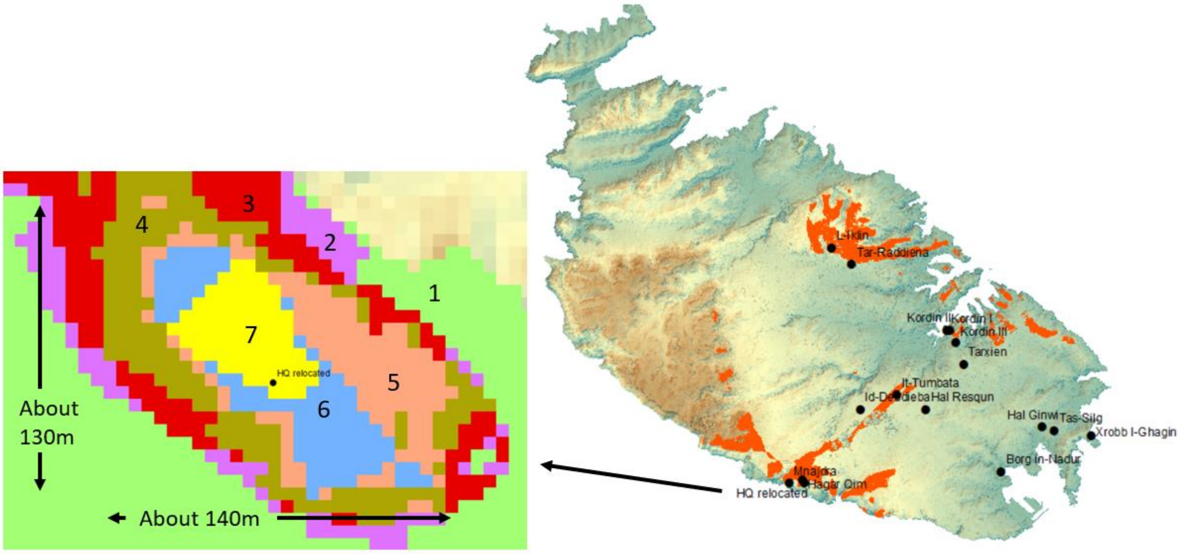


Figure 2.25. Ħaġar Qim relocated and CVS intervisibility.
The GIS map to the right shows in red colour the single viewshed from Ħaġar Qim's relocated position, and overlays four temple sites, being Mnajdra, It-Tumbata, Kordin II, and L-Iklin (ref. Table 2.12). The CVS map to the left indicates Ħaġar Qim relocated with a black dot. The raster colour scheme indicates that in this position Ħaġar Qim has s a visual intervisibility with up to seven sites, excluding itself. The number on the coloured raster cells shows how many sites are visible inside that raster area. Ħaġar Qim in its present location is not included in this analysis.

Ħaġar Qim true location		
Ħaġar Qim can see	Ħaġar Qim can be seen from	Reciprocity
	Mnajdra	
	It-Tumbata	
	Ħal Resqun	
	Tarxien	

Ħaġar Qim relocated		
Ħaġar Qim can see	Ħaġar Qim can be seen from	Reciprocity
Mnajdra	Mnajdra	Mnajdra
It-Tumbata	It-Tumbata	It-Tumbata
Kordin II	Kordin II	Kordin II
L-Iklin	L-Iklin	L-Iklin
	Ħal Resqun	
	Tarxien	
	Tar-Raddiena	

Table 2.12. Ħaġar Qim 5m and temple intervisibility.
Summary of difference in intervisibility between Ħaġar Qim's true location and Ħaġar Qim relocated.

Discussion of results from Qrendi region

The results presented above have shed new light on the intervisibility between Ħaġar Qim and Mnajdra. The intriguing question which arises here is, why was Ħaġar Qim not located in a position that commanded a better view of Mnajdra? A short distance, about 100 m southward, Ħaġar Qim have a full reciprocal view with Mnajdra, but Ħaġar Qim would then have a more restricted view in the direction of Qrendi. Pursuing the hypothesis of what would happen if Ħaġar Qim was located in a position commanding a better view of Mnajdra, it appears that people approaching Ħaġar Qim from Qrendi region (ref. Figure 2.21 page 92) would most probably see the temple considerably later than in its present location. This may suggest that for the builders it was more important for the temple *to be seen* from the Qrendi area than *to see* Mnajdra.

A point suggested by Grima (2008) that temples are located near to areas of more flat land suited for agricultural activity, in this case Mnajdra, does seem to be an exception as it is located in a sloped valley, while Ħaġar Qim fits the model well, because there is a large fairly level area extending northwards from the site. Close to Ħaġar Qim, today there are several private areas used for agriculture, but whether that was also the case during the temple period is an open question. As maritime food products did not seem to be part of Maltese prehistoric society's dietary program (Grima 2008, Richard *et al.* 2001), the closeness to the sea for maritime nutrition purposes was most probably not a reason for the builder to locate the temples here. Their locations may have been chosen based on proximity to embarking points (Grima 2005: 94). According to Pace (1996: 5) temples in Malta are located with easy access to the sea, a presumption that has been statistically confirmed by Grima (2005: 131). Grima (2005: 191) further suggests '…that there is no particular preference…' to locate temple sites in locations that have any visual contact with the sea. Based on Grima's statement, Ħaġar Qim and Mnajdra seem to be anomalous. Their visibility to other temple sites on the wider mainland is limited, but they have an ample open visual contact with a wider part of the sea, including Filfla island. This visual relationship with the sea is also reciprocal, that is the two sites are visible to seafarers arriving to that part of Malta (see Figure 2.26 below).

These considerations raise another hypothesis, which is difficult to test with any certainty. Did the visual relationship with the sea and the conspicuous Filfla island have a higher priority for the builders of Ħaġar Qim and Mnajdra than any visual contact with potential temples on the mainland? According to Farrugia Randon (2006: 43), Temple Period remains such as pottery, jars and animal bones, probably from a sailor's shrine, were retrieved at Filfla, but if it was inhabited or just visited during that period is far from clear. Regardless of what Filfla may have meant to the Temple Period people, its importance as a visual symbolic or factual representation of the Maltese Archipelago could have been a phenomenological experience in some ways comparable to how we see and perceive the islet today. Noting Filfla's visual presence seen from specific apses inside both Ħaġar Qim and Mnajdra, it is not implausible to suggest that a viewscape cosmological connotation to the islet could have been a factor.

Figure 2.26. Filfla island.
Filfla island is today situated about 4.5 km from the southwest shores of mainland Malta. On the right, both Mnajdra and Ħaġar Qim are seen with their modern white protection coverings. Photo: Lomsdalen.

2.5.5 Temple visibility in Mġarr region

This case study of the Mġarr region consists of the following six temple sites: Ta' Ħaġrat, Skorba, Ras il-Pellegrin, Tal-Lippija, Kunċizzjoni, and Ras ir-Raħeb (see Figure 2.27 below). Actually, Kunċizzjoni and Ras ir-Raħeb belongs to Baħrija, but has been included in the present exercise, because the scope is to examine temple intervisibility, and is not concerned by modern municipal boundaries. The aim of the study is not only to investigate which sites have an intervisibility, but also to find out if one or more of these sites can see or can be seen from other sites. The case study is based on the standard

ArcMap CVS analysis used in this study but shall also evaluate temple intervisibility applying QGIS to identify visible target sizes at a given site.

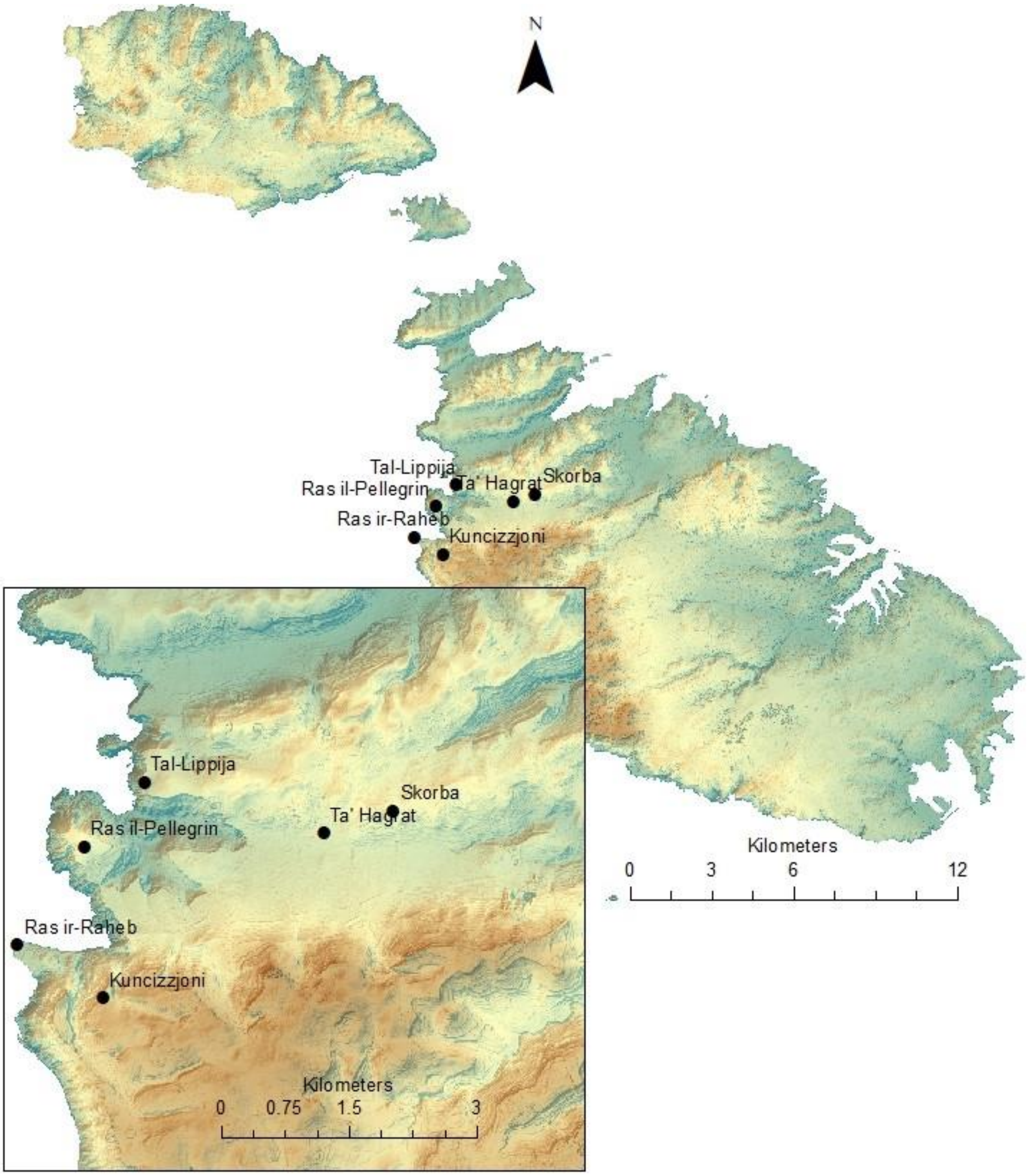


Figure 2.27. Mġarr map.
Location of the six temple sites in the Mġarr region.

Concerning which phase of the Temple Period these temples belong to, it is well documented in the archaeological record that Ta’ Ħaġrat and Skorba originated during the

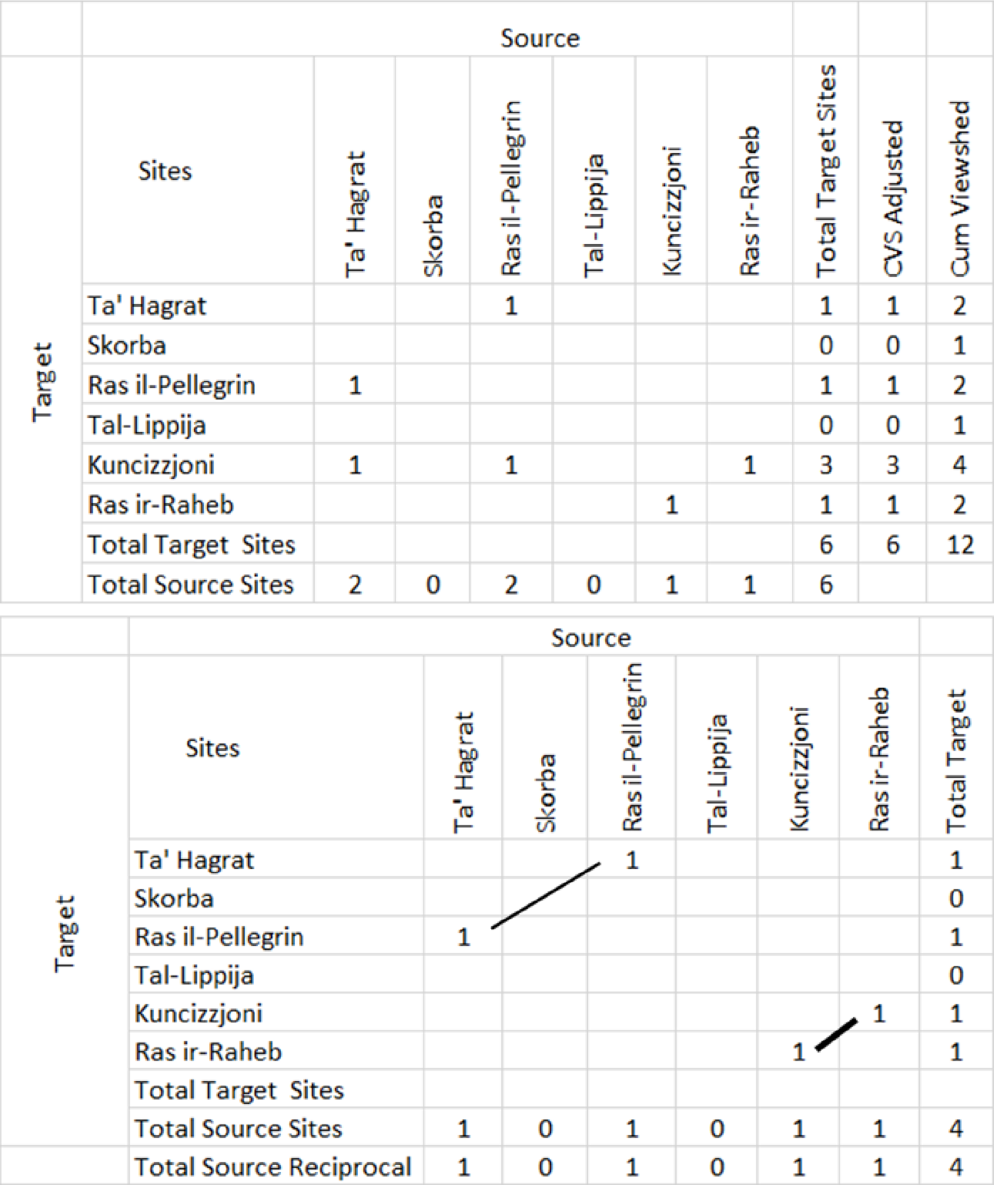
Ġgantija Phase (Evans 1971, Trump 1966a). The timeline for the other sites is more dubious as proper excavations or recordings are missing or do not exist. Trump (2002: 166) suggests that Kunċizzjoni could be early Tarxien Phase based on retrieved pottery sherds, and Zammit (1916-1921: 42) in his personal notes states that Neolithic pottery was found at the Tal-Lippija site. From a personal communication with Bonanno (2020), who attended the excavation of Ras Il-Pellegrin in the 1960s conducted by the Italian archaeologist Rita Virzi from which no records have yet been found, it might be concluded/it transpires that Tarxien pottery was retrieved from the site. As referenced here above, indications are that all other sites in the region besides Ta' Ħaġrat and Skorba were possibly built later than Ġgantija Phase. Ta' Ħaġrat and Skorba are also the only two sites with a recorded height for the surviving ruins, 4 m and 3.9 m respectively (ref. Table 2.1 page 34). Based on the uncertainty of the other temple heights, this study shall be based on the standard CVS parameters explained earlier, of an observer height 1.6 m, target height 3 m, and radius 10 km. An exception is a line-of-sight (LoS) study between Ta' Ħaġrat and Skorba as their temple heights today are recorded (see Figure 2.28 below. In addition, an examination of temple intervisibility applying QGIS (ref. 2.3.7 page 47) to identify visible target sizes at a given distance taking human acuity into consideration, shall also be discussed, in order to further explore whether a target site could actually have been visible from the given observer point.

Table 2.13 below shows the following cases of intervisibility:

- Skorba and Tal-Lippija have no visual contact with any other site.
- An observer at Ta' Ħaġrat can only see Ras il-Pellegrin, while Ras il-Pellegrin as a target can be seen from both Ta' Ħaġrat and Kunċizzjoni.
- An observer at Ras il-Pellegrin can only see Ta' Ħaġrat, and vice versa, concluding that they are visually reciprocal.
- An observer at Kunċizzjoni can see Ta' Ħaġrat, Ras il-Pellegrin, and Ras ir-Raħeb.
- An observer at Ras ir-Raħeb can only see Kunċizzjoni, demonstrating that these two sites have visual reciprocity.

The Mġarr region with six temples seems to have a special situation where temple intervisibility at first impression appears to be rather low. Firstly, out of six temples, two have no visibility to other sites: being Skorba and Tal-Lippija. Secondly, two pairs of sites are mutual visible, these being: Ta’ Ħaġrat and Ras il-Pellegrin, Kunċizzjoni, and Ras ir-Raħeb. To quantify this visual impression, the following calculation was made:

- Total possible visual interconnections are 30 based on 6 x 6 sites = 36, minus 6 which is own site.
- Total Source and Target interconnecting sites (excluding itself) are 6 each, or 20% based on the total potential of 30.
- Total Source and Target reciprocal sites are four, 13.3% based on a total potential of 30.
- Two, or one third (33.3%) of six sites have no visual connection with any other sites.



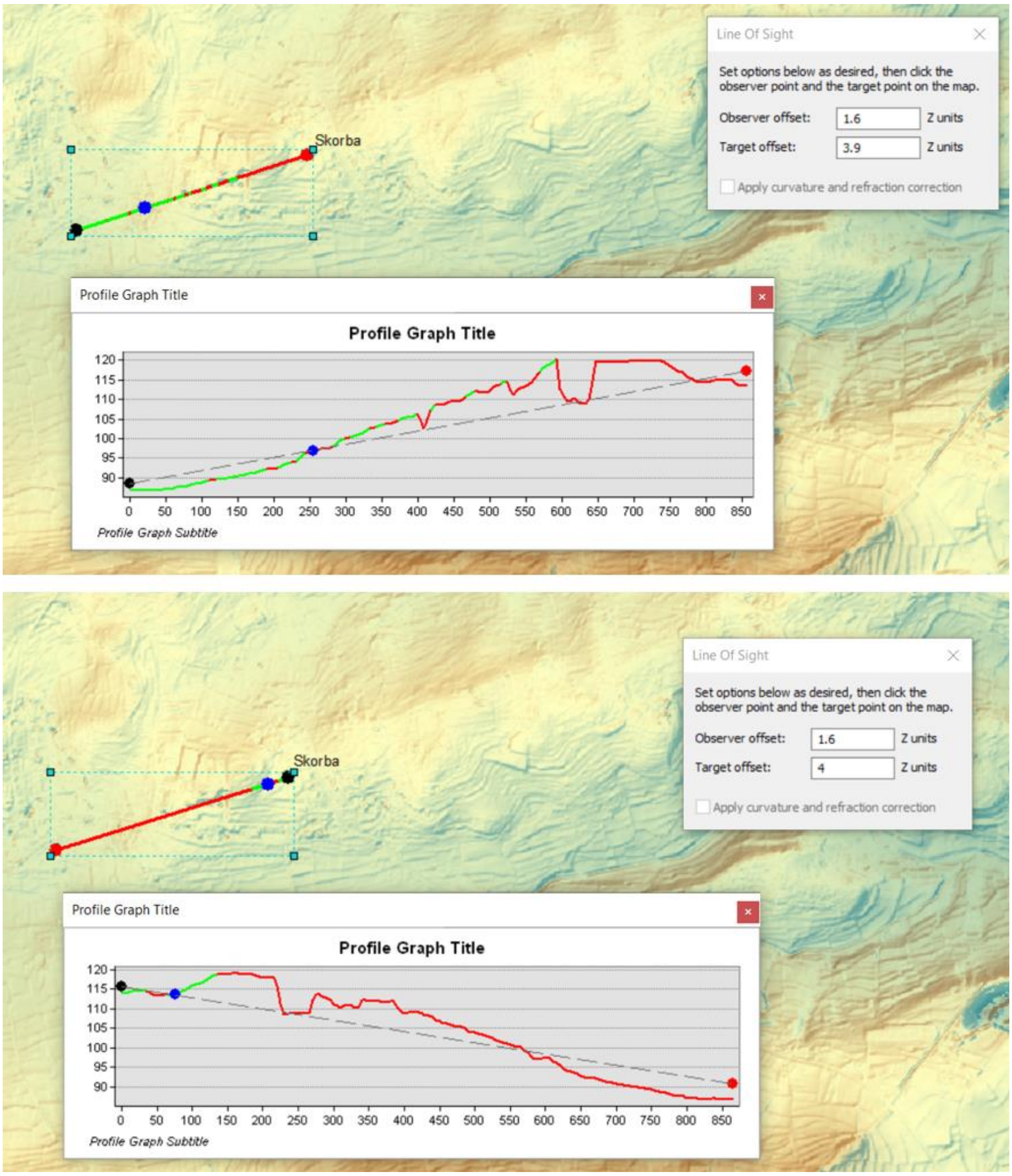
		Source								
	Sites	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Total Target Sites	CVS Adjusted	Cum Viewshed
Target	Ta' Hagrat			1				1	1	2
	Skorba							0	0	1
	Ras il-Pellegrin	1						1	1	2
	Tal-Lippija							0	0	1
	Kuncizzjoni	1		1			1	3	3	4
	Ras ir-Raheb					1		1	1	2
	Total Target Sites							6	6	12
	Total Source Sites	2	0	2	0	1	1	6		

		Source						
	Sites	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Total Target
Target	Ta' Hagrat			1				1
	Skorba							0
	Ras il-Pellegrin	1						1
	Tal-Lippija							0
	Kuncizzjoni						1	1
	Ras ir-Raheb					1		1
	Total Target Sites							
	Total Source Sites	1	0	1	0	1	1	4
	Total Source Reciprocal	1	0	1	0	1	1	4

Table 2.13. Mġarr intervisibility, CVS 3 m.
This matrix does not list the temple names with Maltese characters as it is imported into a spreadsheet from CVS in ArcMap. In both tables, the columns list the Source or observer temples from which another site may be observed, while the rows are the Target, which list the temples that can be seen from another site. The tables do not only list sites, but also intervisibility between sites represented by the value one (1). A value of zero (0) in the total illustrates that a site does not have any visual connection with any other site. In the table on the top, the last column is the sum from the CVS shows intervisibility with another site including itself with a total of 12 visible interconnections. The CVS adjusted column shows one site less as the site itself has been deducted and sums up to 6 visible interconnections. For example, an observer at Ta' Ħaġrat *can see* both Ras Il-Pellegrin and Kunċizzjoni, but Ta' Ħaġrat can only *be seen* from Ras Il-Pellegrin. The bottom table shows two pairs of sites with reciprocal views to each other as indicated with a connecting black line between them, being Ta' Ħaġrat/Ras il-Pellegrin and Kunċizzjoni/Ras ir-Raħeb.

Line of Sight (LoS) Ta’ Ħaġrat and Skorba

As noted above, Ta’ Ħaġrat and Skorba are among the oldest temple construction in the Mġarr region. As their surviving temple heights are registered in the archaeological record, and as they do not have reciprocal intervisibility, it could be opportune to plot a LoS between the sites to examine why this was the case, as illustrated and explained in Figure 2.28. For this figure the LoS is based on the actual recorded surviving temple heights, Mġarr 4 m and Skorba 3.9 m. The distance between the two sites is in a straight line just over 850 m. The top graph shows the LoS from Mġarr to Skorba and that a possible intervisibility is interrupted as the red line goes above the dotted line where the blue point is at about 250 m from the Mġarr site, and consequently makes Skorba not visible represented by a red dot. The bottom graph illustrates the other way around, from Skorba to Mġarr. Also, in this case the intervisibility line is hindered at about 150 m from Skorba site where the green line turns into a red one, resulting in that Skorba cannot see Mġarr.



Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 3.9 Z units

☐ Apply curvature and refraction correction

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 4 Z units

☐ Apply curvature and refraction correction

Figure 2.28. LoS Mġarr and Skorba.
This figure indicates the LoS between Mġarr and Skorba.

Temple intervisibility based on QGIS, 3 m target and distance

Based on the results from 2.4.3 page 66 and Table 2.9 page 76 listing 3 m temples with a TRUE visual portion less than 1 m, this part shall reflect and discuss to what level that would influence temple intervisibility in the Mġarr region. Table 2.22 page 145 shows nine TRUE temples with a Yes or a No for the respective source sites than can or cannot see a target site taking the visible portion of the target size, distance, and human acuity into consideration (ref. Figure 2.41 page 136). When it comes to the Mġarr region, this investigation results in that Ta’ Ħaġrat loses intervisibility with the two following sites, and in addition loses reciprocity with Ras Il-Pellegrin which is further illustrated in Table 2.14:

1. Ta’ Ħaġrat as a source site cannot see Ras Il-Pellegrin with a visible portion of the target size of 0.5 m at a distance of 2.8 km, taking the human acuity into consideration.
2. Ta’ Ħaġrat as a source site cannot see Kunċizzjoni with a visible portion of the target size of 0.6 m at a distance of 3.2 km, taking the human acuity into consideration.

		Source						
	Sites	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Total Target Sites
Target	Ta' Hagrat			1				1
	Skorba							0
	Ras il-Pellegrin							0
	Tal-Lippija							0
	Kuncizzjoni			1			1	2
	Ras ir-Raheb					1		1
	Total Target Sites							4
	Total Source Sites	0	0	2	0	1	1	4

		Source						
	Sites	Ta' Hagrat	Skorba	Ras il-Pellegrin	Tal-Lippija	Kuncizzjoni	Ras ir-Raheb	Total Target
Target	Ta' Hagrat							0
	Skorba							0
	Ras il-Pellegrin							0
	Tal-Lippija							0
	Kuncizzjoni						1	1
	Ras ir-Raheb					1		1
	Total Target Sites							
	Total Source Sites	0	0	0	0	1	1	2

Table 2.14. Mġarr intervisibility, target size, and acuity.
This Table is based on a further analysis from Table 2.13, and illustrates the visual portion of a target, distance between source and target, whilst considering the human acuity. The left side shows that as a source site Ras Il-Pellegrin can see Ta’ Ħaġrat and Kunċizzjoni, and that both Kunċizzjoni and Ras ir-Raħeb can see each other, which is further illustrated on the left side with a black line between them, indicating visual reciprocity.

Kunċizzjoni and intervisibility

Kunċizzjoni’s location draws special attention for further examination as it is has the highest elevation of the sites in the region, and an observer on this site can only see Ras ir-Raħeb, though it can be seen from three other sites, namely Ras ir-Raħeb, Ras Il-Pellegrin, and Ta’ Ħaġrat (ref. Table 2.13). Therefore, this site shall be examined based on a more detailed CVS analysis of intervisibility, while also referring to the first hand experience of the landscape.

In January 2017 Reuben Grima introduced me to the Kunċizzjoni site. After surveying and looking at the remains of the temple, we also started to evaluate the cliff-top area where Kunċizzjoni is located, moving in a northerly direction towards Mġarr. To our astonishment, we reached a point from where all six temple sites in the Mġarr region were visible (see Figure 2.30 below). For the record, this phenomenological experience of making this discovery of a location from where all six temples can be seen, was prior to the commencement of any GIS work in the Mġarr region by this author. Later when doing CVS analysis, the location identified on that occasion was examined and defined using GIS (see Figure 2.29). This is another example of using GIS not only as a recording and display system, but also as powerful analytical tool to identify quantitively a geographical position in the landscape based on personal observation. In Chapter 4 an example of the reverse process is also explained, where a GIS viewshed helps the author not only to establish, but also to discover a celestial orientation of Ħaġar Qim.

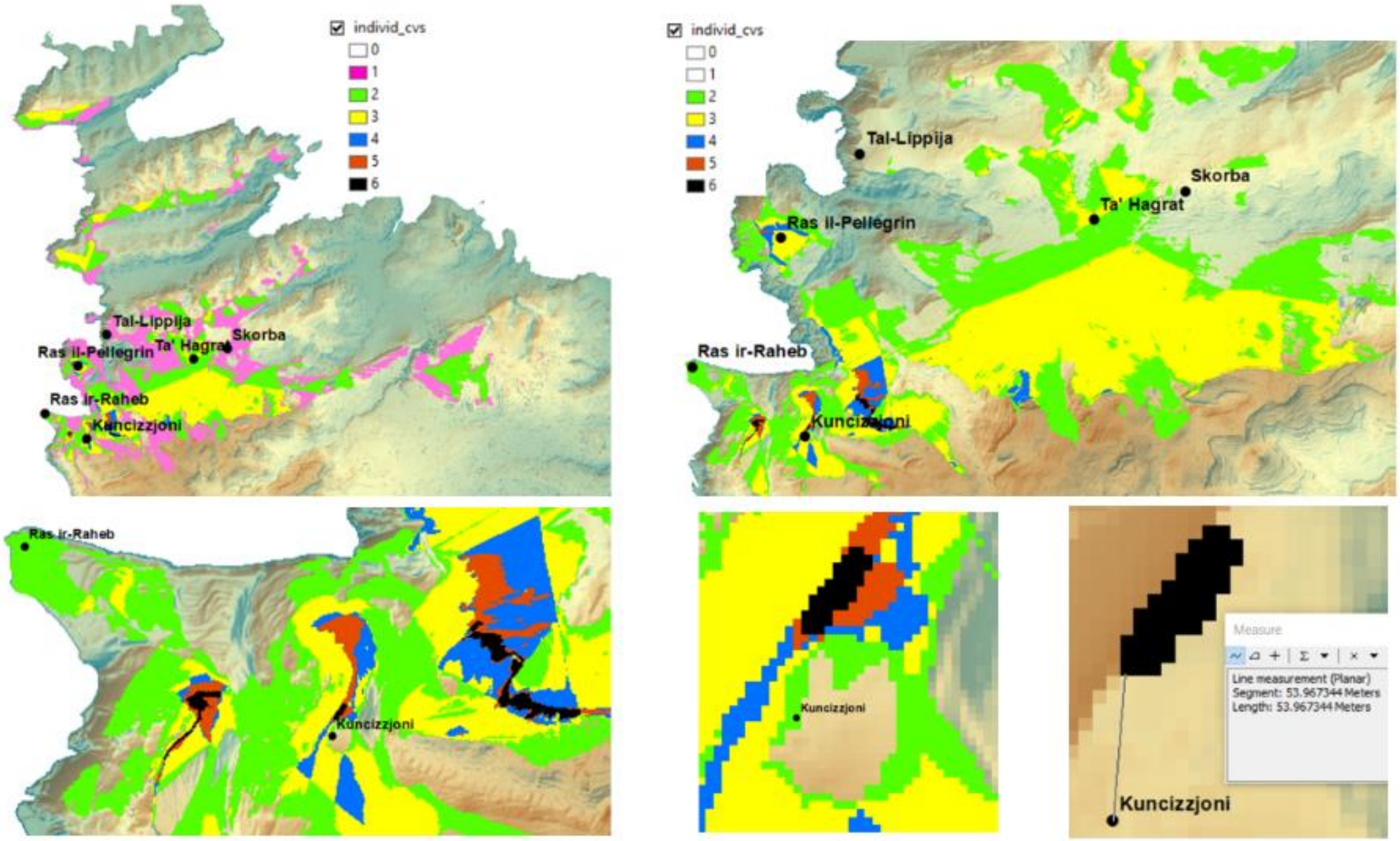
Kunċizzjoni relocated

To examine the Kunċizzjoni site more closely, a detailed CVS was developed and shown in Figure 2.29. Based on the detailed and enlarged raster cells of the CVS, two engaging areas of information were obtained. Firstly, the identification and delimitation of the geographical position from where all six temples in the region were visible.

Secondly, the enlarged CVS of the Kunċizzjoni site shows that if the temple had been located about 50-60 m further to the north than its actual location, it would have had intervisibility with all the other five sites in the area. An intriguing question in this context is, why did the builders not locate the temple a few meters further up on the cliff if intervisibility was their core concern? As there is a clear *no* to this question, there must have been other reasons behind this location rather than intervisibility. This may have indicated by some of the other landscape variations explored by Grima (2005) and Albert *et al.* (2019). If the use of fire to create a beacon in night time or smoke in daytime may be admitted as a possibility, having a short distance between the megalithic monument and the ideal space to locate such a fire would also seem plausible.

A second alternative explanation is that, instead of searching for more general intervisibility, it could be that the builders were more concerned to have a focused visual contact with certain temple sites. As an observer at Kunċizzjoni, since it can only see Ras ir-Raħeb with which it has a reciprocal view, it could be that these two sites had their own local frame of reference distinct from the rest of the region. A third possible cause could also be the importance related to the summer solstice sunset, which has a visual interplay with Ras ir-Raħeb. Around the time of the summer solstice, an observer watching the Sun set from Kunċizzjoni, sees it set into the sea behind Ras ir-Raħeb, while the Sun's rays reflect off the sea directly over Ras ir-Raħeb (see Figure 2.31). It is questionable if such a phenomenon could have been observed if Kunċizzjoni was relocated further north, as the apparent position of the sunset and the two sites would no longer be in line. Regarding Ras ir-Raħeb, it is relevant to be aware of that in any discussion of this site, we must bear in mind that the date of the two megaliths is far from certain. A fourth possible explanation for its location could be for establishing an intervisibility with temple sites in Gozo. This possibility is further elaborated on in next section 2.5.6.

In Figure 2.29 the following CVS maps are presented:
Top left: CVS of the Mġarr area and northern Malta. The legend of individual CVS shows the colour ramp from one to six sites. Top right: detail of the Mġarr region with CVS adjusted, i.e., VS of own site is not included. Bottom left: CVS adjusted of wider Kunċizzjoni site. Here the three black raster areas are from where all the six temples in Mġarr region would be visible. Bottom centre: CVS adjusted for Kunċizzjoni. Bottom right: detail showing distance of about 55 m north from Kunċizzjoni to the nearest black raster area where an intervisibility with all six sites would be possible. The black raster area is about 60 m long.



Line measurement (Planar)
Segment: 53.967344 Meters
Length: 53.967344 Meters

Figure 2.29. Kunċizzjoni and intervisibility.

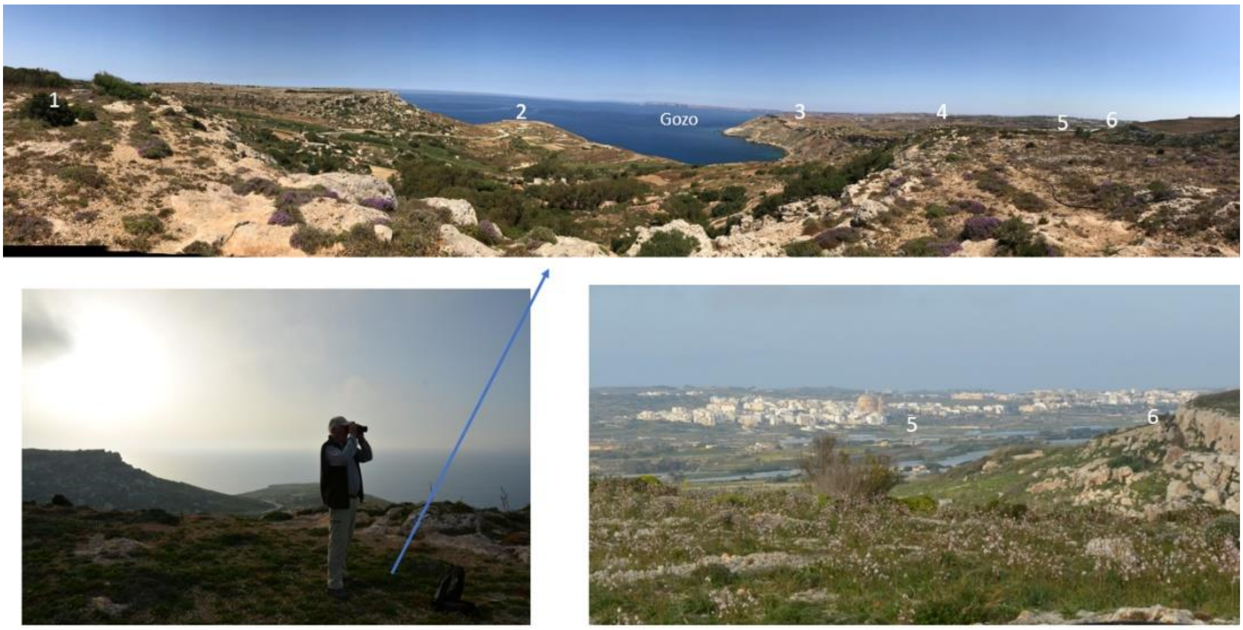


Figure 2.30. Mġarr, six temples intervisibility point.
Top: Panoramic photo taken from the location identified about 55 m to the north of Kunċizzjoni. The numbers indicate the following six temple site locations: 1. Kunċizzjoni, 2. Ras ir-Raħeb, 3. Ras il-Pellegrin, 4. Tal-Lippija, 5. Ta' Ħaġrat and 6. Skorba. Gozo is also visible. Bottom left: author standing at the point (shown with a blue arrow on the panoramic photo) from where it is possible to view all six temples. Bottom right: detail from the panoramic photo showing Mġarr and Skorba, where Ta' Ħaġrat temple site is visible, but the Skorba temple site is hidden by modern buildings. All photos taken by Lomsdalen, except bottom left, taken by F. Silva in March 2017.

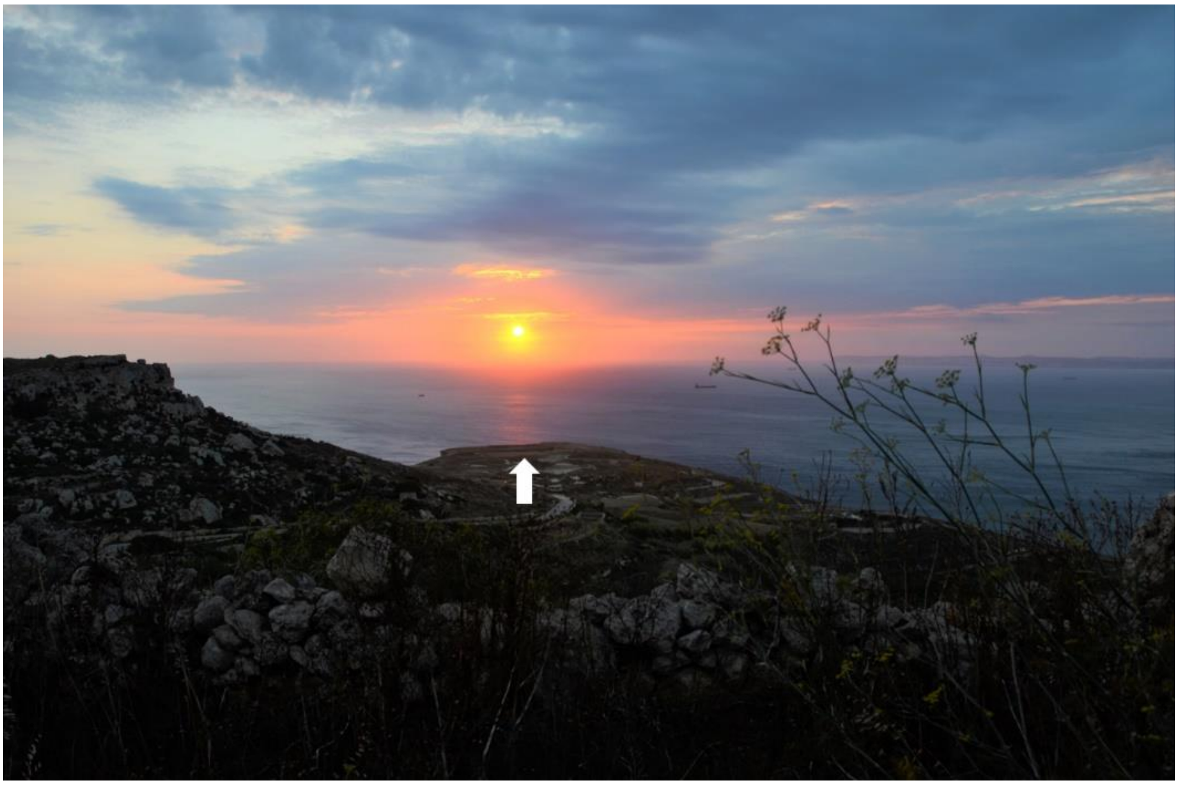


Figure 2.31. Summer solstice setting seen from Kunċizzjoni.
This photo was taken from Kunċizzjoni temple site on 18 June 2017 as the summer solstice Sun sets over the sea, creating a band of reflected light which appears vertically above Ras ir-Raħeb site located close to the cliff-edge, indicated with a white arrow. In the background to the right, Gozo is visible at a distance of about 15 km. Photo: T. Lomsdalen.

Reflections on the Mġarr region

From a modern perspective, to be a part of, or to be in the Mġarr region is a spectacular and engaging phenomenological landscape experience. This is also noted by Grima and Vassallo (2008), with a special effect by visual connection when approaching the valley formation of the Mġarr region. Various areas of this region were surveyed and visited a number of times either by the author alone or accompanied by colleagues with local knowledge such as Mario Vassallo and Reuben Grima.

A focus of this study is temple locations and visual connection both in the landscape and to other temples. With reference to Table 2.14 page 107, a striking point is that there are two temples that have no intervisibility to other temple sites, namely Skorba and Tal-Lippija. Tal-Lippija is located on a cliff-edge and according to Zammit (1916-1921: 42) part of the temple seems to have fallen off the cliff towards the sea. The site has an open sea view to the west and north-west, with a view of Gozo some 15 km away, a similar situation as Kunċizzjoni and Ras ir-Raħeb. Based on a temple height of 6 m, Tal-Lippija and Kunċizzjoni could theoretically have an intervisibility with five and seven temple sites respectively (see Table 2.4 page 68). This raises a potentially higher significance of visual connection with Gozo temples than with regional temple sites, and hypothetically could have been a decisive factor for locating Kunċizzjoni where it is, and not some 50 m further to the north where it could have had reciprocal intervisibility with all six sites in the Mġarr region (see Table 2.14 page 107). In this case, Kunċizzjoni would have been highly conspicuous in the wider landscape and been a clearly defined viewscape target of the Mġarr region. A further reflection to this scenario could be that the builders of Kunċizzjoni and Ras ir-Raħeb wanted to distance themselves from the other temples in the Mġarr region, based either on geographically inaccessible distances, or on differing socio-political opinions, ideologies or concepts of belief systems and a cosmology.

Skorba on the other hand, is located in a hilly formation with a southern open view, but remote from intervisibility with other temples. According to Trump (1966a: 10-11) the excavations at Skorba showed the site had been in occupation since the Għar Dalam Phase, when the first known settlers arrived from Sicily. Based on this scenario, the first settlers were probably more concerned about life sustainability elements than visibility.

If these monuments were constructed and designed for the purpose of religious feasts, ceremonies, and gatherings as have been suggested (Malone and Stoddart 2013: 64, Sagona 2015: 91, Skeates 2010: 156, Tilley 2004: 92, Trump 1972: 24, Zammit 1929a: 46), the pre-Temple Period shrine at Skorba could have be an initiation of the Temple Period’s belief system and worldview. The temples themselves became not only a symbolic, but also a physical representation of a society’s cosmology integrating a liaison with their ancestors. For the record, this is a hypothetical question of which there is not, and never likely to be any proven answer to in the foreseeable future. Nevertheless, it is an essential topic to tackle based on archaeological recordings from Skorba excavation in relation to cosmology of Temple Period Malta, as it is the core topic of this research program.

Regarding temple viewscape, the Mġarr region as already noted, does not seem to have put this concept at a high priority. Ta' Ħaġrat on the other hand, even though it is located on the lower part of a northern hill formation, would most probably have been conspicuous and standing out as a megalithic monument visible from the slightly lower flattish open agricultural land formation and also from the wider neighbouring environment. Ta' Ħaġrat would most likely have been a prominent local landmark close to life sustainable resources (was primarily a dwelling site (Trump 2002: 182)), being an object of viewscape connected to the local society's cosmology. Another site that falls inside this viewscape category is Ras il-Pellegrin. It is located not at the top but on the higher elevation of the Pellegrini hill overlooking most of the Mġarr valley. The temple would be highly conspicuous in the wider local landscape, a scenario similar to Kunċizzjoni as already noted.

2.5.6 Temple visibility in Gozo region

This section examines another regional case study, the Gozo region, which includes the following nine temple sites from the Temple Period: Ġgantija, Santa Verna, Borġ Għarib South, Borġ Għarib North, L-Imrejsbiet, Xewkija, Triq ix-Xabbata, Ta' Marżiena, and Borġ L-Imramma (Figure 2.32 below). The aim of this study is to investigate which sites have intervisibility, and to find out if one or more of the sites *can see* or *can be seen* from other sites (Figure 2.33 below). As there is a measured height of 7.5 m, for the surviving ruins at Ġgantija (ref. Table 2.1 page 34), an additional viewshed examination shall be done with focus on this site based on from where Ġgantija can be seen in its surrounding landscape. Daniel Cilia who possesses a thorough local knowledge of prehistoric archaeological sites on Gozo, has been a valuable support to identify and register the partly destroyed temple sites on the island.

The chronology of the temple sites in Gozo is not straightforward. Besides Ġgantija, Santa Verna, and Xewkija, where excavation has yielded pottery sherds predating the Temple Period, none of the other sites have been properly excavated (Evans 1971: 170-192, Magri 1906, McLaughlin *et al.* 2020a: 32, Trump 2002: 170-187). Santa Verna, Ġgantija and Xewkija were probably the earliest temples in the region, already fully active in the

Ġgantija Phase, while the others have not yielded evidence of being earlier than the Tarxien Phase.

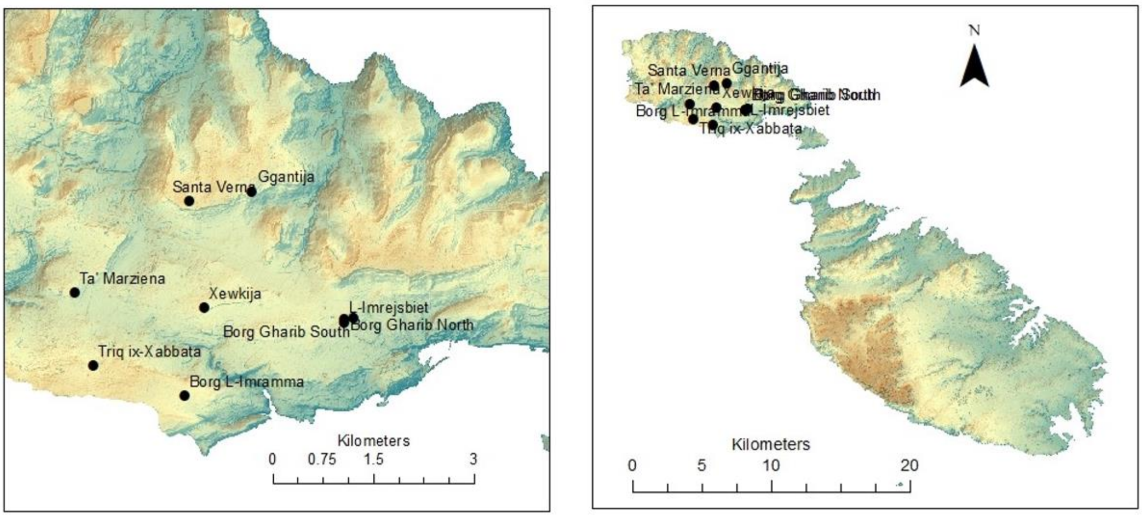


Figure 2.32. Map of Gozo temple sites.
The left map shows the locations of the Gozo temple sites, and the right one the Gozo temple sites within the archipelago.

Temple intervisibility

Temple intervisibility in the Gozo region will be examined in two steps. The first step is to examine the standard CVS analysis used in this study (ref. Table 2.2 page 63) based on an observer height of 1.6 m, temple height of 3 m and a radius of 10 km, and presenting temple intervisibility in a matrix spreadsheet analysis. This part of a 3 m temple height shall also be further analysed using VSA of QGIS where target size, distance, and human acuity shall be considered for verifying if an effect could influence intervisibility (ref. 2.5.4 page 85 and 2.5.5 page 100). The other part is to examine the Ġgantija in relation to from where it can be seen in its landscape from an observer height of 1.6 m, target height of 7.5 m and a visual radius of 25.8 km (ref. Figure 2.2 page 33).

CVS analysis

Figure 2.33 shows the nine temple sites in Gozo plotted against a CVS indicating with a colour ramp the number of sites that can be seen from any point. The distribution of temple sites appears to be clustered in part of the island. This will be further examined below in the matrix analysis.

The black colour in the CVS map (circled in black) shows a raster cell area from where all nine sites can be seen. The lower black area is in the Ta' Ċenċ area, a short distance from Sannat village. The author visited this location in May 2019 after the creation of the CVS in order to ground truth the black raster cell area generated by the CVS result. The black circle higher up in the image is a cliffy area next to Ta’ Kenuna Tower in Ta’ Kenuna village. Ta’ Kenuna was visited by the author prior to this CVS analysis on 22 December 2018 in connection with a physical observer analysis from where the Ġgantija temple could be seen.

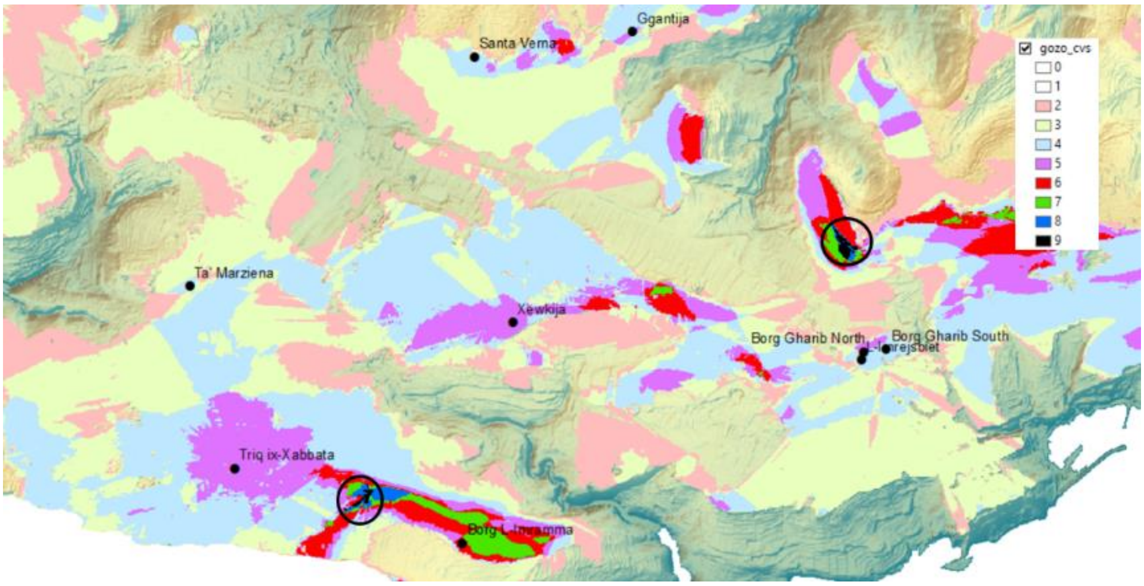


Figure 2.33. Gozo CVS.
This image illustrates CVS of temple sites in Gozo. The legend of individual CVS shows the colour ramp from one to nine sites; however, the CVS adjusted where the site itself is taken out, showing no colour for one (1). Blank cells represent raster cells where no temple site may be seen. This CVS also shows two black raster cell areas from where all nine sites can be seen (both circled in black).

CVS matrix analysis

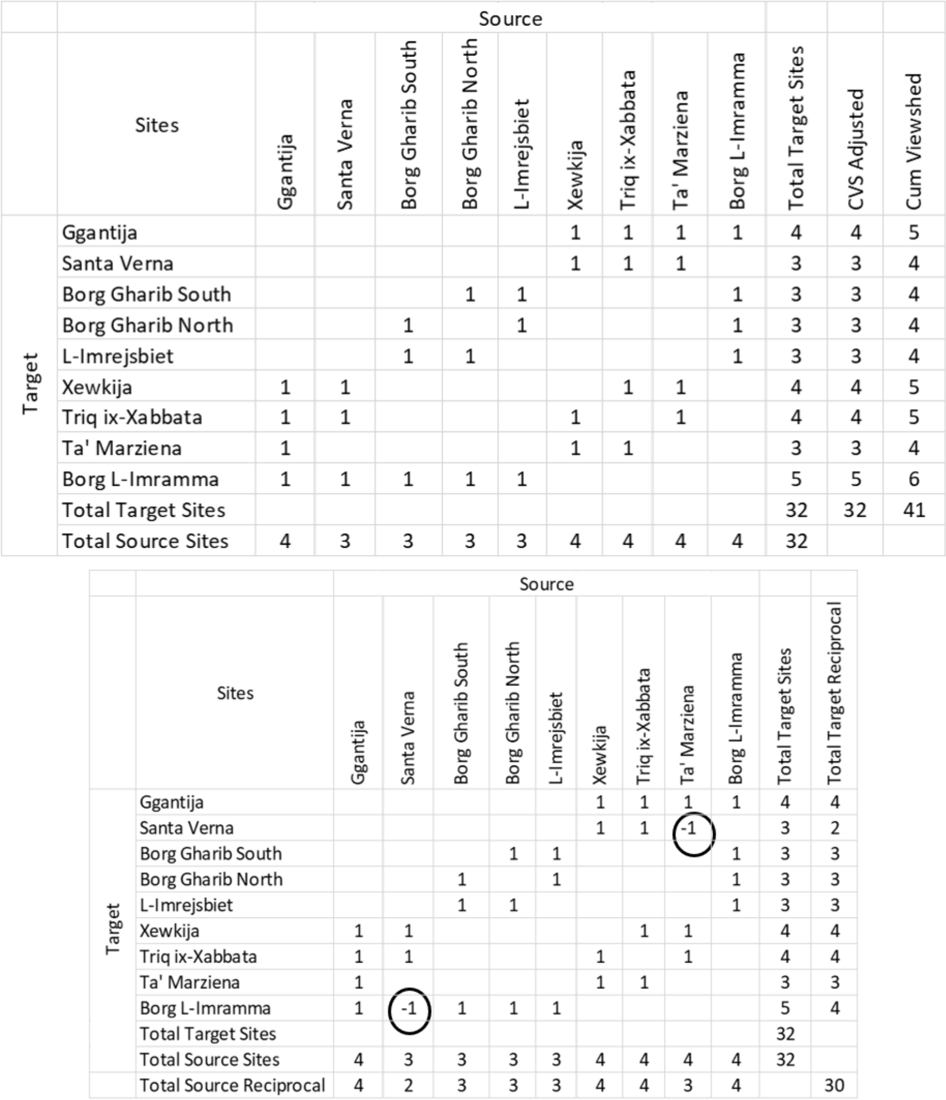
Table 2.15 below shows a total of 32 interconnecting visibility lines between the nine temple sites in Gozo. The Source lists temples where an observer *can see* another site, while the Target classify temples that *can be seen* from another site. The intervisibility of the temple sites are as follows:

- An observer at Ġgantija can see four sites; Xewkija, Triq ix-Xabbata, Ta’ Marżiena and Borġ L-Imramma, and Ġgantija can also be seen from the same four sites, meaning they have a visual reciprocity.
- Santa Verna can see three sites, Xewkija, Triq ix-Xabbata, and Borġ L-Imramma. Santa Verna can also be seen from three sites; Xewkija, Triq ix-Xabbata, Ta’ Marżiena, but not from Borġ L-Imramma. This concludes that Santa Verna has visual reciprocity with Xewkija and Triq ix-Xabbata, but not with Ta’ Marżiena and Borġ L-Imramma.
- The temple sites Borġ Għarib South, Borġ Għarib North and L-Imrejsbiet with a geographical hub-like formation are all mutually intervisible with each other, but these sites also have visual reciprocity with Borġ L-Imramma, but no visual contact with other sites in Gozo.
- Xewkija can see four sites; Ġgantija, Santa Verna, Triq ix-Xabbata and Ta’ Marżiena, and Xewkija can be seen from the same four sites, making them all mutually intervisible.
- Triq ix-Xabbata can see four sites; Ġgantija, Santa Verna, Xewkija and Ta’ Marżiena, and Triq ix-Xabbata can be seen from the same four sites which make them visually reciprocal.
- Ta’ Marżiena can see four sites; Ġgantija, Santa Verna, Xewkija and Triq ix-Xabbata, but Ta’ Marżiena can only be seen from three sites which are the same sites, except Santa Verna indicating that there is no visual reciprocity between Ta’ Marżiena and Santa Verna.
- Borġ L-Imramma can see four sites; Ġgantija, Borġ Għarib South, Borġ Għarib North and L-Imrejsbiet, but can be seen from five sites which are the four already listed plus Santa Verna. This concludes that there is a visual reciprocity between these sites, except for Santa Verna.

The above-mentioned manual temple intervisibility analysis indicates a high number of temples with visual reciprocity. To go one step further into investigation of temple reciprocity which derives from Table 2.15 with 32 interconnecting visibility lines, this has been reduced to 30 by taking out lines from two pars of sites without visual reciprocity. These two pairs of sites are:
- Santa Verna and Ta’ Marżiena
- Santa Verna and Borġ L-Imramma

The interconnecting lines for temple sites that have a visual contact with another site either one way or the other sums up to 32. As the number of sites with visual reciprocity is 30, being two less, gives a result that 93.8% of temple sites in Gozo that have a mutual intervisibility with each other. The comparative figures for 35 temple sites in all Malta are respectively 68.6% and 45.7% (Table 2.11 page 83) and for six temple sites in Mġarr region 13.3% have mutual intervisibility (ref. Table 2.13 page 104).

Based on these figures Gozo does has a high number of sites with mutual or reciprocal intervisibility. At the same time, there also seems to be a cluster of sites like Borġ Għarib South, Borġ Għarib North and L-Imrejsbiet all located in Għajnsielem neighbourhood which do not share any intervisibility besides between themselves, with other sites in Gozo, except they all share visual reciprocity with Borġ L-Imramma. A possible reason for the high number of intervisible sites in Gozo could be explained by the island's topography, a topic that will be discussed further below.



		Source											
	Sites	Ggantija	Santa Verna	Borg Gharib South	Borg Gharib North	L-Imrejsbiet	Xewkija	Triq ix-Xabbata	Ta' Marziena	Borg L-Imramma	Total Target Sites	CVS Adjusted	Cum Viewshed
Target	Ggantija						1	1	1	1	4	4	5
	Santa Verna						1	1	1		3	3	4
	Borg Gharib South				1	1				1	3	3	4
	Borg Gharib North			1		1				1	3	3	4
	L-Imrejsbiet			1	1					1	3	3	4
	Xewkija	1	1					1	1		4	4	5
	Triq ix-Xabbata	1	1				1		1		4	4	5
	Ta' Marziena	1					1	1			3	3	4
	Borg L-Imramma	1	1	1	1	1					5	5	6
	Total Target Sites										32	32	41
	Total Source Sites	4	3	3	3	3	4	4	4	4	32		

		Source										
	Sites	Ggantija	Santa Verna	Borg Gharib South	Borg Gharib North	L-Imrejsbiet	Xewkija	Triq ix-Xabbata	Ta' Marziena	Borg L-Imramma	Total Target Sites	Total Target Reciprocal
Target	Ggantija						1	1	1	1	4	4
	Santa Verna						1	1	-1		3	2
	Borg Gharib South				1	1				1	3	3
	Borg Gharib North			1		1				1	3	3
	L-Imrejsbiet			1	1					1	3	3
	Xewkija	1	1					1	1		4	4
	Triq ix-Xabbata	1	1				1		1		4	4
	Ta' Marziena	1					1	1			3	3
	Borg L-Imramma	1	-1	1	1	1					5	4
	Total Target Sites										32	
	Total Source Sites	4	3	3	3	3	4	4	4	4	32	
	Total Source Reciprocal	4	2	3	3	3	4	4	3	4		30

Table 2.15. Gozo matrix intervisibility.
In both top and bottom tables, the columns are the Source that list the temples that *can see* another site, and the rows are the Target which list the temples that *can be seen* from another site.

In Table 2.15 the last column in the top table is the sum from the Cum Viewshed, which shows visible sites including itself with a total of 41 interconnections. The 'CVS adjusted' column shows nine sites less as the site itself has been deducted and sums up to 32 site lines of the total number of sites in this CVS study. As an example, the last site listed, Borġ L-Imramma *can see* four sites, but *can be seen* from five sites. In the bottom table, the Cumulative Viewshed and the CVS Adjusted columns have been replaced by Total Target Reciprocal sites and has a total of 30, as the intervisible lines of sites have been reduced by pairs of two sites, in this case indicated with a -1 inside a black circle. This reduction of two reciprocal lines, is based on that Santa Verna as a Source cannot see Ta' Marżiena, but Ta' Marżiena as a Source can see Santa Verna. Besides that, Santa Verna as Source can see Borġ L-Imramma, but Borġ L-Imramma as a Source cannot see Santa Verna. This combination of these two pairs of sites reduces the total of reciprocity by two, from 32 to 30.

Temple intervisibility based on QGIS, 3 m target and distance.

This part shall examine the TRUE visible target size of a temple of 3 m taking into consideration the distance from the observer and human acuity similar to the analysis done with the Qrendi and Mġarr regions (ref 2.5.4 page 85 and 2.5.5 page 100). Section 2.4.3 page 66 and Table 2.9 page 76 list the temples which have a TRUE visual portion less than 1 m when a temple height of 3 m is assumed. On the basis of these results, an analysis shall be carried out to determine if this influences temple intervisibility in Gozo.

Based on Table 2.22 page 145 which lists nine TRUE temples with a Yes or a No for the given source sites that can or cannot see a target site considering the visible portion of the target, distance, and human acuity, the only two sites listed for Gozo are Ta' Marżiena and Santa Verna. Even with the very conservative target height of 3 m, Ta' Marżiena as a source site can see 0.864 m of Santa Verna as a target site from a distance of 2.173 km which qualifies for the intervisibility based on human acuity of a nearly 1 m object is visible up to a distance of about 3.4 km (ref. Figure 2.41 page 136). This implies that Gozo temple intervisibility remains intact as presented in Table 2.15 page 119.

Ġgantija and intervisibility

This section shall firstly take Ġgantija as a source site, and secondly Ġgantija as a target site. As already noted, the measured height of 7.5 m of Ġgantija is used as observed target, the observer height is 1.6 m and a radius of 25.8 km to establish a single viewshed seen from the temple (see Figure 2.34 below).

Ġgantija VSA and temples

It must be emphasised that this section of the analysis is *not* a CVS one, but a VSA based on that Ġgantija is a single viewshed source site that potentially can see other sites. As noted in 2.3.4 page 35, a viewshed is a binary model where target cells in a raster are ascribed either as visible or non-visible from a given vantage point, allowing to calculate what can be seen from a determined observation point, with Ġgantija in this case (Chapman 2006: 105, Conolly and Lake 2006: 226, Lake *et al.* 1998: 27, Wheatley and Gillings 2002: 204).

Figure 2.34 shows a close-up of the two regions which the VSA covers, being Gozo and Mġarr in Malta. In Gozo, Ġgantija *can see* four temples, and are the same as in the 3 m CVS analysis. This concludes that when it comes to the Gozo region, there is no difference whether Ġgantija would have a height of 3 m or 7.5 m regarding temple intervisibility. Where the 7.5 m height of Ġgantija brings new perspectives of intervisibility is within the region of Mġarr about 18 km away, with a visual contact with three out of six temples (see Table 2.16).

Figure 2.35 shows a photographic illustration of the intervisibility between the three temple sites in Mġarr region and Ġgantija, which are Kunċizzjoni, Ras ir-Raħeb, and Ras il-Pellegrin. Today Ġgantija is not easily detectable from the Kunċizzjoni site where the photo was taken on 16 June 2017, due to modern vegetation around the Ġgantija site, haze, and air pollution. However, in prehistory the atmospheric conditions were assumingly clearer, and the visibility could depend on if the temple had a more brightly coloured façade than it has today, which is arguably suggested by the discovery of traces of plaster on the interior of the building. Another unconfirmed hypothesis is that the prehistoric inhabitants may have lit fires to create more intervisibility, possibly at special times of the year.

Regarding the relevance of intervisibility between Ġgantija and the three temples in the Mġarr region, a line-of-sight (LoS) was plotted for the three Mġarr temple sites (Figure 2.36). The results of this exercise show that Ġgantija does have reciprocal intervisibility with Kunċizzjoni and Ras ir-Raħeb, but not with Ras il-Pellegrin. Relating to Mġarr region (ref. Table 2.13 page 104), Ras il-Pellegrin has a reciprocal intervisibility isolated to Ta' Ħaġrat. Kunċizzjoni and Ras ir-Raħeb are also two sites with an exclusive mutual intervisibility. Bringing this into a Gozo and Mġarr regional perspective, Ras il-Pellegrin appears to be more visually connected with Mġarr than with Gozo, while Kunċizzjoni and Ras ir-Raħeb appear to be visually connected with both Gozo and Mġarr, but with an emphasis towards Gozo.

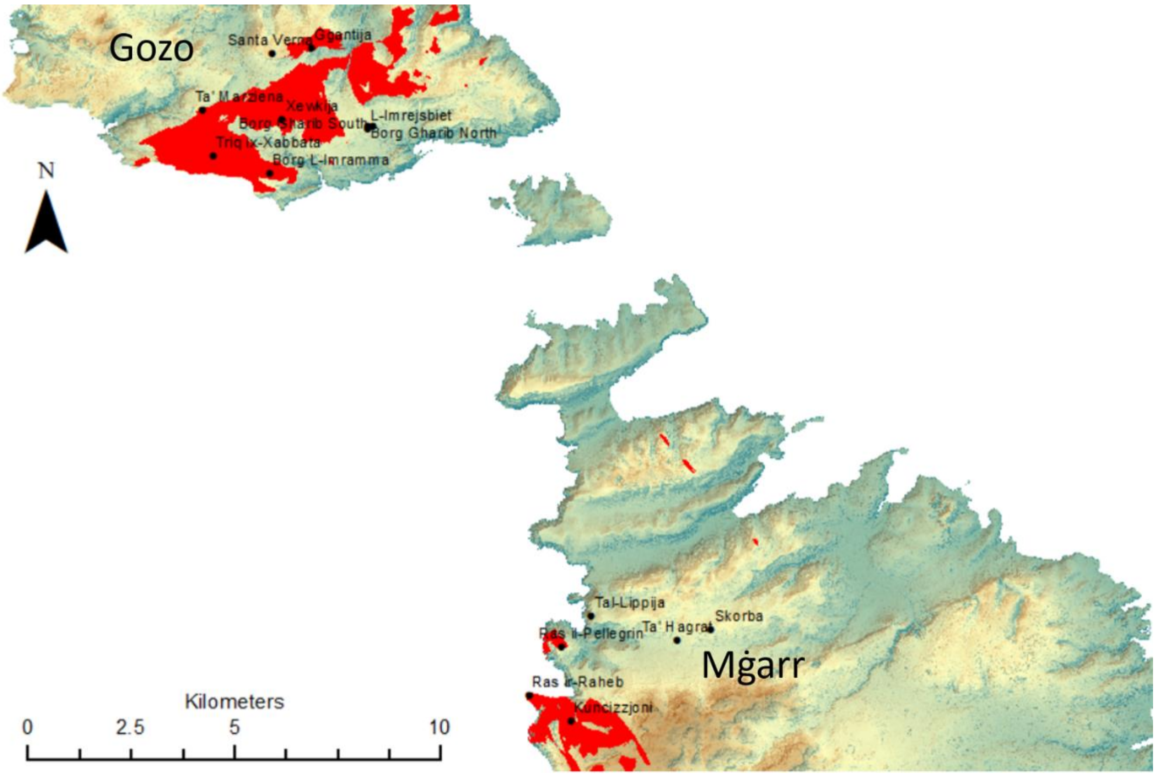


Figure 2.34. Ġgantija viewshed.
The red colour illustrates the single viewshed from Ġgantija, based on observer height 1.6 m, target height 7.5 m and a radius of 25.8 km. Based on these parameters, viewshed covers part of the Mġarr region about 18 km away.

Gozo region	Ġgantija	
	7.5m	3m
Ġgantija		
Santa Verna		
Borġ Għarib South		
Borġ Għarib North		
L-Imrejsbiet		
Xewkija	1	1
Triq ix-Xabbata	1	1
Ta' Marżiena	1	1
Borġ L-Imramma	1	1
Total source sites visible	4	4

Mġarr region	Ġgantija	
	7.5m	3m
Ta' Ħaġrat		
Skorba		
Ras il-Pellegrin	1	
Tal-Lippija		
Kunċizzjoni	1	
Ras ir-Raħeb	1	
Total source sites visible	3	0

Table 2.16. Ġgantija intervisibility, Gozo and Mġarr regions.
This table shows Ġgantija intervisibility in the Gozo and the Mġarr region based Ġgantija temple height 7.5 m or 3 m.

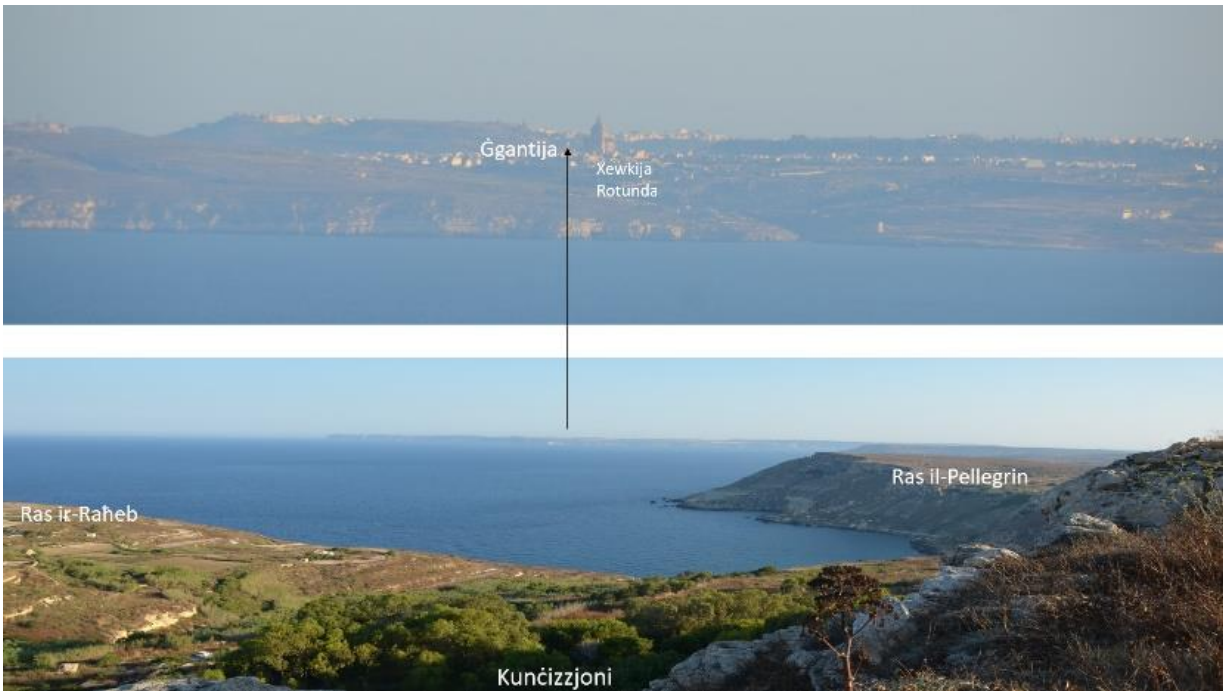
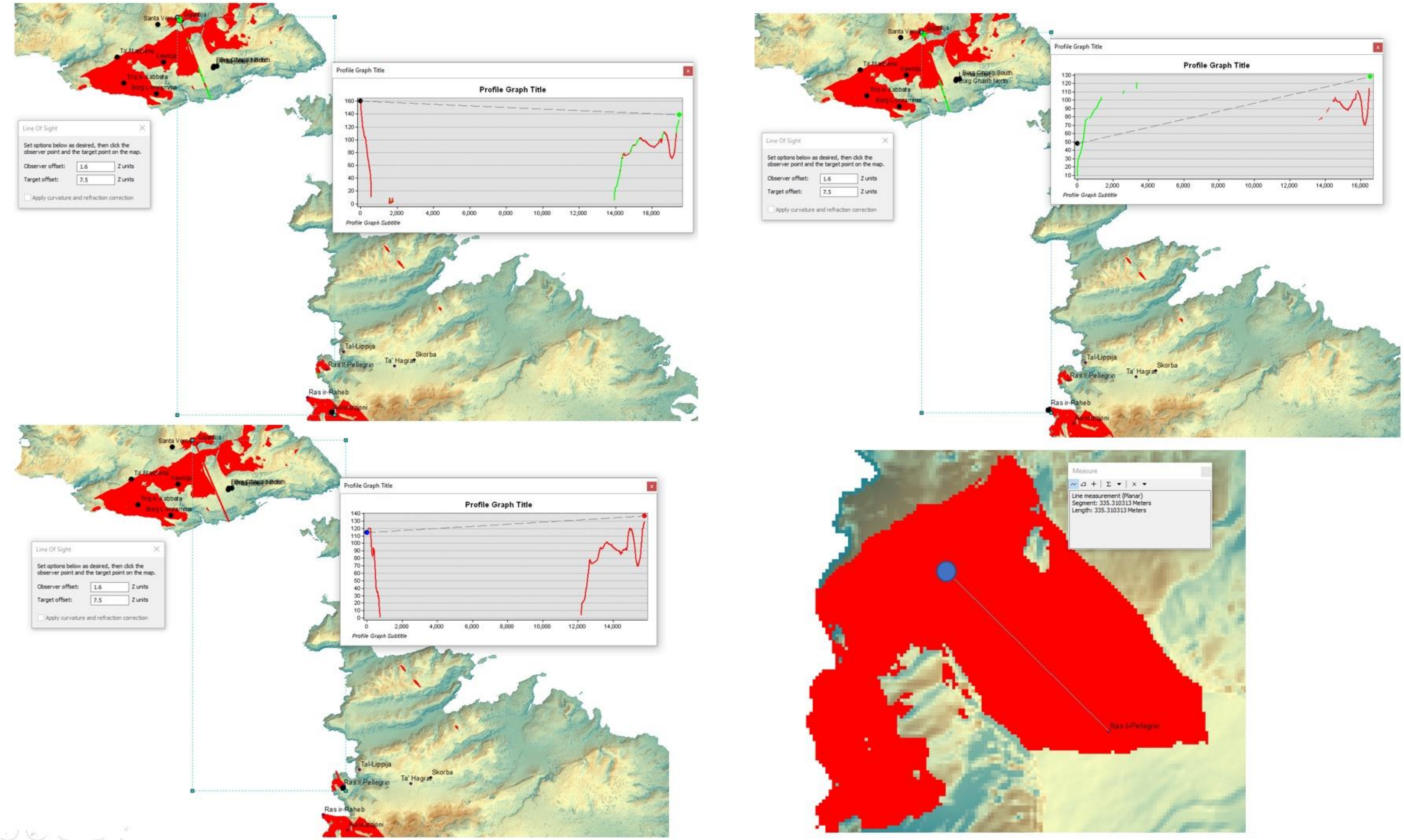


Figure 2.35. Ġgantija seen from Mġarr region.
The bottom is a panorama photo taken from the Kunċizzjoni site, illustrating the intervisibility with Ras ir-Raħeb, Ras il-Pellegrin and the site location of Ġgantija. In the top photo, taken with a 300 mm telephoto lens, Xewkija Rotunda which stands on the site of the Xewkija Temple is a useful reference point.
Photo: Lomsdalen.



Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 7.5 Z units

☐ Apply curvature and refraction correction

Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 7.5 Z units

☐ Apply curvature and refraction correction

Line Of Sight

Set options below as desired, then click the observer point and the target point on the map.

Observer offset: 1.6 Z units

Target offset: 7.5 Z units

☐ Apply curvature and refraction correction

Measure

Line measurement (Planar)
Segment: 335.310313 Meters
Length: 335.310313 Meters

Figure 2.36. Ġgantija and LoS with Mġarr region.

Figure 2.36 illustrates the LoS seen from the three sites in the Mġarr region which were inside the red raster zone of the Ġgantija VSA, based on an observer height of 1.6 m and a target height 7.5 m. The top left is the LoS from Kunċizzjoni, which confirms with a green dot an intervisibility with Ġgantija, confirming a reciprocal intervisibility. The top right is the LoS from Ras ir-Raħeb which also indicates a visual connection with Ġgantija with a green dot and consequently the two sites do have a mutual intervisibility. However, when it comes to the bottom left seen from Ras il-Pellegrin, the LoS is interrupted by a hill formation near the site, confirming that Ras il-Pellegrin and Ġgantija are not reciprocally intervisible, Ġgantija can see Ras il-Pellegrin, but not the other way around. The bottom right illustrates with the blue dot a hypothetical relocation of Ras il-Pellegrin about 300 m further up the hill where it may have been able to see Ġgantija.

Ġgantija VSA and landscape

Ġgantija is located at about 140 m above sea level on a hillside with a southern aspect, which shall be explained further below. A field survey was conducted on 21st and 22nd December 2018 with GPS and photographic documentation of 40 landscape observation points from where Ġgantija could be seen, as illustrated in Figure 2.37 below. The 40 points were arbitrarily chosen based on if Ġgantija could be seen from those points. A hindrance for visibility of Ġgantija is that there are modern palm trees several metres high in the forecourt of the temple, as well as modern vegetation and constructions in its vicinity. Therefore, in some cases a pair of binoculars had to be used to identify the site. This VSA is not meant to be used to define what part of the landscape can be seen from Ġgantija, but the other way around, namely from where an observer in the landscape *can see* the temple, similar to the viewscape a prehistoric person could have experienced when approaching Ġgantija. The fieldwork purposely did not include other temple sites as that intervisibility is GIS identified through CVA (ref. Table 2.15). Figure 2.38 shows all the 40 important landscape points on a Google Earth map.

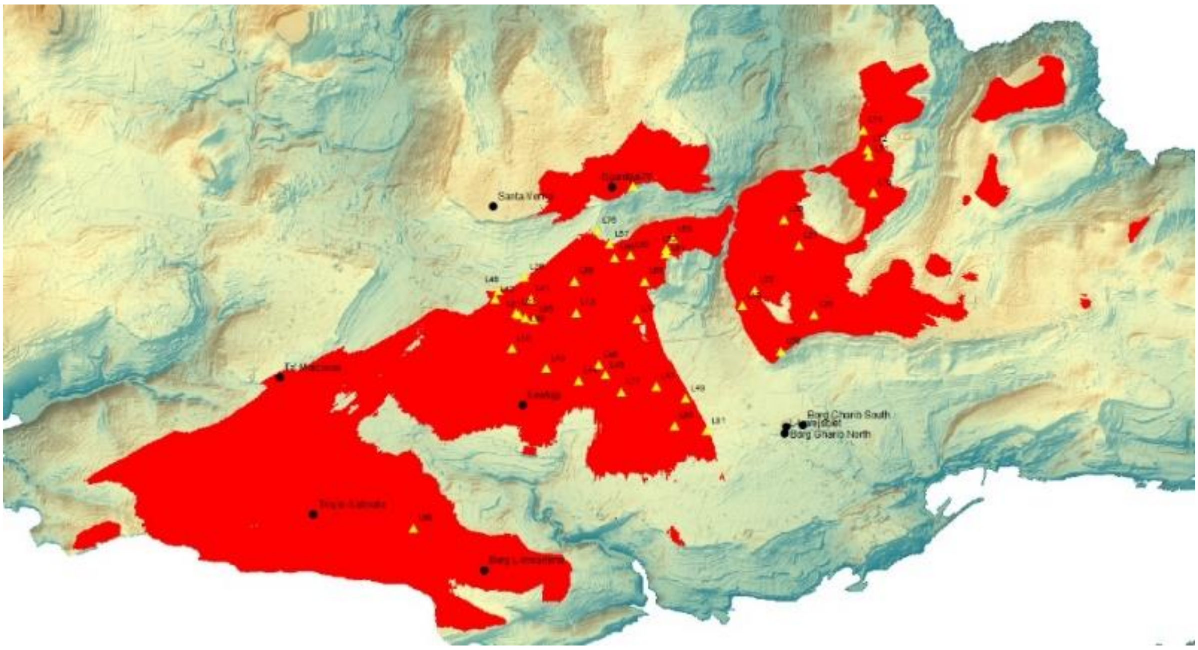


Figure 2.37. Ġgantija VSA, landscape points.
The red coloured area is the VSA of Gozo seen from Ġgantija. The black dots indicate the temple sites in Gozo. The yellow triangles show the 40 landscape observation points identified with an 'L' and a number. The numbers are not in a numerical order.

Figure 2.38. Google Earth map showing Ġgantija observations points.
The 40 observations points (yellow pointer) plotted against a Google Earth orthophoto.

Reflections on Gozo region

The *FRAGSUS Project* retrieved stratigraphic layers deposits under the temple floor at Santa Verna associated to Żebbuġ Phase, indicating a creation of a three-apse temple structure during that phase, and completed as a full five-apse temple during the Ġgantija Phase (McLaughlin *et al.* 2020b: 167). Trump (2002: 182) suggests that Santa Verna 'like Skorba, Kordin III, and Ta' Ħaġrat, been built over the site of a much older village, going back to at least the Grey Skorba phase'. Trump (2002: 55) lists the Grey Skorba Phase to 4,500-4,400 BCE. In addition to Santa Verna, in Ġgantija and Xewkija pottery sherds predating the Temple Period have been found (Evans 1971: 170-192, Magri 1906, Trump 2002: 170-187), and the temples are classified to Ġgantija Phase while all the other sites in Gozo to the Tarxien Phase. As emphasised earlier, temple chronology is relevant when analysing intervisibility and especially so when it comes to the question of *can see* or, *can be seen* from other sites.

Both Santa Verna and Ġgantija are located high up in the landscape on the Xagħra plateau and in the vicinity of steep cliff edges. The difference here is that Santa Verna is positioned about 150 m from the cliff on flat land where there is agriculture activity today. As Grima (2008: 49) suggests, closeness to fertile resources would have been a priority for settlers, and for the temple builders of Santa Verna this factor may have been more essential for the temple builders than *to be seen* in the wider landscape, similar to the situations with Skorba in Mġarr. As noted, Skorba was, according to Trump (1966a: 10-11) a dwelling site prior to the construction of the temple. Ġgantija on the other hand, is positioned in a hill formation with 180° east to west intervisibility to the surrounding landscape. Contrary to Santa Verna, Ġgantija is more likely to have been located in this position for purpose of being conspicuous or outstanding in the landscape.

When it comes to life-supporting resources for prehistoric society, Ruffell *et al.* (2018: 191) maintain that the location of Ġgantija is 'associated closely with springs linked to the geological faults in the landscape'. This argument is sustainable, but more than just the spring scenario for the siting of Ġgantija, the visual relationship with its local landscape cannot be excluded as being a core incentive for the precise positioning of the temple.

Located on a hill formation on the central plain, another of the early conspicuous temples could have been Xewkija (see Figure 2.39). Based on a modern setting where anybody travelling from the ferry landing in Mġarr, Gozo, going to Rabat cannot avoid to see Rotunda St. John Baptist Church, where the Xewkija temple was once located (Magri 1906). Making allowances for the differences in size of the two structures, a prehistoric person walking or staying on the central plain would still have had a similar visual interconnection with the Xewkija temple in its landscape setting as we have with the church today. The height of Xewkija temple would be considerably less. On the other hand, the viewscape and visual contact with the temple would not be disrupted by the village and modern constructions.

Figure 2.39. Xewkija.
This photo shows the Rotunda St. John Baptist Church of Xewkija which is built on the prehistoric Xewkija temple site, which would then also have been highly conspicuous in the central plain landscape setting of Gozo. Photo Lomsdalen.

Another hub of three temple sites that due to their location, lack of intervisibility with other temples except between themselves and Borġ L-Imramma, are Borġ Għarib South, Borġ Għarib North, and L-Imrejsbiet. As Borġ Għarib South, Borġ Għarib North and L-Imrejsbiet are built during the Tarxien Phase, the builder may have had a special reason not to locate the temples with intervisibility with Ġgantija, Santa Verna, and Xewkija. Due to modern constructions, Borġ Għarib South, Borġ Għarib North, and L-Imrejsbiet are not very conspicuous, but during the Temple Period for anybody coming from the Mġarr harbour and moving up the hills in the direction of the central plain and the temples, they would become increasingly conspicuous.

An open and remaining question useful for future studies is why are all the nine temples located on the south-eastern part of Gozo with no archaeological evidence of temple sites elsewhere? One reason of centralised cluster of temples could be, as Grima (2008: 49) maintains of closeness to agricultural exploitation and water sources, a more open and fertile land than further north, and consequently an area that supported more demographical growth. Another possibility may be that temple intervisibility would naturally be reduced or more hampered as the northern part of Gozo has more formations of hills and valleys, while that temple intervisibility in the open southern sunny landscape may have been more important to the prehistoric Gozitans. These southerly temple settings were also more protected from the harsh northern winter winds.

In an overall consideration of viewscape and visibility, the temple locations in Gozo do have a higher percentage of intervisibility compared with temple clusters on the island of Malta (ref. 2.5.3 page 80). Whether this was purposely done by the temple builders or by chance due to the topographical formation of Gozo, remains an open question. Nevertheless, based on that there seems to be various cluster formations of temple locations, this could indicate that temple viewscape was guided by local organisational units on the island. The Gozo Temple Period population is estimated to be around 1400 persons (Clark 2004: 377), indicating that a form of constructional collaboration within the whole island or even from neighbouring Malta, would most likely have been the case. But when it came to deciding the actual location of a temple, a territorial entity could have had a final word, something similar to our modern parish church structure.

2.5.7 Temple intervisibility

As explained in the Methodology 2.3.7, this exercise is to illustrate from a given viewpoint (a temple site), a spatial model of a specific number of target points (temple sites) relating to each other in a network of intervisibility throughout the Maltese Archipelago, and as noted will be referred to as VSQ. Furthermore, this study will quantify how much, if at all, a target is visible taking distance and human acuity into account. For the visible sites, the aim is also to quantify how many sites, and which sites would be intervisible between a target size up to 3 m, and also from 3 m to 6 m. The procedure of this analysis builds in considerations of human visual acuity to eliminate a number of sites which are theoretically intervisible, but not intervisible to the human eye, to come up with a more conservative number of sites which are actually intervisible (ref. Figure 2.41, Table 2.18

and Table 2.20 in this section). The results in 2.4.3 page 66 shall be considered and discussed.

Even though the archaeological record lacks data of precise temple heights, and in addition there are certain limitation in GIS programs, it is nevertheless more informative to engage in a broader analysis of temple heights and intervisibility than to completely ignore such a study (ref. 2.3.9 page 53). By establishing clear and straightforward parameters and being aware of limitations and margin of error, this author argues that it is still valid to explore how intervisibility between Maltese temples could have been. Besides that, this research program may shed some new light and inspiration on an unexplored area for future investigations into Maltese temples and landscape archaeology. As the archaeological record already illustrates, it is highly unlikely that all temples had the same height. There have probably been considerable variations in metric altitudes from the lowest to the highest, similar to how the structural extent of the temples varied.

As shown in results 2.4.3 page 66, this discussion will be centred around intervisibility analysis firstly of a 6 m temple height and secondly on a 3 m one. The reasoning behind selecting these two temple heights for an intervisibility inquiry for all Malta, is based on that these are the two approximate average heights which have a reference to the archaeological record (ref. Table 2.1 page 34). The rationale behind selecting the lower 3 m temple height was based on that in this case a temple would most likely be entirely visible. In ArcGIS/ArcMap, if a site is found to be visible with a target height of 3 m it would mean that temples which were higher would have been clearly visible. If not for all, but for a number of temples, a 5 m and 6 m could have been a likely temple height. Therefore, even when an exercise is conducted in ArcMap and getting a positive result with 3 m target height, that gives us a certain confidence in the results. All this is of course superseded by the use of QGIS which also gives us a value for how much is visible or missing. These heights are furthermore used to calculate how much of a temple is metrically visible, taking the mentioned parameters into consideration which are listed in Results 2.4.3 and also further discussed in this section.

Temple intervisibility 6m height

Figure 2.13 page 67 in results illustrates on the left side 900 interconnecting lines with temples based on a height of 6 m and a radius of 20.6 km, which visually in itself does not tell much more than a general map illustration of interconnectivity on the archipelago. The right-hand map, however, does give more meaning with regard to when the human acuity is taken into consideration, illustrating the TRUE 151 (ref. Table 2.4 page 68) intervisibility lines with a potential cluster combination of sites with intervisibility both inside a local region, but also with other regions. In this regard, Figure 2.40 below illustrates all Malta divided into two main regions, north and south. The maps indicate two elements, either a certain region does have, or does not have a visual connectivity with another region. Another point that stands out regarding intervisibility, is that the archipelago is divided into to a distinct southern and northern territory. One plausible cause for this divide, could be the east to west geographical formation of Malta's Great Fault, more popular known as the Victoria Lines.

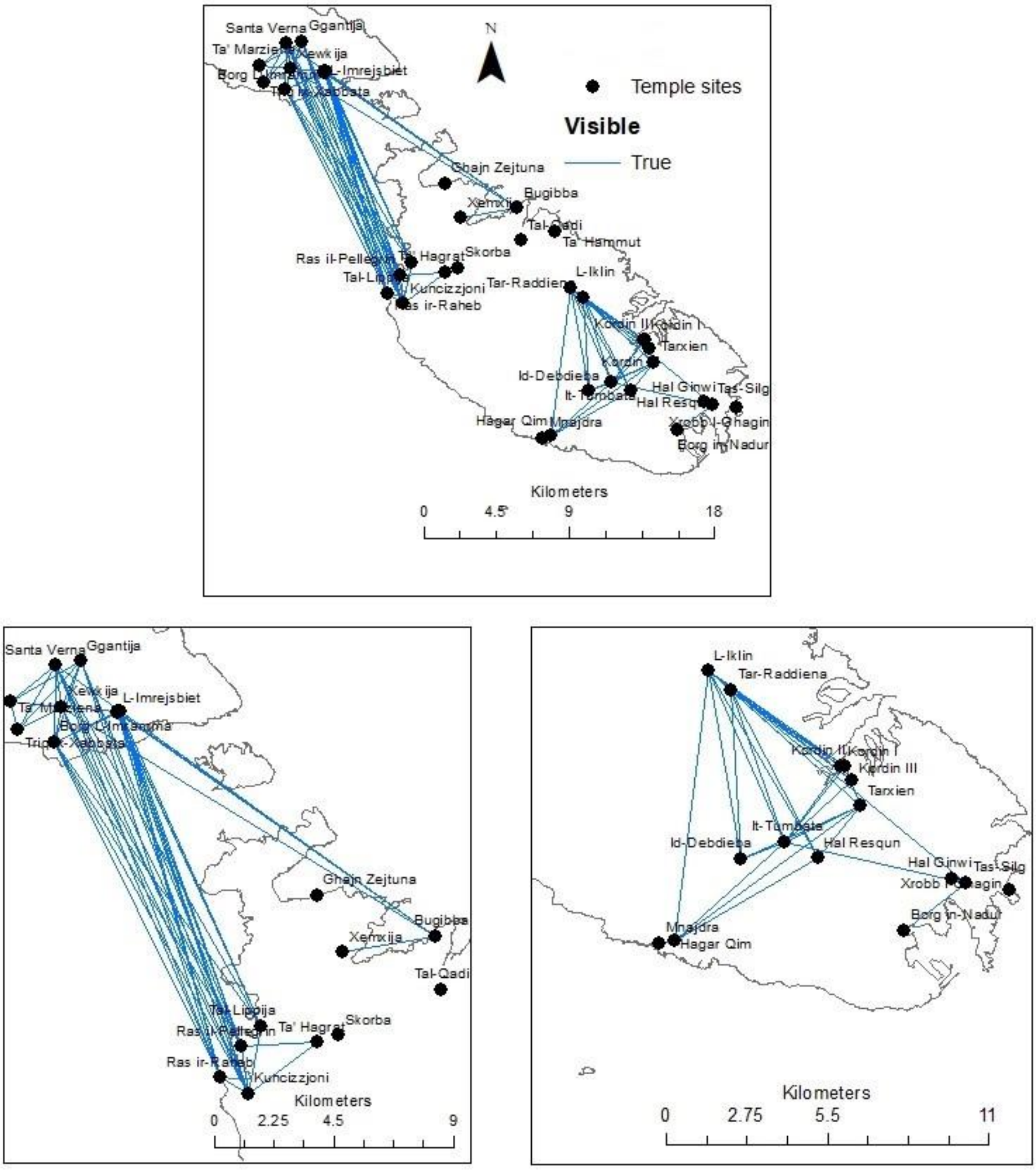
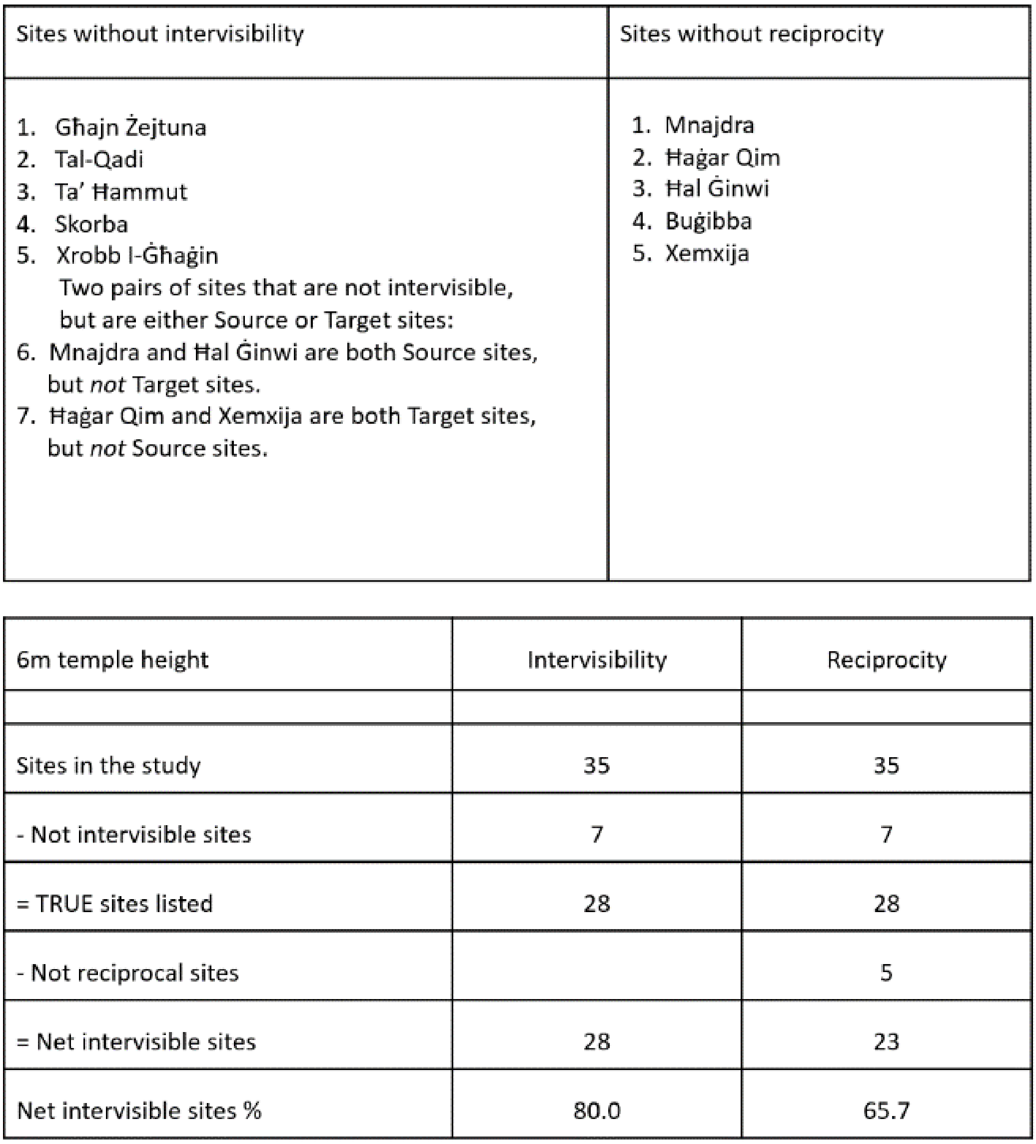


Figure 2.40. Temple 6 m and cluster formations.
Based on a temple height of 6 m and a visual radius of 20.6 km, the top map shows all Malta, while the two bottom maps to the left show the northern and the one on the right shows the southern region of Malta. The blue lines indicate temple intervisibility.

From the VSQ 6 m, two pivot tables were calculated. Table 2.4 page 68 shows in the Grand Total of 151 of visual interconnections between the 28 TRUE temple sites, either in one way or the other, while Table 2.5 page 69 displays in the Grand Total that there are 120 interconnecting lines with visual reciprocity between the sites. The analysis of the results from these two tables is presented in Table 2.17 showing that out of the all the 35 temple sites, 24 temples do have intervisibility in one way or another between them, five do not have a visual interconnection with another site, and another two pairs of sites do not have visual reciprocity, concluding that 80% of the sites have a visual interconnectivity, and 65.7% have a visual reciprocity.



Sites without intervisibility	Sites without reciprocity
1. Għajn Żejtuna 2. Tal-Qadi 3. Ta' Ħammut 4. Skorba 5. Xrobb l-Għaġin Two pairs of sites that are not intervisible, but are either Source or Target sites: 6. Mnajdra and Ħal Ġinwi are both Source sites, but *not* Target sites. 7. Ħaġar Qim and Xemxija are both Target sites, but *not* Source sites.	1. Mnajdra 2. Ħaġar Qim 3. Ħal Ġinwi 4. Buġibba 5. Xemxija

6m temple height	Intervisibility	Reciprocity
Sites in the study	35	35
- Not intervisible sites	7	7
= TRUE sites listed	28	28
- Not reciprocal sites		5
= Net intervisible sites	28	23
Net intervisible sites %	80.0	65.7

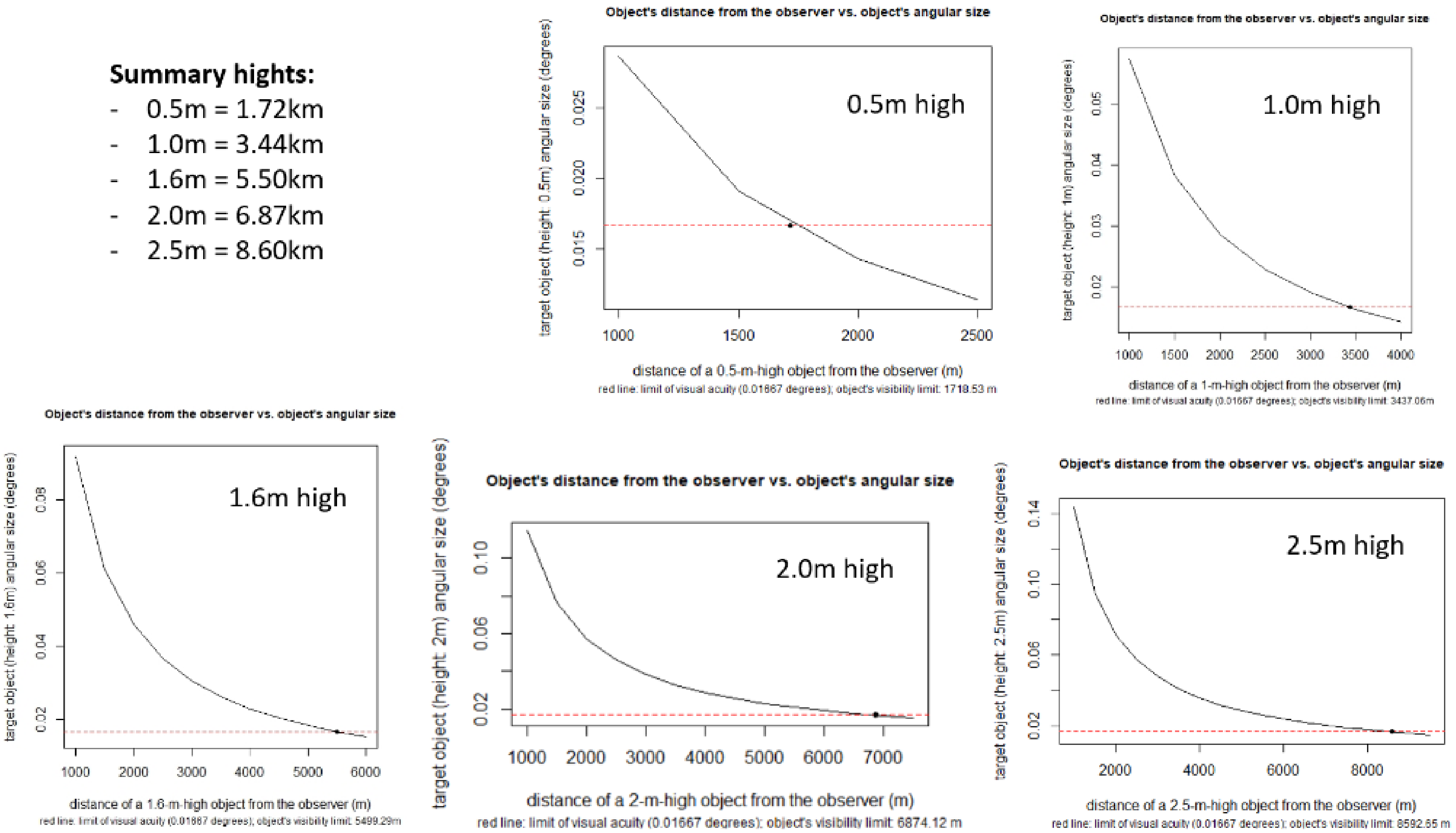
Table 2.17. VSQ 6 m intervisibility.
The top part left specifies five temples that do not have any visual contact with another temple and two pairs of sites that do not have visual reciprocity, as they are listed either as a Source (*can see* another site) or a Target (*can be seen* from another site). The right top side lists five temples without reciprocity. The bottom part presents a numeric result based on a total of 35 temples and the categorising of sites listed in the top part, emerging in that out of 35 temple sites, 28 or 80.0% of them have visual connection either one way or the other, while 23 or 65.7% temples are reciprocally visually connected.

Metric differences in temple intervisibility based on 6 m height.

The method applied for this part of the study is described in section 2.3.7 page 47, and the results in 2.4.3 page 66. Table 2.6 page 71 lists 28 of the 151 TRUE intervisible temple lines, which can see their targets with a visible portion less than 3 m. Based on that result, this study goes one step further into examining how realistic the intervisibility actual is for TRUE sites based on the target's visible portion from the source site and the distance between them. In order to carry out this analysis, the human acuity to see a target of 0.5 m, 1.0 m, 1.6 m, 2.0 m, and 2.5 m was calculated and used as a parameter to evaluate if a source site can see or cannot see a target as indicated in Figure 2.41. This figure shows in the top part left a summary of the five calculations of an object's distance from the observer versus object's angular size followed by the five plots in order of distance: 0.5 m, 1.0 m, 1.6 m, 2.0 m and 2.5 m. The plot variables are explained in Figure 2.2 page 33 (Alberti 2020).

Summary hights:

- 0.5m = 1.72km
- 1.0m = 3.44km
- 1.6m = 5.50km
- 2.0m = 6.87km
- 2.5m = 8.60km



#

Figure 2.41. Human acuity under 3 m.

As Table 2.18 below illustrates, the analysis of these 28 TRUE sites indicates that 13 source sites can see (Yes) their targets, but 15 temples cannot see (No) their targets due to the fact that the visual part of the target size is too small for the given distance between the two sites, particularly when considering human acuity to see an object at a given distance (ref. Figure 2.41). In other words, it can be argued that 15 TRUE visible temples as a source site can not physically see that specific temple as a target object. This validates the importance of analysing and discussing achieved GIS results with regard to temple intervisibility, as data is prone to marginal errors of edge effect when it comes to viewshed borderline analysis as emphasised by Wheatley and Gillings (2002: 209) and discussed in sections 2.5.4, 2.5.5 and 2.5.6.

FID	Source	Target	Visible	TargetSize	Distance	See
838	Xewkija	Ras il-Pellegrin	TRUE	0.062	14453.84	No
361	L-Iklin	Hagar Qim	TRUE	0.21	9256.71	No
773	Borg Gharib South	Bugibba	TRUE	0.496	14550.14	No
894	Borg L-Imramma	Ras il-Pellegrin	TRUE	0.558	13470.63	No
656	Bugibba	Xemxija	TRUE	0.57	3542.91	No
759	Santa Verna	Ras il-Pellegrin	TRUE	0.887	15966.19	No
130	Tarxien	Id-Debdieba	TRUE	0.947	4453.38	No
819	L-Imrejsbiet	Ras il-Pellegrin	TRUE	1.062	13401.21	No
779	Borg Gharib South	Ras il-Pellegrin	TRUE	1.087	13405.77	No
799	Borg Gharib North	Ras il-Pellegrin	TRUE	1.093	13439.87	No
740	Ggantija	Ras il-Pellegrin	TRUE	1.155	15712.71	No
487	Tal-Lippija	Kuncizzjoni	TRUE	1.17	2586.83	Yes
184	Kordin II	Kordin III	TRUE	1.281	523.93	Yes
882	Borg L-Imramma	Santa Verna	TRUE	1.321	2885.85	Yes
833	Xewkija	Bugibba	TRUE	1.386	16497.02	No
185	Kordin II	Tarxien	TRUE	1.422	1451.35	Yes
120	Hal Resqun	Hagar Qim	TRUE	1.722	5632.42	Yes
813	L-Imrejsbiet	Bugibba	TRUE	1.742	14638.04	No
319	Tar-Raddiena	Hal Resqun	TRUE	1.896	6444.8	Yes
793	Borg Gharib North	Bugibba	TRUE	2.069	14655.7	No
832	Xewkija	Borg L-Imramma	TRUE	2.092	1339.04	Yes
145	Tarxien	Hagar Qim	TRUE	2.233	7834.55	No
347	L-Iklin	Hal Resqun	TRUE	2.367	7404.03	Yes
828	Xewkija	Borg Gharib North	TRUE	2.453	2096.9	Yes
70	It-Tumbata	Hagar Qim	TRUE	2.559	5023.93	Yes
72	It-Tumbata	Tas-Silg	TRUE	2.618	6385.37	Yes
45	Mnajdra	Hagar Qim	TRUE	2.728	537.45	Yes
311	Hal Ginwi	Tas-Silg	TRUE	2.955	513.08	Yes

Table 2.18. Visible or non-visible sites based on human acuity and 6m temple height.
The 28 target sites in this table are theoretically visible from the 28 source sites. The final column shows whether they are actually visible in practice, after taking distance, visible target size, and human visual acuity into consideration. Of the 28 sites, 15 are listed as ‘No’ and 13 as ‘Yes’.

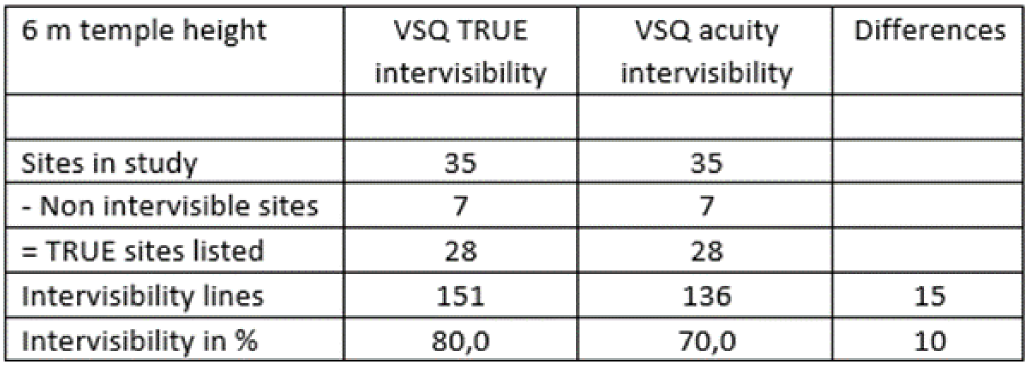
In pursuit of quantifying the effect of 15 source temples which do not have an intervisibility link with a target site, a comparison was prepared, based on Table 2.4 page 68, listing 151 TRUE intervisibility lines before any adjustment to human acuity. Hence, an adjustment was done eliminating the 15 interconnecting lines from the source sites as shown in Table 2.19 indicating the Grand Total of 136 represents TRUE temple intervisibility lines after the target size and the distance have been adjusted with human acuity (ref. Table 2.18). The core difference of what is shown in Table 2.18 and

Table 2.19 is summarised in Table 2.20 illustrating that the original 151 TRUE intervisibility lines have been reduced by 15 to 136, representing a reduction of temple intervisibility by 9.93%. Comparing this figure with the 80.0% intervisibility in Table 2.17, it reduces the issue of temple intervisibility to 70.01%, a reduction of about 10%. Based on the consideration of the QGIS values (VSQ) of how much of the temples are actually visible taking distance and visual acuity into consideration, this author considers that about 70% of all temple sites had a visual connection to at least one other temple on the archipelago.

Another element to be aware of is that when assumed target height is reduced to 3 m, five sites (Għajn Żejtuna, Tal-Qadi, Ta' Ħammut, Skorba, and Xrobb I-Għaġin) are without visibility to another temple, have now increased to six as, Xewkija has no longer intervisibility with any other site. The reason behind this is that Buġibba as a source site can no longer see Xewkija as a target site, and Xewkija is not listed as a source site. The St. Paul's Bay region, shown in Figure 2.40 page 133 with this update would not have any intervisible sites within its own region. The only visual contact this region would have, is that Buġibba as a source can see Santa Verna, as Buġibba has also lost intervisibility as a target site from four sites in Gozo, these being, Borġ Għarib South, Borġ Għarib North, L-Imrejsbiet, and Xewkija as indicated in Table 2.19. This table also shows that Ras il-Pellegrin is the site that has lost the most of its intervisibility as a target site, as seven source sites can no longer see Ras il-Pellegrin but has kept its intervisibility as a source site with Kunċizzjoni and its visual reciprocity with Ta' Ħaġrat.

	Target																													
Source	**Borg Gharib North**	**Borg Gharib South**	**Borg in-Nadur**	**Borg L-Imramma**	**Bugibba**	**Ggantija**	**Hagar Qim**	**Hal Resqun**	**Id-Debdieba**	**It-Tumbata**	**Kordin I**	**Kordin II**	**Kordin III**	**Kuncizzjoni**	**L-Iklin**	**L-Imrejsbiet**	**Ras il-Pellegrin**	**Ras ir-Raheb**	**Santa Verna**	**Ta' Hagrat**	**Ta' Marziena**	**Tal-Lippija**	**Tar-Raddiena**	**Tarxien**	**Tas-Silg**	**Triq ix-Xabbata**	**Xemxija**	**Xewkija**	**Grand Total**	**Total 151**	**Difference**
Borg Gharib North		1		1										1		1		1				1							6	8	2
Borg Gharib South	1			1										1		1		1				1							6	8	2
Borg in-Nadur																									1				1	1	
Borg L-Imramma	1	1				1								1		1		1	1			1							8	9	1
Bugibba																			1										1	2	1
Ggantija				1										1				1			1					1		1	6	7	1
Hal Ginwi																									1				1	1	
Hal Resqun							1																	1					2	2	
Id-Debdieba										1					1								1						3	3	
It-Tumbata							1		1		1	1	1		1									1	1				8	8	
Kordin I										1		1	1		1								1						5	5	
Kordin II										1	1		1		1								1	1					6	6	
Kordin III										1	1	1			1								1						5	5	
Kuncizzjoni	1	1		1		1										1		1	1									1	8	8	
L-Iklin								1	1	1	1	1	1										1	1	1				9	10	1
L-Imrejsbiet	1	1		1										1				1				1							6	8	2
Mnajdra							1																						1	1	
Ras il-Pellegrin														1						1									2	2	
Ras ir-Raheb	1	1		1		1								1		1			1									1	8	8	
Santa Verna				1										1				1				1				1		1	6	7	1
Ta' Hagrat														1			1												2	2	
Ta' Marziena						1													1							1		1	4	4	
Tal-Lippija	1	1		1										1		1			1										6	6	
Tar-Raddiena								1	1	1	1	1	1											1					7	7	
Tarxien								1		1					1								1						4	6	2
Tas-Silg			1							1					1														3	3	
Triq ix-Xabbata						1													1		1							1	4	4	
Xewkija	1			1		1								1				1	1		1					1			8	10	2
Grand Total	**7**	**6**	**1**	**9**	**0**	**6**	**3**	**3**	**3**	**8**	**5**	**5**	**5**	**11**	**7**	**6**	**1**	**8**	**8**	**1**	**3**	**5**	**6**	**5**	**4**	**4**	**0**	**6**	**136**	151	15
Total 151	7	6	1	9	4	6	5	3	4	8	5	5	5	11	7	6	8	8	8	1	3	5	6	5	4	4	1	6		151	
Difference					4		2		1								7										1			15	

Table 2.19. VSQ 136 and 151 intervisibility lines target height set to 6 m.
This table lists the difference of a comparison between 136 and 151 intervisibility lines.



6 m temple height	VSQ TRUE intervisibility	VSQ acuity intervisibility	Differences
Sites in study	35	35	
- Non intervisible sites	7	7	
= TRUE sites listed	28	28	
Intervisibility lines	151	136	15
Intervisibility in %	80,0	70,0	10

Table 2.20. Difference in intervisibility between VSQ TRUE and VSQ acuity.
VSQ TRUE indicates theoretical TRUE intervisibility, while VSQ acuity consider visual acuity taking into consideration what is visible to a normal human eye based on target distance and target height.

Temple intervisibility 3 m height

From results Figure 2.14 page 73, the map on the left clarifies the 400 interconnecting lines (ref. Appendix 7.8) between temple sites based on a visual radius of 10 km and a temple height of 3 m, illustrating temple sites with a potential intervisibility. The right-side map takes human acuity into consideration, showing TRUE 82 (ref. Table 2.7 page 74) intervisibility lines between temple sites. The map also indicates regions or clustering of temple sites that have a higher frequency of intervisibility than other regions. Three regions are emerging with pronounced temple intervisibility as indicated with circles in Figure 2.42 below, being:

1. South-eastern Malta
2. Mġarr
3. Gozo

Hypothesis of regional temple intervisibility have been analysed and discussed in three regional case studies (Qrendi, Mġarr, and Gozo), and some suggestions have been put forward regarding the possible motivations for positioning the temples either with, or without a concern of temple intervisibility. The same considerations may be discussed at the scale of the entire Archipelago. Topography could also have been a natural decisive factor for temple locations, and possibly for positioning the temples in the inherently more visible portion of the landscape as illustrated in results 2.4.3.

Three regions or areas of the island of Malta gave results where there are none or few temples with intervisibility. These three regions are also indicated in Figure 2.42 below with a red circle and are the following:

1. Ħaġar Qim/Mnajdra
2. Birżebbuġa
3. St. Paul's Bay

Based on a larger perspective of regional temple distribution, the sites begin to resolve onto three main groups across the archipelago. One is Gozo with its own temple cluster formation being a separate island from Malta. Sites on Malta resolve into main groups, separated by the natural feature known as the Great Fault, today generally known as the Victoria Lines (indicated by the green coloured line). Whether this divide of regions as we see them today was based on conscious or random circumstances is highly hypothetical, but this physical geographical divide of north and south Malta, could have been related to units of socio-political organisations, which must remain a hypothesis that cannot be confirmed.

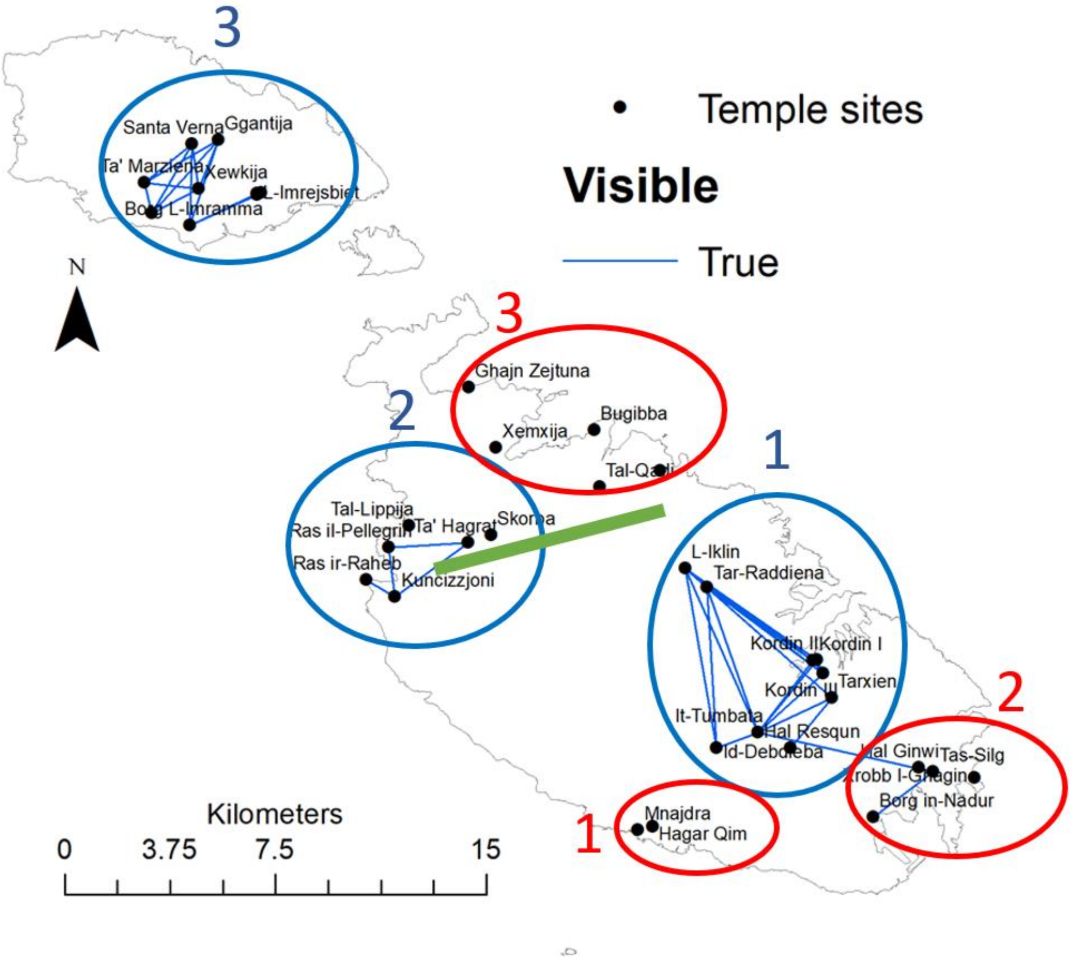


Figure 2.42. Regional intervisibility based on target height 3 m.
This map of Malta illustrates with blue circles numbered from 1 to 3, regions or areas of the Maltese archipelago which have the highest numbers of intervisible temple sites. The blue lines show which temple sites do have an intervisibility in one way or the other. The red circles also numbered from 1 to 3, indicate the regions or areas of the Archipelago which have none or few intervisible sites. The green line shows the approximate position of the Great Fault (Victoria Lines).

From the VSQ 3 m, two pivot tables were calculated. Table 2.7 page 74 shows in the Grand Total 82 visual interconnections between the 24 TRUE temples, either one way or the other, while Table 2.8 page 75 in the Grand Total has 74 interconnecting lines with visual reciprocity between 24 True sites. The results from this analysis of a VSQ 3 m based on QGIS data capture are identical, and have the same number of interconnection lines as the CVS 3 m applying ArcMap (ref. Table 2.2 page 63 and Table 2.3 page 64). This indicates that 68.6% of the temples do have an intervisibility and that 45.7% of the temples have a visual reciprocity (ref. Table 2.11 page 83). The fact that the same results emerge, employing two different GIS applications, manifest a validity and legitimacy of not only the two software programs, but also of the methodology and the analyses applied in this study.

A comparison of results between VSQ 6 m and VSQ 3 m is presented in Table 2.21 below, displaying that the difference in intervisibility between a VSQ analysis based on a temple height of 6 m or 3 m is 11.4%. The difference in reciprocity between these two types of temple structures is 20.0%.

	Intervisibility	Reciprocity	Difference
VSQ 6 m in %	80.0	65.7	14.3
VSQ 3 m in %	68.6	45.7	22.9
Difference in %	11.4	20.0	

Table 2.21. VSQ comparison 6 m and 3 m.
This table shows the difference in percentage of intervisibility and reciprocity based on a VSQ of 6 m and 3 m temple heights.

This result can be considered strikingly marginal, taking into consideration that the two analyses are based on the double of temple heights, being 6 m and 3 m. The relative differences in temple intervisibility and reciprocity, could entail that around two-thirds of temples could have been located in the landscape for intervisibility purposes and more or less half of them positioned for a reciprocal visual contact with another temple. In addition, this analysis and reflection delivers a supporting argument that the temples are *not* randomly located by their builders, but show a tendency to correspond to locations featuring high CVS values of intervisibility and also on being positioned in the most inherently visible portions of the landscape as illustrated in results 2.4.2 page 59 and 2.4.3 page 66.

Metric differences in temple intervisibility based on 3 m height.

The approach of analysing the metric difference for a 3 m high temple target is the same as the one of 6 m as already discussed in this section. Figure 2.41 page 136 is the reference for human acuity also for this part. Table 2.22 below which derives from the original listing in Appendix 7.8, shows nine source sites out of 82 which have an actually visible Target

Size of less than 1 m. All 82 TRUE listed temple sites in Appendix 7.7, considering target size, distance, and human acuity, as all other sites were within the limits considering target size, distance, and human acuity.

This subsection is further divided into to two parts: Temple intervisibility and Temple visual reciprocity.

FID	Source	Target	Visible	Target Size	Distance	See
176	Tar-Raddiena	It-Tumbata	TRUE	0.219	5468.02	No
140	Tas-Silg	It-Tumbata	TRUE	0.229	6385.37	No
39	Id-Debdieba	Tar-Raddiena	TRUE	0.307	5745.07	No
191	L-Iklin	Tar-Raddiena	TRUE	0.374	1029.42	Yes
212	Ta' Hagrat	Ras il-Pellegrin	TRUE	0.502	2809.85	No
210	Ta' Hagrat	Kuncizzjoni	TRUE	0.624	3239	No
385	Ta' Marziena	Santa Verna	TRUE	0.864	2173.16	Yes
119	Kordin III	Kordin II	TRUE	0.909	523.93	Yes
175	Tar-Raddiena	Id-Debdieba	TRUE	0.926	5745.07	No

Table 2.22. Nine TRUE temples Yes or No visible based on target height 3 m.
This table is retrieved from Appendix 7.7, but listing only the nine Source sites that have a visual Target Size less than 1 m. The See column shows the sites that either have an intervisibility (Yes) or not (No), inhering six 'No' and three 'Yes', based on Target Size, Distance, and human acuity.

To quantify these six 'No' See sites in a numeric order of temple intervisibility (ref. Table 2.22 above), two pivot tables were created to compare with previous result of temple intervisibility and reciprocity.

Temple intervisibility

The first of these two pivot tables, Table 2.23 shows the effects of reducing the six 'No' See sites based on the initial 82 listed intervisibility lines in Table 2.7 page 74, to a Grand Total to 76 interconnections, representing a reduction of 7.31%. The Grand Total of 76 represents TRUE temple intervisibility lines following that target size and distance have been adjusted according to human acuity with the six 'No' See sites (ref. Table 2.22). The Grand Total of 82 is the TRUE temple intervisibility lines before this modification (ref. Table 2.7 page 74). The Difference indicates the reduction in number of source and target sites are six intervisibility connections which are the six 'No' sites. As an example, based on the 82 interconnecting lines Ta' Ħaġrat as a Source site could see two sites, Kunċizzjoni and Ras il-Pellegrin, but in this case loses intervisibility with both of them (ref. Table 2.23), which is illustrated with zero (0) in the Grand Total of Ta’ Ħaġrat as a Source sites, though Ta’ Ħaġrat remains as a Target that can be seen from Ras il-Pellegrin as a Source site (ref. Table 2.24). This entails that Ta’ Ħaġrat does not have any intervisibility with any other site, implying that the previous 11 temple sites without intervisibility (ref. Table 2.10 page 82) now increases to 12.

This new revelation regarding Ta’ Ħaġrat seen in combination with the discussion of temple intervisibility of the Mġarr region in 2.5.4 page 85, mentions that the first two temples to be built in the Mġarr region were Skorba and Ta’ Ħaġrat. As already noted, due to the topography, Skorba and Ta’ Ħaġrat have no visual connection with each other (ref. Figure 2.28 page 106). The question of habitat and a vicinity to natural resources of food and water could have had a higher priority in choice of location than intervisibility. According to the archaeological record (Evans 1971, Trump 1966a), Skorba and Ta’ Ħaġrat were the first two temples in the area, implying that their location may have been heavily influenced by considerations other than visibility. Ras il-Pellegrin is a Tarxien Phase site and when constructed could consequently have had an interest of visual contact with Ta’ Ħaġrat, as already debated in the Mġarr region discussion. An inter-regional variation due to this examination of Target Size, results in that Tas-Silġ can no longer see It-Tumbata as indicated with a blue line between blue circle 1 and red circle 1 illustrated in Figure 2.40 page 133. This emphasises that temples could have been located based on more regional and local organisational priorities than inter-regional.

	Target																									
Source	**Borg Gharib North**	**Borg Gharib South**	**Borg in-Nadur**	**Borg L-Imramma**	**Ggantija**	**Hal Resqun**	**Id-Debdieba**	**It-Tumbata**	**Kordin I**	**Kordin II**	**Kordin III**	**Kuncizzjoni**	**L-Iklin**	**L-Imrejsbiet**	**Ras il-Pellegrin**	**Ras ir-Raheb**	**Santa Verna**	**Ta' Hagrat**	**Ta' Marziena**	**Tar-Raddiena**	**Tarxien**	**Tas-Silg**	**Triq ix-Xabbata**	**Xewkija**	**Grand Total**	**Total 82**	**Difference**
Borg Gharib North		1		1										1											3	3	
Borg Gharib South	1			1										1											3	3	
Borg in-Nadur																						1			1	1	
Borg L-Imramma	1	1			1									1											4	4	
Ggantija				1															1				1	1	4	4	
Hal Resqun																					1				1	1	
Id-Debdieba								1					1												2	3	1
It-Tumbata							1		1	1	1		1								1				6	6	
Kordin I								1		1	1		1							1					5	5	
Kordin II								1	1				1							1					4	4	
Kordin III								1	1	1			1							1					5	5	
Kuncizzjoni																1									1	1	
L-Iklin							1	1	1	1	1									1	1				7	7	
L-Imrejsbiet	1	1		1																					3	3	
Ras il-Pellegrin												1						1							2	2	
Ras ir-Raheb												1													1	1	
Santa Verna				1																			1	1	3	3	
Ta' Hagrat																									0	2	2
Ta' Marziena					1												1						1	1	4	4	
Tar-Raddiena									1	1	1										1				4	6	2
Tarxien						1		1					1							1					4	4	
Tas-Silg			1																						1	2	1
Triq ix-Xabbata					1												1		1					1	4	4	
Xewkija					1												1		1				1		4	4	
Grand Total	**3**	**3**	**1**	**5**	**4**	**1**	**2**	**6**	**5**	**5**	**4**	**2**	**6**	**3**	**0**	**1**	**3**	**1**	**3**	**5**	**4**	**1**	**4**	**4**	**76**	82	6
Total 82	3	3	1	5	4	1	3	8	5	5	4	3	6	3	1	1	3	1	3	6	4	1	4	4	82		
Difference							1	2				1			1					1					6		

Table 2.23. VSQ 76 and 82 intervisibility lines target height set to 3 m.

Temple visual reciprocity

Analysing all the six ‘No’ sites in Table 2.22 for any consequences for reciprocity between temple site results, only the following two pairs of sites (four sites) lose their visual mutual exchanges, but not necessarily lose intervisibility with other sites:

1. Ta’ Ħaġrat and Ras il-Pellegrin
   As specified in Table 2.23, Ta’ Ħaġrat loses intervisibility with Ras il-Pellegrin, but Ras il-Pellegrin as a source site maintains intervisibility with Ta’ Ħaġrat, though the visual reciprocity is lost. Table 2.7 page 74 illustrates which target sites Ta’ Ħaġrat can see as a source site.

2. Tar-Raddiena and Id-Debdieba
   Table 2.23 shows the Grand Total that Tar-Raddiena loses intervisibility with one site, which is Id-Debdieba, and Id-Debdieba also as a source site loses intervisibility with Tar-Raddiena, concluding that visual reciprocity between the sites is not present. Table 2.7 page 74 indicates which sites can be seen by an observer at Tar-Raddiena and Id-Debdieba.

Based on this analysis, these two pairs of temple sites have no longer visual reciprocity as illustrated that the Grand Total goes from 74 to 70 with a difference of four sites as listed in Table 2.24. This table shows that The Grand Total of 70 is the TRUE temple reciprocal intervisibility lines after that target size and distance have been adjusted according to human acuity. The Difference of four from 74 represents the two pairs (four sites) of temple sites which have lost their visual reciprocity. There are two examples of this, one of which is the fact that Ta’ Ħaġrat as a Source site cannot see Ras il-Pellegrin, but Ras il-Pellegrin as a Source site can see Ta’ Ħaġrat, thereupon no reciprocity. The other is, that both Tar-Raddiena and Id-Debdieba as Source sites cannot see the other site as a Target, consequently there is no mutual intervisibility.

Source	Borg Gharib North	Borg Gharib South	Borg in-Nadur	Borg L-Imramma	Ggantija	Hal Resqun	Id-Debdieba	It-Tumbata	Kordin I	Kordin II	Kordin III	Kuncizzjoni	L-Iklin	L-Imrejsbiet	Ras il-Pellegrin	Ras ir-Raheb	Santa Verna	Ta' Hagrat	Ta' Marziena	Tar-Raddiena	Tarxien	Tas-Silg	Triq ix-Xabbata	Xewkija	Grand Total	Total 74	Difference
Borg Gharib North		1		1										1											3	3	
Borg Gharib South	1			1										1											3	3	
Borg in-Nadur																						1			3	3	
Borg L-Imramma	1	1			1									1											4	4	
Ggantija				1															1				1	1	4	4	
Hal Resqun																					1				1	1	
Id-Debdieba								1					1												2	3	1
It-Tumbata							1		1	1	1		1								1				6	6	
Kordin I								1		1	1		1							1					5	5	
Kordin II								1	1				1							1					4	4	
Kordin III								1	1				1							1					4	4	
Kuncizzjoni																1									1	1	
L-Iklin							1	1	1	1	1										1				6	6	
L-Imrejsbiet	1	1		1																					3	3	
Ras il-Pellegrin																									0	1	1
Ras ir-Raheb												1													1	1	
Santa Verna																							1	1	2	2	
Ta' Hagrat																									0	1	1
Ta' Marziena					1																		1	1	3	3	
Tar-Raddiena									1	1	1										1				4	5	1
Tarxien						1		1					1							1					4	4	
Tas-Silg			1																						1	1	
Triq ix-Xabbata					1												1		1					1	4	4	
Xewkija					1												1		1				1		4	4	
Grand Total	**3**	**3**	**1**	**4**	**4**	**1**	**2**	**6**	**5**	**4**	**4**	**1**	**6**	**3**	**0**	**1**	**2**	**0**	**3**	**4**	**4**	**1**	**4**	**4**	70	74	**4**
Total 74	**3**	**3**	**1**	**4**	**4**	**1**	**3**	**6**	**5**	**4**	**4**	**1**	**6**	**3**	**1**	**1**	**2**	**1**	**3**	**5**	**4**	**1**	**4**	**4**	**74**		
Difference							1								1			1		1					4		

Table 2.24. VSQ 70 and 74 reciprocal lines based on target height set to 3 m.

A final evaluation in this study would be to compare quantitatively intervisibility and reciprocity based on two different GIS software packages, one is CVS from ArcMap and the other is VSQ from QGIS, where the results are listed in Table 2.25. The results from this table show that about 50% of all temples do have an intervisibility in one way or other with another temple and that about 34% of them do have a visual reciprocity. Also to be borne in mind, is that this analysis is based on the lowest physically measured temple height of any temple, being Tarxien with a height of 3 m (ref. Table 2.1 page 34), and further adjusted for the visible portion of a target considering distance and human acuity. This result gives a certain numeric validity that a visual connection to specific temples could have been a motivational force for temple locations for the builders.

3 m temple height	Intervisibility			Reciprocity		
	CVS	VSQ	Diff.	CVS	VSQ	Diff.
Total visible connections	82	76	6	74	70	4
Sites in the study	35	35	0	35	35	0
- Not visible sites	11	12	1	11	12	1
- Diff. in reciprocal sites		5	5	8	11	3
= Net visible sites	24	18	6	16	12	4
Net visible sites %	68.6	51.4	17.2	45.7	34.3	11.4

Table 2.25. Comparison 3 m CVS and VSQ.
This table gives a comparison between intervisibility analysis based on 35 temples with a height of 3 m applying two different GIS programs, being CVS from ArcGIS and VSA from QGIS. The Total visible connections derives from Table 2.2 page 63 and Table 2.23 page 147, respectively. The row Net visible sites show the number of sites after Not visible sites and Diff. in reciprocal sites have been subtracted with a representation in percentage in the row below. The differences are listed in the column Diff. where for both systems the difference in Total visible connections and Net visible sites have the same number though the number of Not visible sties and Diff. in reciprocal sites do vary between the two systems.

2.5.8 Temple visibility and cosmology

This part shall follow up from 2.2.2 page 23 and discuss whether a belief system, worldview or a cosmological phenomenon was the underlying factor for a viewscape hinged on visibility and intervisibility that could have been an underlying factor for temple location.

By looking at the maps of the temple distribution of the archipelago (ref. Figure 2.1 page 27, Figure 2.40 page 133 and Figure 2.42 page 143) do give a certain impression that temples are concentrated within a geographical area or a region. This could indicate that there could have been a driving force within a local society that decided where to locate the temples in the regional landscape. On the other hand, the high level of building engineering quality in temple structures (Torpiano 2004: 364), and also based on a standardised temple constructional plan in both form and layout (Anderson and Stoddart 2007), further suggests that there may also have been a constructional coordination and engagement throughout the archipelago. The main variation of a typical temple lies in the number of apses, being three, four, five, or six (Bonanno 2017, Evans 1971: 86-87, Trump 1999, Trump 2002: 69-75). Based on Renfrew's (1973: 170-172) original statement of a regionally based hierarchical chiefdom society, which he later modified (Renfrew 2007: 12), and these above mentioned suggestions of Torpiano (2004: 364) and Trump (1999, 2002: 69-75), an intriguing outcoming inference could be that there may have been a collaboration between more local and more island-wide efforts, employing and conforming their special abilities and interests.

The literature on what kind of social structure might have been the driving force behind the construction of the Maltese temples has been reviewed in section 2.2.1 page 20, without concluding on what the driving force behind temple constructions may have been, besides that it could have had a ritualised or ceremonial cause. Nevertheless, investigating temple intervisibility may bring some additional insight into the local and social organisation behind temple construction. It could reflect why some temples were located to have an intervisibility with other temples whilst others were not. It could also echo a form of viewscape and visual connection to a common belief system, a cosmology linked to ritualised temple practices, architectural structure, and internal layout. The Maltese prehistoric temples' relation to a belief system, worldview and cosmology have already been noted in the literature (Anderson and Stoddart 2007, Grima 2007, 2008, Lomsdalen 2014a, 2014b, Malone and Stoddart 2009, 2013, Robb 2007, Skeates 2007, 2010, Stoddart *et al.* 1993), but whether temple viewscape could have played a role in such a belief systems has as far as this author is aware of, never been approached.

Regarding the organisation behind temple constructions, the case may be that a planning unity behind temple constructions had a social structure somewhere halfway between

Renfrew's (1973: 170-172) group-oriented chiefdom society and Cazzella and Recchia's (2015: 106) ritual specialists with no political power. Skeates (2007: 161-163) suggests that the 'domain of the living' began to construct monumental shrines of enduring megalithic blocks based on shared religious ideals manifested in an ideology praising the durability of their living communities, land and faith, but the presence of a priesthood development should not be ignored. Neither should it be underestimated a potential cosmological affiliation to the very origin of the first temple structures as they have layouts similarities to earlier rock-cut tombs both in Malta and in Sicily (Evans 1959: 88-91, Skeates 2010: 163). The ceremonial liaison between burial places for the dead, the temples for the living and the sky for the ancestors has been suggested by Malone and Stoddart (2009: 376) as a cosmological component in the worldview of Maltese Temple Period's society. As already mentioned, sites have been built on previous dwelling sites and even in combination with shrines, which brings in an affiliation to preserve a cosmological connection with ancestors.

According to the present author, it is arguable that there would have been an organising driving force that had very clear purpose when erecting these temple compounds both logistically and structurally. A hypothetical provocation advocated by Skeates (2010: 163) related to this topic, might be that a form of priesthood and socio-economy class collaborated with a possible common goal for themselves and the people of Malta based on a unified worldview, belief system, and a consolidated cosmological ideology. As noted by the scholars already mentioned, there seem to be an affiliated suggestion that the Maltese temples were a place of ritual and ceremonial practices. This could be either religious or secular in its form, constituting a cosmology, a common worldview, or a certain cause that would be important and meaningful to the temple builders, which could then further influence where to build a temple, and when to pay attention to its visibility and viewscape. Through temple visibility and viewscape this would probably remind the viewer primarily of the cosmology the temple represented, but also of the hierarchical entity of its builders, similar to what churches and mosques do today.

Some final reflections on viewscape and cosmology related to temple intervisibility and location may be made with reference to the specific case of Ħaġar Qim and Mnajdra.

Mnajdra's visibility may have been less important than that of Ħaġar Qim, as the latter is conspicuous in its local landscape, such as when a person is approaching from the local region of Qrendi. That said, it may also have been that it was more important for Mnajdra to see and have a viewscape of Ħaġar Qim than the other way around. In Gozo, Ġgantija and its distinguished complexity as a temple and its widely conspicuous location in the landscape, having a reciprocal intervisibility with nearly half of all temples in the region, suggests that temples may have been constructed with the purpose of intervisibility to accentuate a viewscape of a common cosmology between these temples in question.

We now turn to consider areas or regions with no or little intervisibility between temples like Birżebbuġa and St. Paul's Bay, where the latter based on the adjusted TRUE 3 m temple height does not have any temples with intervisibility. St Paul's Bay could be an area where the exigence of having local visual contact with another temple was not a priority, unless of course the temples did have a variation of heights more than 6 m when human acuity is taken into consideration (ref. Table 2.18 page 138). Xemxija is the temple with the highest potential of a conspicuous location in St Paul's Bay area. A plausible reasoning behind its position and lacking temple intervisibility, could have been a cosmological significance as it is situated in the vicinity of the higher located Xemxija Tombs (Grima and Farrugia 2019: 79). The vicinity of temple and tombs could insinuate in this case that a cosmological liaison between the dead and the living was stronger than temple viewscape, as the tombs are definitely placed on more conspicuous grounds than the temple. That a cosmological correlation with temples above the ground being for the living and temples or funerary sites under the ground for the dead has also been suggested by Malone and Stoddart (2009: 376) with the affiliation of the burial site at Xagħra Circle with Ġgantija and Santa Verna temples in Gozo. A similar scenario is Tarxien, where the Ħal Saflieni Hypogeum has a central location among several temple sites in that area.

The Birżebbuġa area consist of four extant temple sites, Tas-Silġ, Borġ in-Nadur, Ħal Ġinwi and Xrobb l-Għaġin. Tas-Silġ is the temple that has the most conspicuous location and as suggested by Grima and Mallia (2011: 243) it is located on a '…spine of a saddle-backed ridge near the coast…', with a compelling view over local landscape and part of the sea similar to the location of Ħaġar Qim. A temple height of 6 m widens up the visual connection to It-Tumbata and L-Iklin, however based on 3 m Tas-Silġ has reciprocal view with Borġ in-Nadur and no other visual connection with another temple (ref. Table 2.4 page 68 and Table 2.23 page 147). Ħal Ġinwi is a site in solotude and had no intervisibility with another temple (ref. Table 2.10 page 82).

From a cosmological perspective, the builders of Tas-Silġ could have placed the temple on this hill formation for a viewscape purpose to be conspicuous in the wider local landscape for anybody approaching the site either from the sea or the land (Grima and Mallia 2011: 227-228). Xrobb l-Għaġin may according to Pace (2004a: 103) have been constructed in the Ġgantija Phase with continuous use during Tarxien Phase. Evans (1971: 27) suggests a long term use of the site as pottery from pre- to post-Temple Period has been found. Xrobb l-Għaġin may be the first temple to be constructed in the area, located on a steep cliff overlooking the sea, distancing itself from the local environment. This could imply that the viewscape and visual connection to the sea and the wider world incorporates the cosmological priorities of its builders, or it could be related to emphasising a viewscape of the cosmology the temple represented for any nearby seafarer.

All four temples in the Birżebbuġa and Marsaxlokk area do have visual contact with the sea, but temple intervisibility is absent or rather low. One plausible cause for this could be related to what Gambin (2014: 4) proposes that 'In the late Neolithic, the inhabitants of the Maltese Islands constructed places of worship in prime coastal areas…'. For the local builders, a viewscape of temples could have been a manifestation of an integration of terrestrial and maritime cosmology, either when approaching temples from the sea or the land. Grima (2001: 63) also suggests a cosmological interaction when temples are located on the borderlines between land and sea which could have been '…echoed in the internal spatial order, locating ritual activity in a cosmological frame of reference.' Even in modern times, seafaring involves a level of danger, and further quoting Gambin (2014: 3): 'The relationship between seafarers and the divine is not limited to a particular chronological period, religion or geographical zone.' The scenario from this part of Malta with a possible cosmological affiliation of viewscape, landscape and seascape, could have been a motivation behind locating temples on the archipelago with a reciprocal visual contact to and from the sea. A future GIS viewshed study analysing the Maltese temples affiliation to landscape and seascape could bring more clarity to this topic.

Based on the many scholarly suggestions referred to here, the megalithic structures arguably were temples. The label - 'temple' implies a centre or a structure related to a form of ritual or ceremonial performances under the conduct of a kinship contributing to a spiritual welfare to individuals and the society (Skeates 2010: 163). Based on the scenario that the temples were cosmological centres for a society, and through this empirical investigation as discussed that the majority of all temples seemingly had an intervisibility lends support to the idea to that temple viewscape could have been a consideration in the choice of location, to reflect sensing, seeing, and expressing a cosmological arena in the cultural landscape.

Temple chronology and how it may have influenced temple intervisibility and cosmology is another relevant area to consider. As analysed in the three sections (2.5.4, 2.5.5, 2.5.6 on regional temple intervisibility, it is proposed that temple intervisibility in the Ġgantija Phase appears to have been given less importance than during the Tarxien Phase. Ħaġar Qim and Mnajdra in the Qrendi region do not have a reciprocal intervisibility, and in the Mġarr region, Ta' Ħaġrat and Skorba are not intervisible. According to the archaeological record (McLaughlin *et al.* 2020a) the two first temples constructed in Gozo were Santa Verna and Ġgantija which do not have intervisibility. In the Birżebbuġa region the only temple listed to the Ġgantija Phase (ref. Appendix 7.2) is Xrobb l-Għaġin, which as previously explained in this section, has no intervisibility with any other temple. Regarding the Paola/Tarxien region, only Kordin III and Tarxien Far East are listed to the Ġgantija Phase (ref. Appendix 7.2), and there are no intervisibility between these two sites (ref. Table 2.4, Table 2.7), consequently regional temple intervisibility is not a cosmological issue. As already discussed in this thesis, the reasoning behind temple location in the Ġgantija Phase could have been related to more practical factors than intervisibility. The Tarxien Phase witnessed an increase in temple development both in numbers, sophistication and iconographical representations, and in addition greater visual contact with other temples, which may possibly have been significant for the islanders' cosmology.

To sum up, the present research has shown that the Maltese prehistoric temples were not accidentally located in the cultural landscape. Most of the temples were deliberately located, and that in many cases visibility and intervisibility were a unifying element for the viewscape of the cosmology they all shared.

2.6 Conclusion

For this study of temple intervisibility, it would have been futile without employing GIS applications to conclude on what Bender (1993: 2-3) suggests that landscape has to be contextualised mirroring humans cultural historical conditions and how dwellers perceived the world they lived in.

The central research question investigated in this chapter was if the Maltese prehistoric temples were positioned in the landscape in a manner that allowed for intervisibility. The research program hinged on a very clearly specified methodology primarily applying GIS software, but also required ground truthing and direct observations of temple sites in the landscape. Another core objective was to test any GIS results statistically and to validate empirical findings on levels of intervisibility among the 35 temple sites. GIS was also employed to examine if temples were located in the most inherently visible portions of the landscape, and how the temples are topographically located with emphasis on elevation, slope, and aspect. The overall paradigm of the thesis related to viewscape and cosmology has also been evaluated as a backdrop in both considering a temple's locations in its cultural landscape and temple visibility and intervisibility.

As earlier noted, applying GIS to examine visibility of historical monuments has been researched in several parts of the world. The topic has become an important element in archaeology particularly for prehistoric monumentality, but when it comes to Maltese archaeology, prior the present research it was an uncharted area of exploration, expect for a preliminary study as already mentioned. Due to the uncertainty of the heights of the temples, an innovative approach of this study was not only to produce a standardized viewshed or a cumulative viewshed analysis from ArcMap, but in combination with QGIS generating values for the visible portion of a target from a given observation point, which could then be evaluated taking distance and human acuity into account. Another new and innovative research method that was applied here for the first time to Maltese archaeology, was to apply ArcMap (ArcGIS) and QGIS to establish if temples were located in the most inherently visible geographical positions in the landscape, and also for researching temple intervisibility. These parts are core elements of knew knowledge brought through GIS to Maltese archaeology.

The four areas of findings from this study are as follows:
1. Temples and topography.
2. Temple visibility and landscape.
3. Temple intervisibility.
4. Temple visibility and cosmology.

1. Temples and topography

The statistical results are explained in 2.4.1 page 56 and illustrated in Figure 2.10 page 58.

Elevation:

Considering the Archipelago as a totality, there is no statistical preference for low or high elevations of temple locations.

Slope:

The statistical analysis of the Archipelago confirms that there is a significant distribution for slope variation between 4° and 14° as there is a larger than expected proportion of temple sites within this range of slope.

Aspect:

The data from the archipelago show that there is a larger portion than expected of temple sites facing the southern hemisphere with a slight emphasis towards east and west.

It would seem ambitious to search for a single reason why temples were located in these positions in the topographical landscape, but this would most likely largely depend of the geological formations of the local landscape. The causes for locating temples in the southern hemispherical aspect positions could also be based on having the Sun as source of heating energies, and in the slopes to protect from the harsh winter winds. A sloped countryside could also have held an appeal to the builders for wider view of the landscape, where temple intervisibility could have been one of their considerations.

2. Temple visibility and landscape

The findings from this part of the study are shown in 2.4.2 page 59, divided into the two listed components; CVS and random points, and TVS and random points based on 3 m temple heights which is a conservative estimate based on lowest of measured extant temples (ref. Table 2.1 page 34).

Cumulative viewshed (CVS) and random points

The result from the Mann-Whitney and Barchart tests show a tendency that CVS temple sites feature higher values than CVS random sites (ref. Figure 2.11 page 61). This concludes that the temple sites were *not* randomly located. This insinuates that the builder assumingly had a system or a plan where to erect the temples, without qualifying what that plan may have been.

As illustrated in Table 2.2 page 63 for temple intervisibility and Table 2.3 page 64 for visual reciprocity, which is qualitatively summarized in Table 2.11 page 83, resulting in that 68.6% of temples have an intervisibility and 45.7% do have a visual reciprocity. These results can generate an argument that for the majority of the builders, temples intervisibility was a priority. This does not exclude that there may also have been alternative plans behind temple locations, as previously noted vicinity to natural resources.

Total viewshed (TVS) and random points

The result from Mann-Whitney and Barchart tests display that TVS sites tend to have larger values than the TVS random sites (ref. Figure 2.12 page 65). As TVS sites feature higher values than the TVS random sites, this concludes that the temples were located in the most inherently visible portions of the landscape. The true reasoning behind these locations will remain as an open question. However, since temple intervisibility in the landscape has manifested as an arguable cause, and that temples are located in the most natural visible parts of the landscape, a presumption could be that there was an influential combination of temple and visibility in the landscape from the builder's side.

3. Temple intervisibility.

The results from temple intervisibility based on 6 m and 3 m temple heights are shown in 2.4.3 page 66 and empirical evidences in 2.5.7 page 130 where the visible portion of a target is calculated based on distance from a source site and considering human acuity.

Based on a temple height of 6 m, the outcome of this investigation shows that 80% of all temples do have intervisibility in one way or the other, while 65.7% of them have visual reciprocity (ref. Table 2.17 page 134). This result is a strong argument for temple intervisibility, but a deficiency of this hypothesis is that it is implausible that all, or the majority of temples had a height of 6 m. On the other hand, the strength of this study applying VSQ analysis based on 6 m, is to quantitatively manifest the difference in visible (TRUE) and not visible (FALSE) portions of a given target, considering distance and human acuity (ref. Table 2.18 page 138).

An intriguing part of this analysis as explained in 2.5.7 page 130, and illustrated in Table 2.18 page 138, is to consider not only the 151 TRUE temple interconnections, but also the actual physical visible upper 3 m part of a 6 m target based on distance and human acuity. This investigation is summarised in Table 2.20 page 141 indicating a reduction of intervisibility by 15 (9.93%) interconnections from 151 to 136, and reduces the 80% intervisibility to about 70%. This 70% is arguably a more reliable figure than the 80% based on the assumption that all temples were 6 m has been eliminated. Now temples with a height between 3 m and 6 m are considered and also taking into account distance to target and human acuity. If not all, but several temples potentially had a height between 3 m and 6 m, and is feasible based on what has been suggested in the archaeological record (ref. Table 2.1 page 34).

Contrary to the 6 m temple height analysis, a temple intervisibility based on a rigid conservative 3 m temple height potentially reflects a higher degree of credibility based on results from both CVS of ArcMap, and even more so applying VSQ from QGIS, where the visible portion of a target based on distance and human acuity are implemented in the empirical results (ref. Table 2.25 page 150).

The most rigorous intervisibility scenario from all these different analyses is the 3 m VSQ, which would carry a considerable argument for that 51.4% of all temples did have intervisibility with another temple and that 34.3% of them have a visual reciprocity. In addition to this strong revelation that about half of all temples were positioned in the landscape to aspire intervisibility, other causes such as closeness to natural resources or reflecting needs of a local society could be more engaging than visual connection to other temples in the area. This priority could have been a case for the other half of the temples that did not have intervisibility with another temple site. Taking into consideration statistical inferential testing (ref. 2.4.2 page 59), the argument for premeditated temple visibility and intervisibility by their builders is further strengthened.

When it comes to regions the question of, *to have* or *not to have* intervisibility, seems to carry a factor of local priorities. Based on the three regions in this study, for Qrendi it seems more likely that the temple builders did not prioritize intervisibility (ref. 2.5.4 page 85). The same scheme reflects Mġarr region based on a VSQ analysis resulting in that 13.3% of temples have intervisibility and 6.7% are visual reciprocal. For Gozo the synopsis is different. Based on a 3 m CVS analysis (see Table 2.15 page 119), 100% of all temples in Gozo do have an intervisibility and 93.8% are visually reciprocal. An examination applying VSQ of the CVS results, shows no change in intervisibility or reciprocity (ref. Table 2.22 page 145). Even though all temples in Gozo are visually connected with each other in one way or the other, it does not signify that Gozo was a unified society when it comes to temple constructions (2.5.6 page 114). Cluster formations of temple intervisibility, implies geographical sub-divisional organisational units prioritizing visual interrelation with specific localities on the island.

Temple viewscape and cosmology

As the Maltese prehistoric megalithic structures have been suggested by several authors (ref. 2.5.8 page 150) to be centres for ritual and ceremonial performances organised by a local kinship or priestly class, it is highly conceivable that the buildings were temples representing the society's belief system and worldview. As substantiated through statistical inference that the temples were not randomly located and that slightly more than half (51.3%) of them based on the most rigid scenario, were positioned in the landscape for intervisibility with other temples, does accentuate that, even if it was not the case for all local societies, nevertheless the Archipelago seen as territorial unit, it can be argued that visual connection to a temple was a part of the prehistoric society's viewscape and cosmology.

To summarize and to answer the paradigm of this chapter's research question, if temples were built on locations that allowed for intervisibility, this study has shown that temple intervisibility does carry a certain legitimacy that visibility to specific temples were, if not the only reason, but arguable one of the priorities of the builders to locate a temple in a premeditated position in the landscape. Another supporting factor for a non-arbitrary selections of temple locations by their builders, is further inferred through statistical analysis manifesting that temples were not randomly located and they were also positioned in the most inherently visible part of the landscape. This combination of methods, scientific analysis and reflective discussion does further insinuate that temple intervisibility was presumably both meaningful and significant to the Maltese prehistoric society. However, to draw an indivisible conclusion, further studies should be conducted.

3 Did specific features on the apparent horizon influence the location of temple sites in the landscape?

3.1 Introduction

The purpose of this chapter is to examine to what extent the Maltese prehistoric builders were influenced by specific features on the apparent horizon when selecting the location for a temple site in the landscape. The research is divided into two specific questions. The first question is whether the apparent horizon was open or restricted, while the second question is whether there was a relationship with specific astronomical phenomena on the apparent horizon.

The present study is the first to undertake this type of horizon study in Malta. A similar one has been published by Cummings *et al.* (2002) researching Neolithic chambered cairns in the Black Mountains, Southeast Wales, which has been an inspiration for this study. According to Cummings *et al.* (2002: 57-58) Neolithic monuments' positioning have been studied with a diversity of approaches in landscape archaeology, mainly based on two alternative methods. One is a more traditional, 'etic' approach, taking a more detached and Cartesian view of cultural activity in the landscape. The alternative, the 'emic' approach, considers cultural activity in the landscape from an experiential or phenomenological perspective. Cummings *et al*. (2002) investigated if the configuration of an open or restricted horizon could influence the orientation of the central axis of the Neolithic chambered cairns in South Wales. Their aim was to re-examine various previous studies of the cairns, and based on their own observations reproducing a 360° layout vista from a predetermined area in the centre of the monument (Cummings *et al.* 2002: 58-59). They suggested that their findings indicate that the internal axis of the cairns in respect to the landscape of an open and restricted horizon represented a bodily transformation from the symmetry of being alive to the asymmetry of being dead (Cummings *et al.* 2002: 67). The difference in landscape setting between monuments and cairns is, according to Cummings *et al.* (2002: 67), that monuments are bounded by landscape features '…such as mountain ranges or river valleys…', while cairns were built in places with a more balanced landscape profile '…are felt to possess the correct range of topographical elements…', and that these landscape features were accentuated upon construction.

Cummings *et al.* (2002) were exploring to what extent the prehistoric builders of the Black Mountains were influenced by specific features of the apparent horizon when selecting the location of the site. Drawing on this approach, the present study investigates if the Maltese temple builders were influenced by the same features on the apparent horizon. Considerations of the open and restricted landscape in relations to symmetry and asymmetry of the axis of the cairns, which were a part of the study by Cummings *et al.* (2002: 67), will not be a part of the present study since this study is not concerned about ritualized spatial structural arrangement inside the temples, but it is primarily about temple locations in the landscape.

The second research area is also concerned with distinctive features on the apparent horizon, and their possible relationship with the rising and setting positions of celestial objects. Ruggles (1999: 154) maintains that the horizon is '…the place where the earth meets the heavenly vault...' Ruggles (1999: 113) further proposes that the surrounding landscape of prehistoric monuments were symbolically important, and the landscape and the apparent horizon surrounding a monument should be examined for prominent natural features and celestial phenomena, as this may shed light on the possible reasoning behind a monumental location.

The studies relating to Higginbottom *et al.* (2015), and especially Higginbottom and Clay (2016a) monumentality in Scotland, are directly relevant to the present research. Higginbottom and Clay (2016a: 177-178) researched to what extent the builders, prior to or during construction, were concerned with astronomical bodies' rising and setting position on the horizon, an area that is also a key concern of the present study. The essence of their study was to test for evidence the interest in monumental interconnection with landscape horizon features, such as whether any mountainous or flat, prominent hills, peaks or water, and whether these were associated with astronomical phenomena (Higginbottom and Clay 2016a: 184-186). Based on local topographical formations of the horizon, Higginbottom and Clay (2016a: 186) conclude that these landscape features in combination with astronomical events could have been of special meaning to the builders of the monuments and could also have been a determining factor for site locations and structural orientations. Higginbottom and Clay (2016a: 186-187) further suggest the possibility that, in Scotland, as well as also along the western coast of Britain, there may have been a tradition of relating monumental constructions with horizon features and sky events.

Pimenta *et al.* (2015) researched 688 Neolithic open air rock carvings distributed among mountainous regions between Alva and Ceira rivers in central Portugal. These sites could have been used as solstitial markers or an interrelation between the podomorph illustrations and the summer full Moon or Alfa Centauri. Their archaeoastronomy project was aimed to find out how the sites of the petroglyphs were selected, the orientations of the slabs, engravings, and the sites themselves in the landscape. Statistical analysis suggested that the sites were chosen to be markers of the summer and the winter solstices, with a south-oriented preference for rock slabs. Archaeoastronomical results and ethnographic sources suggest that the rock art sites with podomorphs were used for fertility rites affiliated with the Moon, stellar target as Alpha Centauri and for days around the summer solstice setting (Pimenta *et al.* 2015: 233).

When it comes to the Sun and Moon rising and setting on the apparent horizon from a given location, this is not an arbitrary question. The reason for this is that celestial bodies have observable cycles anywhere in the world, regardless if one wants to construct a monument on a certain location or not. Therefore, a more specific research question for this study is whether there was a preference to construct temples on locations where the Sun and Moon are seen to rise and set on specific horizon features.

Studies related to landscape archaeology and horizon astronomy similar to Cummings *et al*. (2002) and Higginbottom and Clay (2016a) have not been done on the Maltese archipelago.

This has given use to the need to fill a gap of knowledge, firstly to research to what extent the builders could have been influenced by an open vs. restricted horizon; secondly, to examine to what extent the location of the rising and setting of the Sun and the Moon were deciding factors for the builders to locate a temple in the cultural landscape.

Although the study is concerned with the apparent horizon observable from a given temple site, it shall also examine the formation and features of the horizon applying two distinct fields. The first is landscape archaeology, which it shall evaluate to examine what extent there could have been a preference for an open or restricted view of the horizon to locate a temple. The second is skyscape archaeology which studies whether the temple builders were concerned if the Sun and Moon would rise or set on specific features or points on the apparent horizon.

In search for an answer to this paradigm, a distinct methodology is established applying a 360° circumference 3-D rendering of the horizon of each of the 35 temples sites involved in this study. The study is further complimented by statistical testing of any emerging patterning and a discussion analysing achieved results, where cosmological relevance is considered. Based on the results, a conclusion of the findings shall be presented.

As Malta is an archipelago, it should therefore be highly relvant to statisically investigate not only the open and restriced vista from a site, but also which part of the apparent horizon the Sun and Moon rise and set within all the possible horizon variables an archipelago offers. This is a study that has not previsouly been conducted and therefore sheds new knowledge on this topic.

In a wider Maltese archaeoastronomical perspective, there are no studies applying manually, photomontage, or visual 3D-rendered computer panoramas of rising and setting of celestial bodies along the 360° circumference view of the topographical horizon from a temple site. Therefore, this study is an innovative research program when it comes to the Maltese apparent horizon landscape. Based on relevant previous studies, this research shall fill a gap in researching Maltese Temple Period. The approach of contextualising horizon astronomy with skyscape archaeology, viewscape, and cosmology of the Maltese Temple Period's society, gives this study a more groundbreaking justification of bringing new knowledge to humanity.

3.2 Literature review

This section describes the relevant literature applied to this chapter. It focuses on landscape archaeology with emphasis on the interrelationship between monuments positioning in the cultural landscape and their apparent horizon. Furthermore, the rising and setting of celestial bodies on the visible horizon seen from a prehistoric monument is related to a potential cosmological consideration which can be considered as a domain of horizon astronomy and skyscape archaeology.

Horizon seen from a landscape archaeology perspective

Darvill (2008a: 198-199) defines horizon as a cultural link between human and artefacts, or a subdivision of a natural or anthropogenic soil profile, without referring it to be the line or the profile where the surface of the earth and the sky appears to meet. David and Thomas (2008: 38) suggest that landscape 'is as much about ontological and cosmological dimentions of places as it is of physical characteristics'. How David and Thomas here describe landscape in archaeology is one of many samples of how people experience the visual world and the space they live in. Tilley (1994: 12) describes relationship between 'Being and Being-in-the-world', which is an objectified process of bridging a gap in space, between a subject and an object through various perceptual means (hearing, seeing, touching), bodily movements, locating emotions, embodied in a belief system or decision-making.

What David and Thomas (2008) and Tilley (1994) here propose relating to this study, would be how the temple builders or the society's decision-makers could have perceived, understood, experienced or prioritised being in the totality of the world where the horizon as a visual landscape boundary between the Earth and the sky could have influenced temple locations. In other words, how important and what importance, if any at all, could a special topographical formation of the apparent horizon have been to the Temple Period society. The present author (Lomsdalen 2017: 123) maintais that:

> Modern landscape archaeology encompasses areas like monumentality in landscape connected to political acts and concepts of unification, social transformation, and the landscape's spiritual, religious, cult, pilgrimage and holy significance influencing location and orientation of prehistoric monuments [(Brady 1991, Harding 2012, Richards and Thomas 2012)].

Fleming (2012: 70) refers to Tilly (1994), *A Phenomenology of Archaeology*, suggesting that places, paths, and monuments which represent disparate sites should be linked to distant hills, water courses or other geographical features to create a networked archaeological landscape, and that archaeology could take the road of archaeoastronomy to test for more valid and rigorous apparent significant patterning of monumentality in a landscape setting.

When it comes to landscape archaeology or any area of archaeology for that matter, archaeologists often refer to mountains and hills, symbolically or factual, but seldom or basically never use the word 'horizon' to describe the visual borderline between earth and the sky. Not even in the landscape archaeological literature describing orientations of monuments and celestial events, the word horizon does not seem to be part of a standard terminology (David and Thomas 2008, David and Wilson 2002, Meirion Jones *et al.* 2012). Grima (2001, 2005, 2011, 2016b) and Grima and collaborators (Grima and Mallia 2011, Grima and Vassallo 2008) seem to be some of the few cases, according to this author, who directly use the word 'horizon' or 'apparent horizon' as geographical reference point in the monumental landscape in Malta.

Allen and Gardiner (2002: 114) provide another example where horizon is used where the approaching view on the 'horizon' is framed by an immovable landscape object, as in this case the location of Stonehenge in the landscape. Prendergast (2021: 24-27) does not use the word 'horizon', but describes the phenomenology of high places where the prehistoric burial tombs in Ireland were located at the highest mountainous points in the landscape representing ‘the middle cosmic level (earth) to the highest cosmic level (sky) as a part of a burial ritual’. As just referenced by Prendergast in the edited publication, *Space, Place and Religious Landscapes: Living Mountains* (Gunzburg and Brady 2021), Tilley (2021: xvii) also emphasises that mountains contribute to phenomenological thoughts how they touch us in a form of visionscape, soundscape, smellscape and taskscapes without mentioning horizon or the sky, for that matter. To quote Silva (2021) in the same edited volume, mountains contribute ‘to the intersection between heaven and earth, of myth and ritual of people and the world around them’. It is not crucial that archaeologists do not mention the word ‘horizon’, as long as they specify a target or specific features on the visual borderlines between Earth and sky, being mountains, valleys, sea view, or rising or setting of celestial objects, though with reference to Fleming’s (2012: 70) previous statement, the word ‘horizon’ would give a more descriptive division of the universe we live in.

When it comes to the more specific research objectives to this study regarding examining how prehistoric Maltese temples were located in respect to which part of the landscape was considered open or restricted seen from the site itself, the work of Cummings *et al.* (2002) from the Black Mountains landscape in Wales has been an essential inspirational source.

In line with what has just been noted on using the world ‘horizon’ in landscape archaeology, Cummings *et al.* (2002: 61) do use horizon to describe when a site view was considered ‘restricted’ as when the near horizon entirely restricts the view, and ‘open’ when the topography allowed a more distant view. The primary research objectives to Cummings *et al*. (2002: 59-61) were to find a ‘symmetry’ or an ‘asymmetry’ of the open or restricted view in relation to the orientation of the central axis in the cairns in order to bring the horizon patterns into a cultural context of the builders. While the axis of the cairns were important, they were seldom oriented to landscape features (Cummings *et al.* 2002: 61). In a wider context, the interest was to establish if symmetry and asymmetry occurs throughout the natural world (open vs restricted in this case) and if the asymmetrical essence of the cairns in the Black Mountains could be considered in a broader significance of phenomenology (Cummings *et al.* 2002: 68). This is a suggestion that is in line with Bradley (2000: 104-105) maintaining that building monuments in places transforms the way these locations are experienced.

The aim behind their project was to re-examine previous claims about the Black Mountains cairns by various observers which according to Cummings *et al*. (2002: 58-59) lacked clarity. Cummings *et al*. (2002: 58- 60, Fig. 2) applied a methodology of recreating a 360° circumference schematic plan representation around each monument recording various features in the landscape and plot their observations around a circle seen as a 'bird's eye view' based on maps and prismatic compass. They claim that their study had a higher degree of clarity than the previous ones, even though their representation is based on subjective viewpoints, but recorded micro-topographic location of the monuments as well a detailed architectural feature of each tomb (Cummings *et al.* 2002: 59). Their findings showed that the asymmetrical internal burial chambers and the landscape was a place of transformation '…where the body changed from the symmetry of the living to the symmetry of the dead…', where their conclusion was attained by subjective and a phenomenological approach concerning qualities of a monument in relation to its location in the landscape (Cummings *et al.* 2002: 67-68). In a more recent and similar research program on megalithic sites in Wales, Cummings (2008: 287-289) utilised a method of making a 360° panoramic photomontage in addition to more modern technological applications such as viewshed analysis from GIS and QTVR (Quick Time Virtual Reality) software enabling users to look around from a fixed point. Cummings *et al*. (2002: 67-68) conclude that the cairns in the Black Mountains were constructed in a way to intensify asymmetry or sidedness, symbolizing how the cairns were built and used in their landscape setting.

In Malta, Grima (Grima 2002, 2004, 2005, Grima and Farrugia 2019, Grima and Vassallo 2008) has applied landscape archaeology to examine how temples may have been located in their cultural landscape, and also argued for a cosmological significance. As mentioned in the GIS Chapter 2.5.2, Grima (2004: 340) based on a chi-square test, concludes that there is a strong preference for temple locations having a southern aspect and locations with a less distinct preference for a western aspect. Though Grima analyses the compass directions of a slope in the landscape without researching the apparent horizon as such, nevertheless his discovery does have a relevance to this study with a significant outcome of an open vista towards the southern hemisphere (ref. 3.4.1). Bonanno (1986b), Bonanno *et al.* (1990) and Stoddart (2002) have also analysed monuments in the landscape, not in relation to the local topography, but rather with a focus on the correlation of architectural, sociological, socio-economic, and cultural affiliation which implied changes in the social, political and religious life of the Temple Period that may have been tied to the rise and fall of monumentality in the Maltese landscape.

Horizon seen from an archaeoastronomy perspective

This author has not been able to find a straightforward definition of the word 'horizon astronomy' in the literature. Silva (2015d: 3) describes 'horizon astronomy' as an informal term, though nevertheless being one of the primary tools in archaeoastronomy, representing the dynamics of rises and sets of celestial objects. In archaeoastronomy, horizon astronomy has traditionally been applied in researching orientations of monumental constructions, horizon calendars, and more recent studies related to a holistic dynamic where skyscape and cosmology can be an integral part of horizon astronomy observations (Silva and Henty 2018).

When referring to horizon in this chapter, it is the apparent horizon from a given observation point and in this case that is a temple site. The horizon may have been made up of landscape features as well as the natural horizon observable over open water.

Chapter 4 focuses specifically on horizon astronomy in relation to orientations and calendric perspectives with emphasis on Maltese prehistoric temples. The present chapter is not concerned with temple orientations or calendric issues *per se*. Having said that, there is a considerable amount of archaeoastronomical literature indicating the importance of ancient societies' concern with the rising and setting of celestial bodies on the horizon as a device to keep track of time and seasons. Therefore, according to this author, it cannot be ignored that the use of the horizon as calendar could have been an underlying factor for temple builders' potential interests in astronomical phenomena happening on the horizon. The star group Pleiades could have been such a device indicating a start of the agricultural season (Dicks 1970) and also a spring equinox seasonal marker for the Maltese temple society (Ventura 2004, Ventura *et al.* 1993). Greek astronomy was focused on the construction of star calendars (Brady 2015: 78). According to Belmonte (2009: 128) the ancient Egyptians had just one calendar, a civil one, invented in the first half of the 3rd millennium BCE with a duration of 365 days based on detailed solar observations from an older monthly lunar Nile-calendar.

Ruggles (2015a: 20-24) suggests that horizon calendars '… reference the changing rising or setting position of the Sun along the horizon over a seasonal year…', and that a true horizon solar calendar is made by what is visible and physical, and not by any transcendental assessments. On the other hand, the native American Hopi culture in Arizona did not use the normal cardinal directions of space and times as north/east/south/west, but points on the observed horizon which mark the places of sunrise and sunset at the summer and winter solstices for the timing of ceremonial circuits (Hoskin 1997: 20-21, McCluskey 1977: 174, 1990: S1). According to Aveni (2008a: 208-209) horizon calendars have received little attention as they tend to be prosaic, and difficult to substantiate archaeologically. In a test from various archaeological sites, Aveni (2008a: 208, Table 8.1) illustrates the result from a possible Anasazi horizon calendar from various pueblos in Chaco and Rio Grande region in US, indicating that the majority of these sites could have been suitable for horizon calendar observations. Malville (2008: 149-150) suggests that early eleventh century CE the residents in Chaco Canyon invented the concept of horizon calendar enabling the leaders of the canyon to schedule periodic festivals. Ruggles (2005: 188-189) who referencing the Aztecs of Central Mexico, suggests that early horizon calendars probably existed from the first millennium BCE, where temples were built on observation points with natural features on the horizon defining significant calendric events.

Again according to Ruggles (2015a: 24), 'An alignment upon an astronomical event does not, in itself, constitute a calendar'. In the case of the Maltese temples, a substantial amount of research on temple alignments to astronomical events has been undertaken, mainly related to the equinoctial and solstitial sunrises, suggesting that temple orientations could have been a seasonal marker (Agius and Ventura 1980, Barratt 2018a, Cox 2001, Cox and Lomsdalen 2010, Lomsdalen 2014a, Tilley 2004, Vassallo 2000, 2011a, 2011b). Micallef (1990) named the Mnajdra Temple a ‘calendar in stone’, Mnajdra South Temple is probably the only Maltese temple that can be qualified as a ‘true’ horizon calendar as it not only indicates date and time for solstitial and equinoctial sunrises, but also divides the solar year into cross-quarter and eight days (Bonanno 2017: 40-41, Lomsdalen 2014a: 126-127, Micallef 2000, Thomson Foster 1999, Trump 2019: 125-127, Ventura 2004: 316-321). Lomsdalen (2014a: 1-3) argues that the Mnajdra South Temple qualifies as the oldest known megalithic site in the world to be a device for keeping track of time throughout a solar year, even earlier than the sites referred to by Ruggles (2010) as the oldest cases, namely the Taosi site in China, and the Chankillo site in Peru.

Regarding the cycle of the Moon, Cox (2009) concluded an innovative archaeoastronomical study of some Maltese temples and their orientation towards the southerly major lunar extreme, an event that happens every 18-19 years when the Moon rises further south than the Sun ever does. This research is also mentioned in a paper by Cox and Lomsdalen (2010). Lomsdalen (2014a: 84) suggests a possible Moon alignment at the Mnajdra Middle Temple. The interrelationship of the Moon and the temples is a field that required further study in future.

The initial motivation to investigate horizon astronomy on the Maltese archipelago was inspired by a Scottish project by Higginbottom and Clay (2016a). This led to further engagement in horizon astronomy literature such as Higginbottom *et al.* (2015), Higginbottom and Clay (2016b), Ruggles (1999), and Pimenta *et al*. (2013, 2015). These publications investigated prehistoric monuments in Scotland and Portugal with orientations towards the rising and setting positions of specific astronomical events on the horizon observable from a given prehistoric site.

Applying Higginbottom and Clay’s (2016a) approach to the Maltese context, the key question is this: to what extent could astronomical phenomena on the apparent horizon have influenced the choice of location for the building of a monument? Both Higginbottom and Clay and the present study build on previous horizon astronomy research in respective to Late Neolithic Scotland and Neolithic Malta. By applying the visible horizon Higginbottom and Clay (2016a: 178) intended to demonstrate the connection between a megalithic site and '…continuety of cosmology over two millennia more firmly than can the the accompanying archaeological evidence…', and furthermore confirms that the archaeological record is funamental to fully reckognize and apprehend a megalithic site. Higginbottom and Clay (2016a: 181-183) found two dominant horizon landscape patterns in their study. When water was visible, they asked whether it was to the south or to the north. They also asked if the closest or more distant horizon lay to the north or to the south, or if the Sun and the Moon rise or set over the ranges of hills, or over more open ground. Their findings, based on statistical testing, show that the megaliths were located in 'reversed' landscapes that are blocked in the south, therefore hindering the observation of astronomical phenomena and, in addition, shortening daylight time and diminishing the strength of moonlight at night (Higginbottom and Clay 2016a: 186). Based on their recent work, Higginbottom and Clay (2016a: 186) suggest a combination of astronomical alignment and topographic locational preferences, and that this interconnection between landscape and sky, seems to have been 'known some time before setting of the stones'.

In Malta, since the pioneering paper by Agius and Ventura (1980) several studies have examined rising and setting of celestial objects, but these were more focused on the orientation of temples in relation to the Sun's rising and setting points on the horizon. Regarding the cycle of the Moon, Cox (2009) published research from 2005–2007 on 'Observations of Far-Southerly Moonrise' from three Maltese temples.

3.3 Methodology

This section describes the justification of methods, applicable data capture, and statistical analysis in order to address the research question.

The research is dived into two different stages, *Horizon open and restricted*, and *Horizon astronomy*, where the methodology is basically the same. The difference is, how to look at a horizon in characteristically two functionalities. The first stage considers the topography, while the second stage also takes into account astronomical phenomena. Therefore, some parameters will vary. These shall be further highlighted accordingly. But firstly, some of the applicable astronomical terminology shall be described.

3.3.1 Astronomical terminology

Latitude (Lat) and longitude (Long)

Latitude and longitude are essential in archaeoastronomical calculations for the reason that they give an address to any location on the earth based on a geographic coordinate system identified by the axis of the earth's rotation (Hoskin 1997: 84, 175-182). In simple terms, lines of latitude are horizontal lines measuring in degrees from 0 to 90, showing how far north or south a location is from the earth equator which is at zero degrees. Lines of longitude vertically show how far east or west a location is from the Prime Meridian at the Royal Observatory in Greenwich, England, which is defined as longitude zero (Longley *et al.* 2015: 86-88). As an example, latitude and longitude for Valletta in Malta has geographical coordinates in degrees, minutes, and seconds, 35° 53′ 56.1″ North, 14° 30′ 52.4″ East, or in decimals, 35.898908N, 14.514553E (Country Coordinates 2021).

Azimuth (Az) and altitude (Alt)

As Figure 3.1 shows the coordinates of azimuths and altitudes together identify the position of a celestial body such as the Sun, planets, or a star in the celestial sphere, relative to an observer at a given point (Malville 2008: 30-40, Ruggles 1999: 18-25). An azimuth is an angular measurement in a spherical coordinate system measured from north through east in degrees. The azimuth of a point on the apparent horizon from a given location is measured clockwise in degrees from the north. An object which is due north has azimuth = 0°; for due east, azimuth = 90°; for due south, azimuth = 180°; and for due west, azimuth = 270°. Altitude on the other hand is the angular distance measured in degrees above the horizon towards the zenith in other words, the elevation of an object above the horizon. It ranges from 0° at the horizon to 90° at the zenith, the spot directly overhead. The word altitude is also used to measure the elevation of the apparent horizon in degrees from a given observation point. In these cases, the altitude can be either positive or negative depending on whether it is higher (positive) or lower (negative) than the position of an observer.

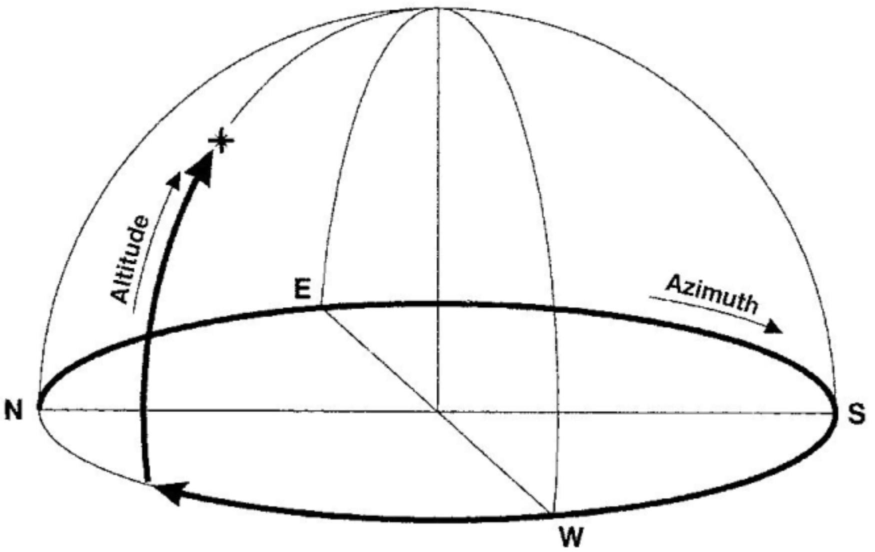


Figure 3.1. Azimuth and altitude, after Malville (2008: 30, Fig. 3.5).
The celestial sphere with the coordinate system azimuth and altitude.

Declination (Dec.) and right ascension (RA)

As Figure 3.2 illustrates declination and right ascension as a celestial coordinate system (Magli 2016: 4-5, Malville 2008: 35-42). Declination, a north-south coordinate and right ascension, an east-west coordinate, together define the position of an object in the sky (Kelly and Milone 2005: 16-17, Ruggles 1999: 168-170, 258). Any particular star has the same RA and Dec. for all observers on Earth. Altitude and Azimuth, on the other hand, are local coordinates and each observer sets his own reference frame from a given position on Earth. Declination is diversely like a celestial latitude and right ascension is like a celestial longitude. Declination is an important positional concept in astronomy and will commonly be referred to throughout the methodology and statistical analysis sections. Malville (2008: 35) defines declination as 'The distance of the sun, a planet, or a star from the celestial equator', and is considered positive when the object is north of celestial equator and negative when to the south of it. The celestial equator, which is the terrestrial equator projected into the celestial sphere, is the line where the declination is zero degrees. Declination is always a line in the sky (like latitude is a line on the earth) and it is the apparent path taken by a star or the Sun on a given day, as seen by an observer on Earth. To be exact, it is the approximate path, as the Sun changes declination a little over the period of a single day, while the moon changes its declination dramatically over the course of a day/night. Three sets of data are needed to calculate a declination of a celestial body, being the azimuth, the altitude of a point on the apparent horizon, and the latitude of a set observation point.

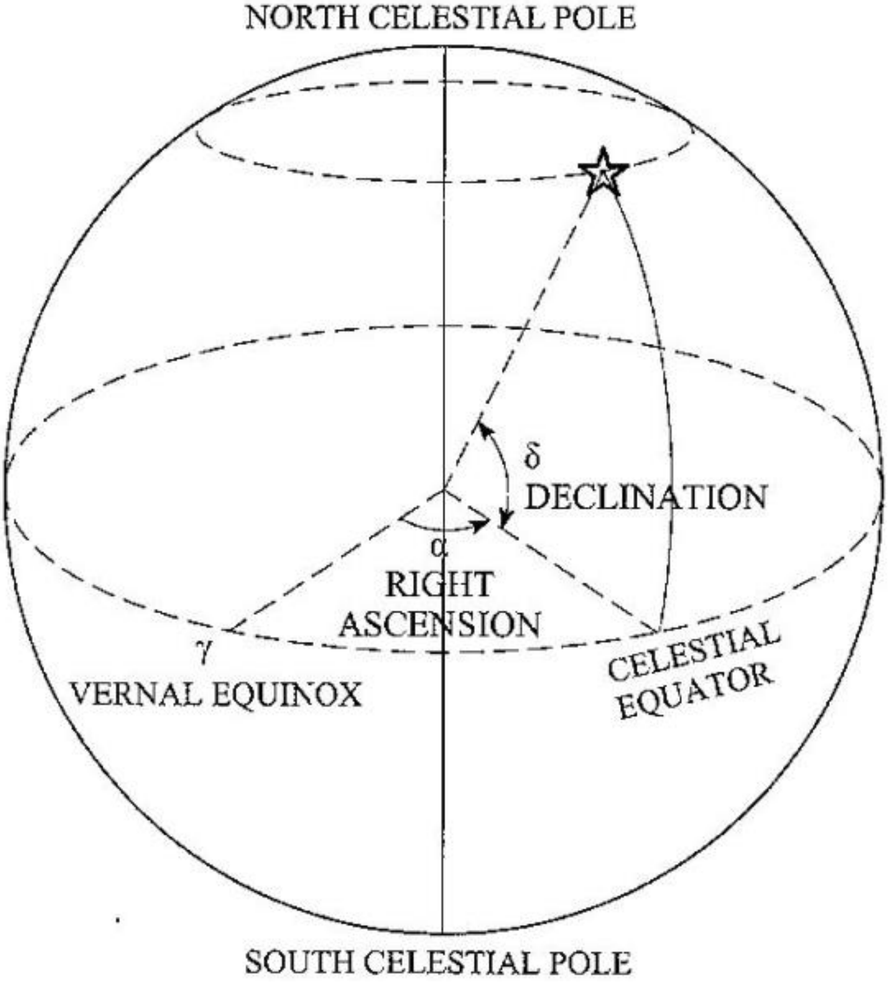


Figure 3.2. Declination and right ascension, after Magli (2016: 5, Fig. 1.2).
The celestial sphere with the coordinate system declination and
right ascension.

Solstice and equinox

Figure 3.3 portrays the path of the Sun at the summer solstice, equinox and the winter solstice (Magli 2016: 6-7). The Sun's path through the sky during a year is related to its declination, and at present varies over an annual cycle from approximately +23.4° at the summer solstice in June, and -23.4° at the December winter solstice. During the Maltese Temple Period the annual cycle of the Sun was wider, and went from a declination approximately +/- 24.0° (Agius and Ventura 1980: 13). At the spring and autumn equinox the Sun has a declination of 0° as these are the two times in a solar year that the terrestrial and celestial equator are aligned when the ecliptic intersects the celestial equator at these points. That is why all over the world days and night are seemingly equally long, about twelve hours each, though that is not completely exact in minutes and seconds.

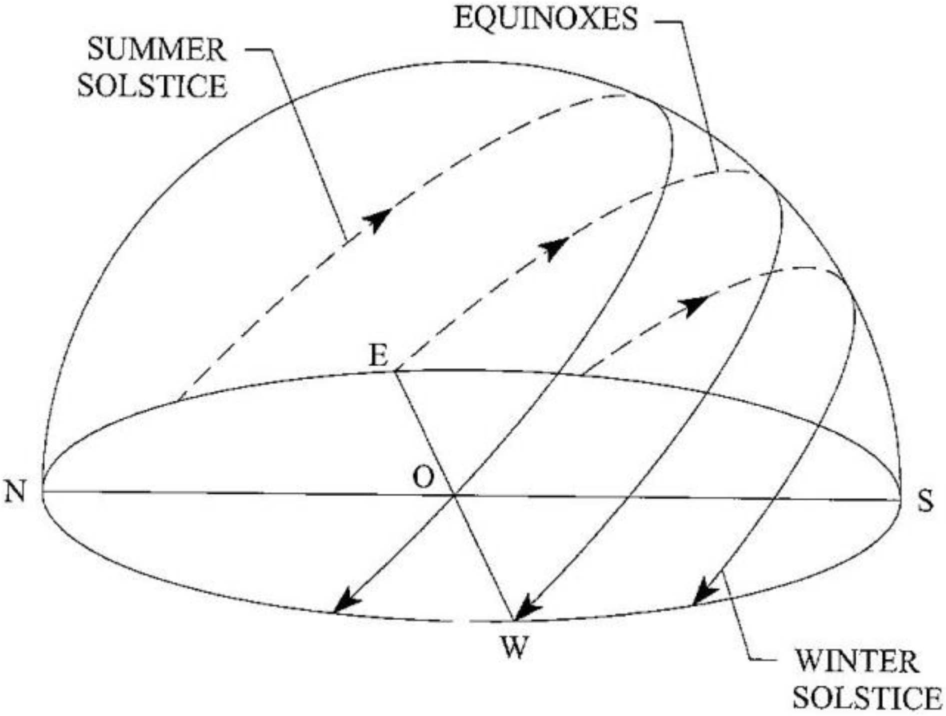


Figure 3.3. Solstice and equinox, after Magli (2016: 5, Fig. 1.2).
The apparent motion of the Sun at equinox, summer and winter solstices as observed above the tropics on a flat horizon.

Major and minor lunar extreme (MjLX and MnLX)

Figure 3.4 displays the major and minor lunar extreme, also called major and minor lunar standstill, which are celestial phenomena that happen every 18.6 years, due to the precession cycle of the lunar nodes at that rate (Cox 2009, Cox and Lomsdalen 2010, Gonzalez Garcia 2016, Kelly and Milone 2005: 35-36, Magli 2016-22, Malville 2008: 8, Malville 2016, Ruggles 1999: 36-37, Sims 2016a, 2016b, 2016c, Thom 1971: 15-27). Ruggles (1999: 36) suggests that the word ‘standstill’ is convenient but is actually misleading as the moon in no sense is ever standing still. The major lunar extreme refers to when the moon reaches the maximum northern and southern position in the sky, reaching further north or south than the Sun ever goes. In these cases, the moon reaches a latitude 28.7° north/south before the moon reverses course from north to south and vice versa. The minor lunar extreme occurs when the moon ‘stops’ on the latitude 18.1° north/south and happens 9.3 years after a major lunar extreme (Malville 2008: 38-39).

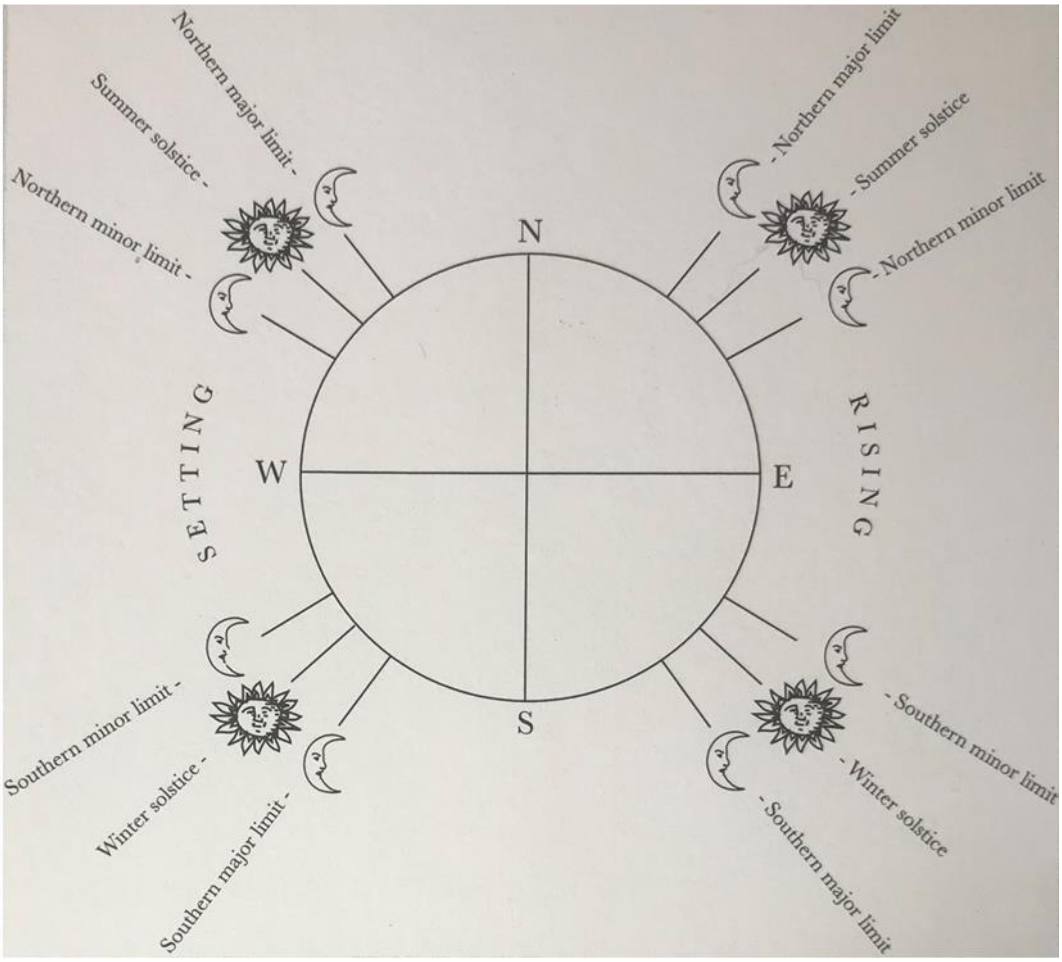


Figure 3.4. Major and minor lunar extreme, after Ruggles (1999: 37).
The figure illustrates a schematic representation of the solstitial sunrise and sunset together with the positions of the minor and major lunar limits.

Alignment and orientation

Though both words have to do with astronomical directions, there is a clear distinction in usage. According to Ruggles (Ruggles 1999: 154) alignment is used to state the occurrence of a special property of an astronomical event, such as the presence of Sun, Moon, or a star in line with a building or a monument. In astronomy an alignment is calculated in declination as it positions a celestial object in the heavenly sphere. Orientation on the other hand, describes the geographical direction of a building or a monument in cardinal points within the 360° hemispherical circle. It is usually expressed in azimuths degrees, but can also be expressed as declination in order to position a monument in relation to the celestial sphere (Ruggles 1999: 154). In short, any archaeological structure will have one or more orientations, and an alignment is when one of those orientations matches the rising or setting position of a celestial object.

3.3.2 Justification of methodology

This section gives first a general introduction to methods applied, and then an explaination of the reasoning behind why this specific methodology was chosen. It is divided into two parts, Choice of methodology and Ground truthing.

This research has been inspired by relevant studies as listed in the following section 3.2, particularly Cummings *et al.* (2002) and Higginbottom and Clay (2016b). Based on that, this study has developed its own theories and methodology regarding data capture and statistical testing to examine and retrieve any possible patterning. Though the Maltese open landscape in prehistory seems to have been similar to what it is today, an impediment to this study was that many temple sites in today's Malta do not have an open 360° vista to the surrounding horizon, due to modern constructions. Therefore, whenever possible hand-drawn sketches or photographic documentation were prepared as part of the site survey documentation. However, in order to have comparable data for the horizon of all sites, a 3D-rendering using the Horizon program incorporating a 5 m DTM was an absolute necessity for this methodology (Smith 2017b, 2020).

Choice of methodology

An initial, exploratory stage in this study was to survey all accessible temple sites by personal firsthand observation and direct phenomenological experience of their setting in the landscape. The overall reason for this was to acquire more insight into possible relationships of the apparent horizon to a site. Below is the example of the six temples of the Mġarr region, used to illustrate the method, as most of them have a non-restricted 360° view of the horizon.

The on-site apparent horizon observations were registered by hand-drawn renderings by the author (ref. Figure 3.5) and further complemented by a 360° panorama photo (see Figure 3.6), taken with a Nikon 8000 camera with a zoom 18-200 lens, f 3.5, set at a 'normal' focal length of about 50 mm, to best approximate the focal depth of the human eye (Higuchi 1983: 40). Shots were taken with an overlap of around one-third and usually resulted in around 12 shots per session. The camera was mounted on a tripod whenever possible, otherwise handheld.

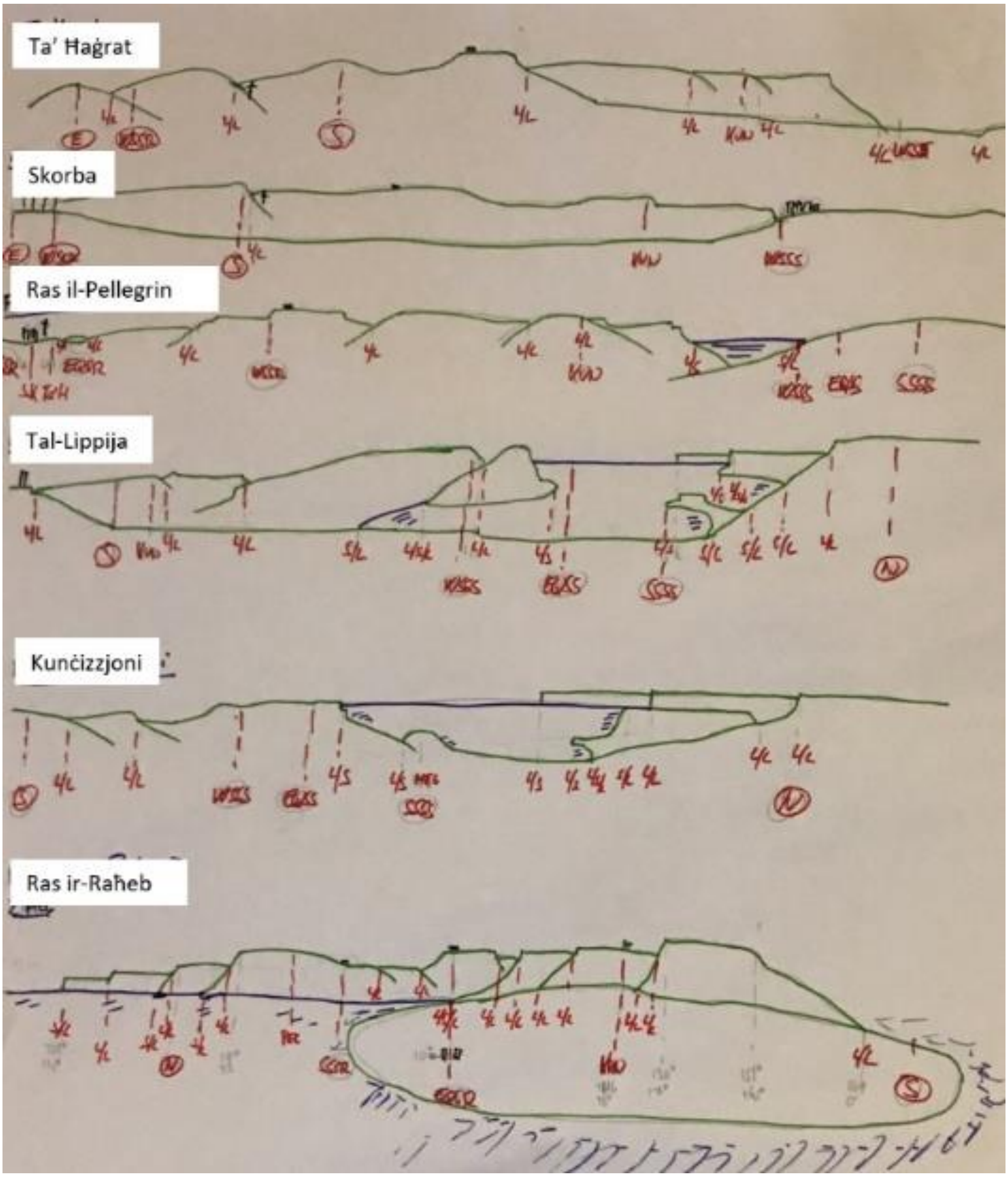


Figure 3.5. Hand-drawn apparent horizons.
Hand-drawn rendering of the apparent horizon seen from the six named temple sites in the Mġarr region. It indicates topographical features slopes and ridges on the horizon, as well as where a land feature meets another land feature (L/L), land meets sea (L/S), and sea meets land (S/L). It also indicates observations photographically documented by the author such as the rising and setting positions of the Sun.
Drawing by T. Lomsdalen.

Figure 3.6. Photographic panorama of temple sites, Mġarr region.
A 360° photographic panorama rendering of four of the temple sites in the Mġarr region. Ras ir-Raħeb, Kunċizzjoni and Ras il-Pellegrin all have an open horizon, while Skorba horizon is partly restricted by modern buildings. Photos by T. Lomsdalen.

Another site in Mġarr region where it proved to be problematic if not impossible to observe or register a 360° circumference horizon was Ta' Ħaġrat as shown in Figure 3.7. Today most of the horizon is blocked by modern buildings and basically only the southern part of the horizon is visible. Based on these experiences from Mġarr, and evaluating other sites on the archipelagos, it soon became evident that the most robust way to proceed was to use the same approach for all 35 sites for both the investigation of restricted vs open horizons, and for horizon astronomy. Therefore, a 3D-rendering of the horizon and the landscape without modern construction was the preferred method chosen. ArchMap was also considered but disregarded as it would not create a 3D-rendering of the visible apparent horizon, which is the intersection between land and sky. Alternative horizon software programs were considered, such as HeyWhatsThat (2008), but Horizon (Smith 2016) was finally chosen. A valuable collaboration of the present author with Smith (2017b) who incorporated the Maltese DTM5m into the Horizon software to create a 5 x 5 m 3D-rendering of the landscape, as illustrated in Figure 3.7 and Table 3.2. For this study, Smith converted the Horizon's code from a coordinate system, based on the geodetic reference ellipsoid commonly known as International 1924, to the WGS84 ellipsoid which Horizon supports. Permission from The Department of Classics and Archaeology, UM, was granted in May 2017 to use the DTM5m resolution developed by Dr Gianmarco Alberti, University of Malta from Planning Authority data (MEPA 2012) as noted in the GIS Chapter 2.3.2.

An application that can be used in the field of landscape archaeology and archaeoastronomy is available as a free download Horizon program from Smith's (2020) homepage with the relese of the latest verion in January 2019 (Smith 2018: 272). According to Smith (2017a: 269) 'Horizon is a Geographic Information System (GIS) tool designed for archaeoastronomers investigating alignments of prehistoric monuments with astronomical phenomena.' The Horizon program has been of indubitable value to this study for rising and setting of celestial objects on the horizon observable from a given temple site. Horizon works with a 3D-rendering technique applicable for landscape archaeology which allow archaeologists to visualise an observable landscape. Horizon further uses field measurements to calculate the horizon free of atmospheric obscuration and modern constructions and vegetation, which was an absolute must in order to conduct this horizon research in Malta. The topographical landscape formations are recreated with coordinates, altitudes, and distances from a predestined vantage point based on geographical longitudes and latitudes. The time period of sky events and also the observer's height are adjustable, and in this case was set to 3,000 BCE, while the observer height was set to 1.6 m as also used in the GIS study (ref. 2.3.4).

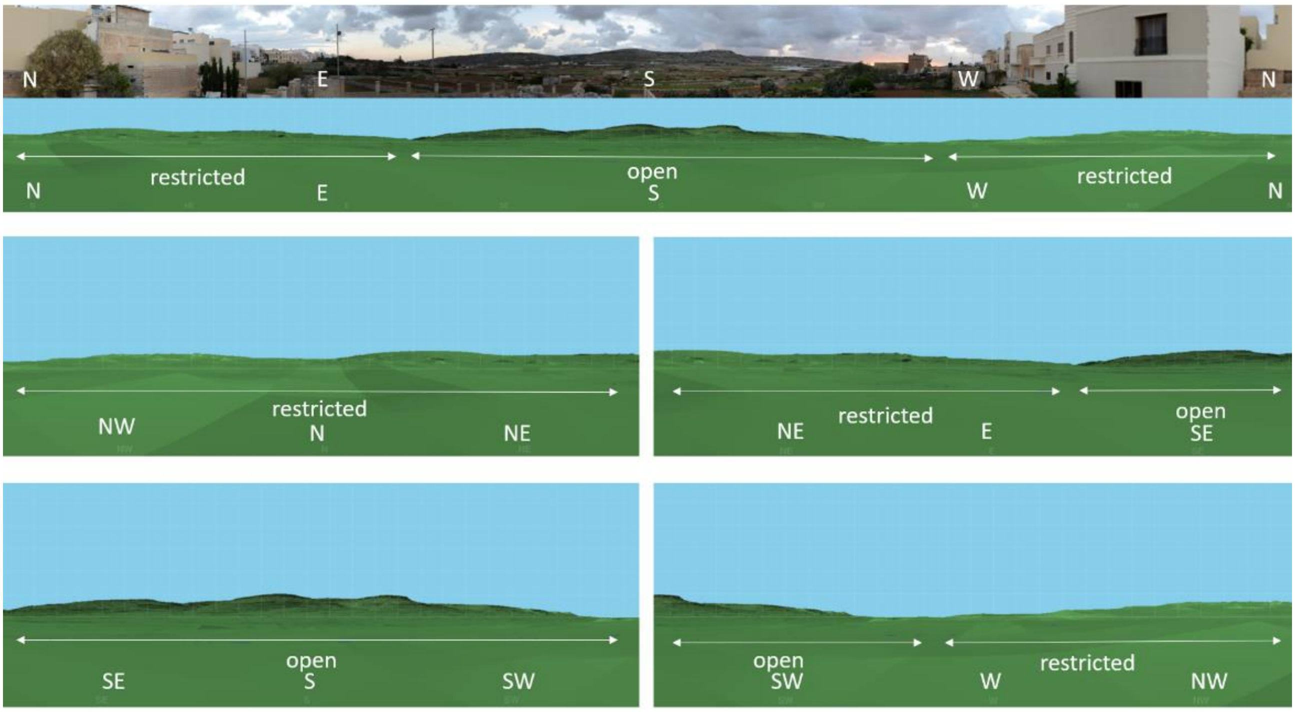


Figure 3.7. Ta' Ħaġrat 360° horizon landscape and coordinates.
The top photo is a panorama photo taken by T. Lomsdalen in 2018 illustrating from the site itself which part of the natural horizon is obstructed by modern construtions. Due south is at the centre of the panorama photos. The illustration immediately below the panorama photo is a 3D landscape rendering from the Horizon program and shows the same 360° circumference horizon without any modern obstructions. The lower four illustrations are an enlarged version of the 360° panoramic view centered on the four cardinal directions, as further explained in Table 3.2. The open and restricted vistas are schematically indicated .

Ground truthing

One purpose of taking these measurements was so that they could later be used to compare statistical cross-checking the Total Station (TotS) against the Horizon program measurements. Table 3.1 below, lists the MEAN error and the standard deviation of the mean (SDOM), which shows values for MEAN ERROR of Az of 0.8±0.1 and 0.2±0.0 for Alt, respectively. The core value of this result is that the calculated mean errors for both azimuth and altitude imply that Horizon has a reliable accuracy of better than 1°, and hence is as reliable as a standard compass. The reason behind selecting Tal-Lippija, Kunċizzjoni, and Ras ir-Raħeb for this analysis is that they have a 360° circumference open view to the horizon (see Figure 3.6).

The method applied for this statistical analysis was that the topography of the horizon was registered both in azimuth (Az) and horizon altitude (Alt) by means of two measuring tools. One was a handheld magnetic compass with a clinometer (SUUNTO 2019) and the other was a Total Station. Wherever feasible and a site was open to the sky, a SOKKIA SET5, D20B16 Electronic Total Station (TotS) was applied (SOKKIA 1994). Contrary to normal procedure when using a TotS in archaeological fieldwork applying intersection and triangulation to find the geographical coordinates based on Geodectic markers (Betts 1992: 60-66, Hogg 2015-120, Howard 2007: 12-26), this research used a ‘sun sight method’ also known as sun-azimuth calibration (Ruggles 1999: appendix 1). This method consists of taking azimuth measurements of the selected features in the landscape, and then calibrating the data with the actual azimuth position of the Sun at real time in relation to the GPS position of the TotS. The altitudes of the specific features of the horizon were also registered by the TotS.

		HORIZON		TOTAL STATION		ABSOLUTE DIFF.	
SITE	**TARGET**	**Az**	**Alt**	**Az**	**Alt**	**Az**	**Alt**
Tal-Lippija	1. Lippija cliff S	171.3	4.7	169.4	4.5	1.9	0.2
	2. Baħrija cliff	201.5	1.9	202.3	2.0	0.8	0.1
	3. Pellegr. cliff	238.4	2.4	238.4	2.5	0.0	0.1
	4. L/S	265.3	-4.3	264.8	-4.2	0.5	0.1
	5. S/L	301.4	-7.1	300.5	-7.5	0.9	0.4
	6. Gozo edge	311.2	0.1	312.1	0.1	0.9	0.0
	7. L/L cliff	326.5	0.1	325.8	0.1	0.7	0.0
Kunċizzjoni	1. Cliff	198.7	0.7	198.8	1.3	0.1	0.6
	2. Cliff	209.3	0.2	208.5	0.4	0.8	0.2
	3. Baħrija cliff	277.1	-0.4	278.1	0.1	1.0	0.5
	4. Baħrija cliff	278.7	-0.2	279.5	-0.5	0.8	0.3
	5. Gozo edge	317.7	-0.1	319.3	-0.1	1.6	0.1
	6. Mellieħa cliff	349.1	-0.3	350.8	-0.4	1.7	0.1
	7. Pelleg.r cliff	346.5	-1.1	348.2	-1.0	1.7	0.1
	8. North cliff	357.2	-0.3		0.4		0.7
Ras il-Pellegrin	1. L/L	51.1	0.0	52.3	0.0	1.2	0.0
	2. L/L (church)	111.1	1.0	110.9	1.0	0.2	0.0
	3. Cliff	114.2	1.9	113.6	2.0	0.6	0.1
	4. Cliff (military)	122.0	2.4	121.7	2.3	0.3	0.1
	5. Cliff (behind)	180.3	1.2	179.7	1.3	0.6	0.1
	6. Baħrija cliff	190.4	1.2	189.6	1.2	0.8	0.0
	7. L/L	201.0	-2.1	199.9	-2.1	1.1	0.1
	8. S/L	243.1	0.2	242.7	0.2	0.4	0.0
				MEAN ERROR		0.8	0.2
						±	±
				SDOM ERROR		0.1	0.0

Table 3.1. Comparison Horizon and Total Station.
This table shows the absolute difference between using the Horizon program or a Total Station when measuring specific horizon features in azimuths (AZ) and altitudes (Alt) of the three listed temple sites in Mġarr region. The statistical validity of these differences is indicated by the MEAN ERROR being 0.8 for (AZ) and 0.2 for (ALT) and the SDOM ERROR of 0.1 and 0.0 respectively.

Figure 3.8 illustrates a visual example from Tal-Lippija temple site of the methodology applied for this comparison of Horizon and Total Station, listing seven measured observation points on the horizon. As the figure shows, these points were selected as they were recognizable points on the horizon. Tal-Lippija was chosen for this example as it includes all the horizon variables used for statistical analysis (ref. Table 3.5).

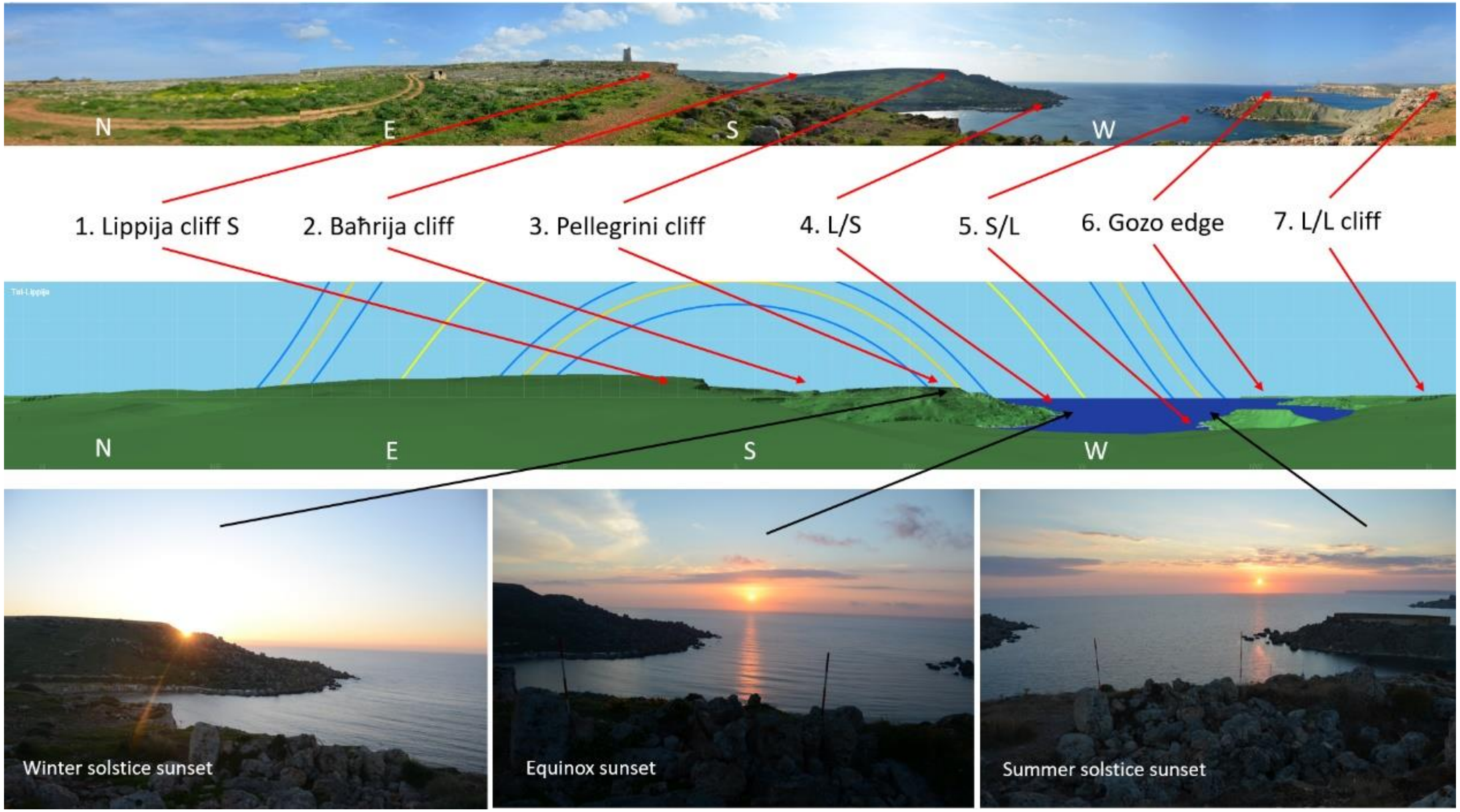


Figure 3.8. Comparison Tal-Lippija.
The top 360° panorama photo shows the horizon around Tal-Lippija. Below it, the same horizon is shown as derived from the Horizon program. Horizon feature measurements 1 to 7 (shown by red arrows) are given in Table 3.1. The black arrows show the present setting position of the Sun. Photos by T. Lomsdalen.

3.3.3 Data capture

This section describes the method used for collecting data for the two following steps, namely Horizon open vs restricted, and Horizon astronomy.

As explained in 3.3.2, the Horizon program is the fundamental application used for the data capture to investigate both these issues. An essential feature for the data collection of specific areas of the horizon, was that the program allows the horizon screen to scroll from left to right, simulating the way an observer would stand and turn around on a temple site. For this exercise the 360° circumference horizon is centred on the south. The software allows specific areas to be enlarged for more detailed inspection of the topographic features, and their hemispherical azimuths, territorial elevations both in degrees and meters, and the metric distance of the visible horizon to any given observation point in the landscape.

Though the Horizon was used for both areas, there is nevertheless an adjustment of data capture in each area when selecting and constructing parameters. This will be further explained in the following sub-sections regarding the two respective investigations.

Open and restricted horizon

Cummings et *al*. (2002) investigated landscape characteristics in relation to the burial mounds' central axis. Due to destruction and lack of preservation, it is not possible to establish a clear central axis for all 35 temple sites.

Cummings *et al.* (2002: 60-61) divided the 360° circumference horizon in a two dimensional coordinate system, north/south and east/west, in order to compare landscape characteristics with a cairn's central axis. The present study will instead go one step further by sub-dividing the 360° circumference natural horizon into eight cardinal directions. These are: north (N), northeast (NE), east (E), southeast (SE), south (S), southwest (SW), west (W), and northwest (NW). The parameters applied by Cummings *et al.* (2002: 61) evaluating an open horizon was that it had a wide-ranging view, and considered restricted if the ground was rising and creating a near horizon.

Although a similar subjective horizon evaluation of Cummings et al. (2002) was applied to this study, a more objective approach was initially explored. However, it was quickly concluded that this would be problematic. For example, one could consider a combination of horizon elevation and distance to be the parameters that define whether a vista is open or restricted. However, the choice of parameter values at which a vista would change from being restricted to open is in itself subjective. As an example, consider the horizon of Ta' Ħaġrat, both Figure 3.7 page 184 and Table 3.2. This shows both visually and numerically respectively that Ta' Ħaġrat is considered to have an open view towards southeast (1870 m), south (1617 m), and southwest (2622 m) while the rest of the natural horizon is considered as restricted. Notice, however, that it is the open part of the horizon that has the highest elevation due to the mountain towards the south. If the site was located closer to the mountain the vista may have been considered restricted, but at what distance the vista would change is entirely subjective. Therefore, this study employs a subjective evaluation of the horizon similar to Cummings et al. (2002: 58-59).

Ta' Ħaġrat	Azimuth	Elevation	Distance (m)	Vista
North (N)	00.0	+2.1	894	restricted
Northeast (NE)	45.0	+2.5	491	restricted
East (E)	90.0	+1.8	262	restricted
Southeast (SE)	135.0	+3.7	1870	open
South (S)	180.0	+4.3	1617	open
Southwest (SW)	225.0	+2.2	2622	open
West (W)	270.0	+0.5	98	restricted
Northwest (NW)	315.0	+3.2	238	restricted

Table 3.2. Ta' Ħaġrat horizon measurements.
This table shows the eight cardinal points of the 360° circumference horizon with azimuths, the elevation in degrees, the distance in meters, and the vista.

Horizon astronomy

The core emphasis in this methodology is to research if astronomical patterning on the apparent horizon may have influenced choice of location of the Maltese temples. For this study only the rising and setting of the Sun and Moon at 3,000 BCE shall be considered.

Stars are excluded from this exercise. Stars and temple alignments are examined in the following Chapter 4 of this thesis.

The list below shows the different phenomena at critical fates throughout the year that were considered in this exercise for the Sun and for the Moon. Figure 3.9 illustrates the trajectories of these phenomena for the Sun and the Moon. As the time period is set to 3,000 BCE the declinations of the rising and setting positions are calculated by the Horizon software for that date.

The abbreviated terminology used for peridocal rising and setting of the Sun and the Moon are as follows:

Sun
Summer solstice: rising (SSSR), setting (SSSS).
Equinox: rising (EQSR), setting (EQSS).
Winter solstice: rising (WSSR), setting (WSSS).
Moon
Northern major lunar extreme: rising (nMjLXR), setting (nMjLXS).
Northern minor lunar extreme: rising (nMnLXR), setting (nMnLXS).
Southern major lunar extreme: rising (sMjLXR), setting (sMjLXS).
Southern minor lunar extreme: rising (sMnLXR), setting (sMnLXS).

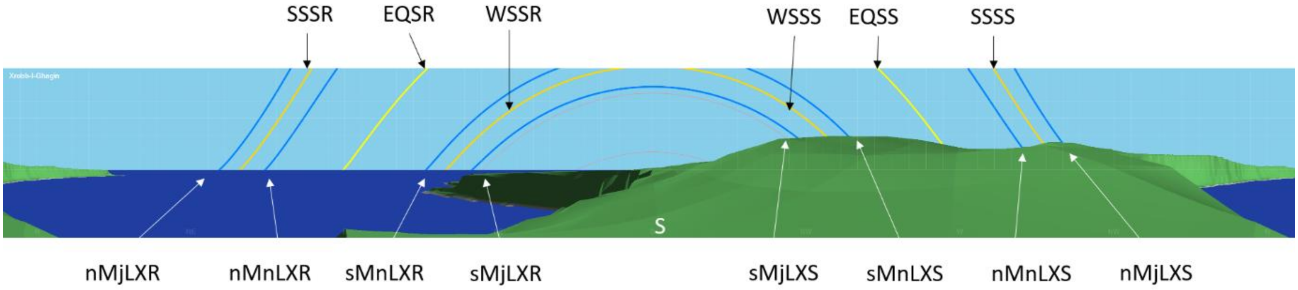
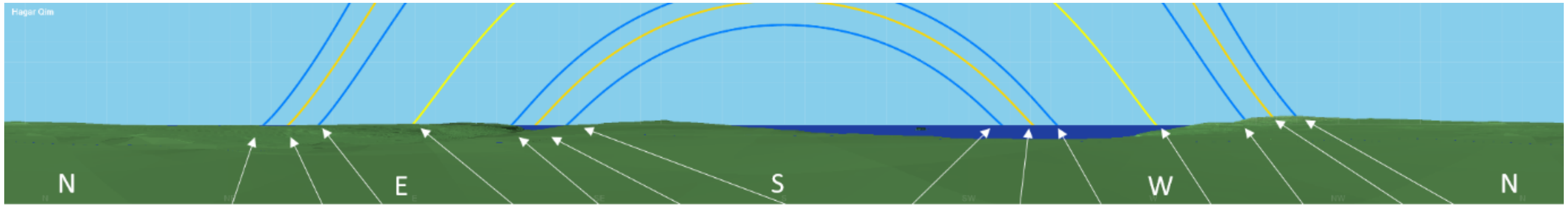


Figure 3.9. Sun and Moon periodical rising and setting.
This Horizon 3D-lanscape rendering is from Xrobb l-Għaġin temple site, illustrating the periodical rising and settings of the Sun and Moon with their abbreviated denominations.

As shown in Figure 3.10, the core purpose of this study is to test for any possible patterning if the Sun and Moon rise or set on the following topographical horizon formations:

- Flat horizon (F) when there are less than 2° variation in horizon altitude.
- Sloped horizon (H) when there are more than 2° variations in landscape altitude.
- Sea horizon (Se), a view to the open sea.
- Where land meets the sea (L/S) with a maximum difference of 2° azimuth between land and sea, or there is a difference in altitude of 0.2° or less between where visible land meets the sea.
- Where sea meets the land (S/L) with a maximum difference of 2° azimuth between sea and land, or there is a difference in altitude of 0.2° or less between where visible sea meets the land.

For all the above measurements the margin of error for altitudes is rounded up to +/- 0.2° and the mean error in azimuth is +/- 0.8° (ref. Table 3.1 page 186).



	nMjLXR	SSSR	nMnLXR	EQSR	sMnLXR	WSSR	sMjLXR	sMjLXS	WSSS	sMnLXS	EQSS	nMnLXS	SSSS	nMjLXS
Hagar Qim	F	F	F	F	L/S	Se	S/L	Se	Se	Se	Se	H	H	H

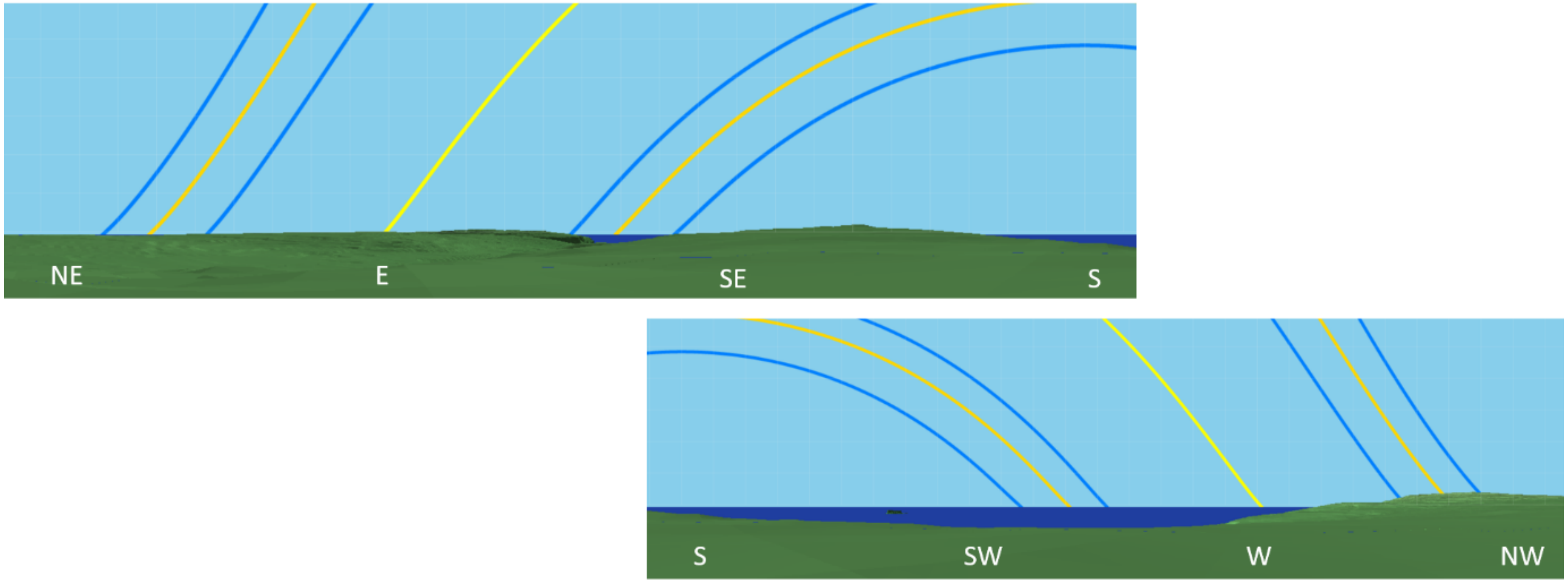


Figure 3.10. Sun and Moon rise and set on the horizon.
Horizon 3D-lanscape rendering for Ħaġar Qim. The top rendering shows a 360° circumference view of the horizon centred around south. The two lower 3-D renderings are enlarged areas from the 360° horizon illustrating details of the landscape where the Sun and Moon rise and set from northest to northwest.

3.3.4 Statistical testing

This study shall test the distribution of categorical variables between open or restricted vistas of the 360° circumference horizon of a temple site, and if the distribution of the positioning of the rising and setting of the Sun and Moon on the apparent horizon may have influenced temple site selections by their builders.

The statistical testing procedure has been informed by Agius and Ventura (1980: 8-9) applying chi-square tests based on the null hypothesis that the temple builders did not have any preference for any particular direction when constructing their temples. This method makes it possible to test the distribution of categorical variables of a sample against the distribution of categorical variable of another sample. This work has also been informed by the discussion by Shennan (1988) of more general statistical considerations of uncertainty in preference of placing a monumental site in the archaeological landscape.

According to Franke *et al*. (2012: 449), Pearson's (1900) chi-square test is considered to be one of the founding models in statistics, however the chi-square test is among the most misinterpreted in statements that have no or little statistical support based on the performed analysis. Shennan (1997: 106-107) explains that a chi-squared test, 'presupposes a set of observations divided up into a number of number of mutually exclusive categories'. The test subtracts the expected value from the observed value for each category, squares this difference, and divides the result by the expected value, and by repeating this procedure for all categories, obtains the result of the chi-square test which is the p-value (Shennan 1997: 106). In the standard applications of the chi-square test, also known as Pearson chi-square test, the observations are classified into mutually exclusive classes to test a single hypothesis. The result of the chi-square test (the p-value) is then measured against the null hypothesis (H0), as noted in the GIS Ghapter 2.3.8.

The Null hypothesis (H0)

The purpose of the test is to evaluate how likely the observed frequency distributions of open vs restricted vistas or the rising and setting of Sun and Moon at specific horizon features have been generated at random (the null hypothesis). A typical significance threshold for this is to consider that a calculate p-value lower or equal to 0.05 means that the data are so exceptional that they would occur five times or less in 100 cases and, therefore, the null hypothesis can be rejected. To assess a statistical significance, chi-square test was used with the free open-source software (Past 2021). The significance distribution between two variables of observed vs expected is based on the p-values with a threshold of 0.05 from the chi-square calculation with a permutation test of 9999 replications (Hammer 1999-2021: 89).

There shall be a different null hypothesis for the two questions being investigated in this chapter, as follows:

- Horizon open vs restricted
Null Hypothesis: the temple builders did not have any preference for a particular location in relation to an open or restricted vista of the apparent horizon.

- Horizon astronomy
Null Hypothesis: the temple builders had no preference for a location from where the Sun and Moon would appear to rise or set on a particular landscape features of the apparent horizon.

3.3.5 Limitations

The methodology used to research an open and restricted vista and the rising and setting of Sun and Moon on specific horizon features observed from a given temple site is not free of challenges, obstacles, or potential disputes, and these shall be further examined.

The first question is how much has the present-day Maltese topography changed since the Temple Period. According to Fenech (2007: 114) and Gambin *et al.* (2016: 290), Malta’s topography today may not have been that different from prehistory, and environmental changes were mainly caused by changing climate conditions. However, some of the steep cliff formations may have been altered due to land erosion. Xrobb l-Għaġin temple site is an eloquent example where cliff-edge erosion has occurred since the Temple Period (Borg and Grima 2015). Tal-Lippija temple site is another such example (Zammit 1916-1921: 42).

According to Gambin *et al.* (2016: 290) the Maltese archipelago had an open landscape in the early Neolithic, however developed into a dense ‘*Pistacia* scrubland’ during the Temple Period, due to a more moist period, and once again became open in the time of the Bronze Age. Regarding the sea level variations, Gambin (2020: 344) suggests landscape changes of about 6 m due to fluctuations of the sea level in the Burmarrad region from about 5,500 BCE up to present day. Marriner *et al.* (2012: 61-63) hold a similar view on change in palaeogeographies of the Burmarrad ria. Another area of low land coastal area is the Marsa region. Gambin (2018) argues the shoreline at Marsa would have been further inland at 6000 cal BCE, about half way across today’s racecourse for horses.

A further methodological consideration is to establish from which point within the site the observation of the apparent horizon should be taken for this study. When standing at the main entrance of a temple, the temple walls themselves restrict the view of its 360° horizon. The methodology applied for the purpose of this part of the research was to consider the compound as a ‘site’, and to consider the horizon vistas as unobstructed by the megalithic building, also taking into account that the vistas from a location may have been considered before the construction of the temple itself. The coordinates of temple sites are listed in Appendix 7.3.

Another challenge regarding this study is the risk that our modern mind-set or cultural attitudes and perceptions of vistas and landscapes influence our readings of how Temple Period society may have experienced or considered a horizon vista from a temple site, or from anywhere else on the archipelago for that matter.

The core challenge is that the apparent horizon of several sites is partly obstructed with modern buildings and constructions and consequently could not be reproduced. This was to a large extent resolved thanks to the use of a Maltese DTM5m and the Horizon program.

3.4 Results

This section shall present the results based on the methodology described above.

3.4.1 Horizon open vs restricted

Table 3.3 shows how the horizon vista of each temple site was categorized as open or restricted, for each octant of the apparent horizon, as explained in 3.3.3 page 188. The totals and percentages for each octant are also shown. In aggregate, 67.9% of temple vistas were classified as ‘open’ and 32.1% of their vistas were classified as ‘restricted’.

	OPEN									RESTRICTED									OPEN/RESTR.
	N	NE	E	SE	S	SW	W	NW	Total	N	NE	E	SE	S	SW	W	NW	Total	Total
Hagar Qim	1	1	1		1	1	1	1					1						
Mnajdra				1	1	1	1			1	1	1					1		
Il-Tumbata	1	1	1	1	1	1	1	1											
Id-Debdieba	1	1				1	1	1				1	1	1					
Hal-Resqum		1	1	1	1	1	1			1							1		
Tarxien						1	1	1		1	1	1	1	1					
Kordin I	1				1	1	1	1			1	1	1						
Kordin II	1				1	1	1	1			1	1	1						
Kordin III			1	1	1	1	1	1		1	1								
Borg-in-Nadur	1	1	1	1	1										1	1	1		
Tas-Silg	1	1	1	1	1	1	1	1											
Xrobb-l-Ghagin	1	1	1	1										1	1	1	1		
Hal-Ginwi				1	1	1				1	1	1				1	1		
Ta'Raddiena				1	1	1				1	1	1				1	1		
I-Iklin			1	1	1	1	1			1	1						1		
Ta' Hagrat				1	1	1				1	1	1				1	1		
Skorba	1	1	1	1	1	1										1	1		
Ras il-Pellegrin			1	1	1	1				1	1					1	1		
Tal-Lippija	1				1	1	1	1			1	1	1						
Kuncizzjoni	1					1	1	1			1	1	1	1					
Ras ir-Raheb	1	1	1	1	1	1	1	1											
Tal-Qadi				1	1	1	1	1		1	1	1							
Ta' Hammut			1	1	1	1				1	1					1	1		
Bugibba	1	1				1	1	1				1	1	1					
Xemxija	1	1	1	1	1	1	1	1											
Ghajn Zejtuna	1	1				1	1	1				1	1	1					
Ggantija Souh			1	1	1	1				1	1					1	1		
Santa Verna	1	1	1	1	1	1	1	1											
Borg Gharib South	1	1	1	1	1	1										1	1		
Borg Gharib North	1	1	1	1	1	1	1										1		
L-Imrejsbiet	1	1	1	1	1	1										1	1		
Xewkija	1	1	1	1	1	1	1	1											
Triq ix-Xabbata	1	1						1				1	1	1	1	1			
Ta' Marziena	1	1	1	1	1	1	1	1											
Borg L-Imramma		1	1	1	1	1	1			1							1		
Total Temple sites	22	20	21	25	28	32	23	19	190	13	15	14	10	7	3	12	16	90	280
Total sites in %	11.6	10.5	11.1	13.2	14.7	16.8	12.1	10.0	100.0	14.4	16.7	15.6	11.1	7.8	3.3	13.3	17.8	100.0	
Total open/restr. in %									67.9									32.1	100.0

Table 3.3. Horizon open and restricted.
Totals in numbers and percentages for each of the octant hemispherical coordinates, and a summarized total of open or restricted vistas, represented as 190 (67.9%) and 88 (32.1%) respectively.

Figure 3.11 is a graphical summary of the results from Table 3.3. The graph to the left shows that most open vistas are towards the SE, S, and SW, while most restricted vistas face N, NE, E, W, and NW. The chart on the right is a summary of the total open and total restricted vistas for all sites.

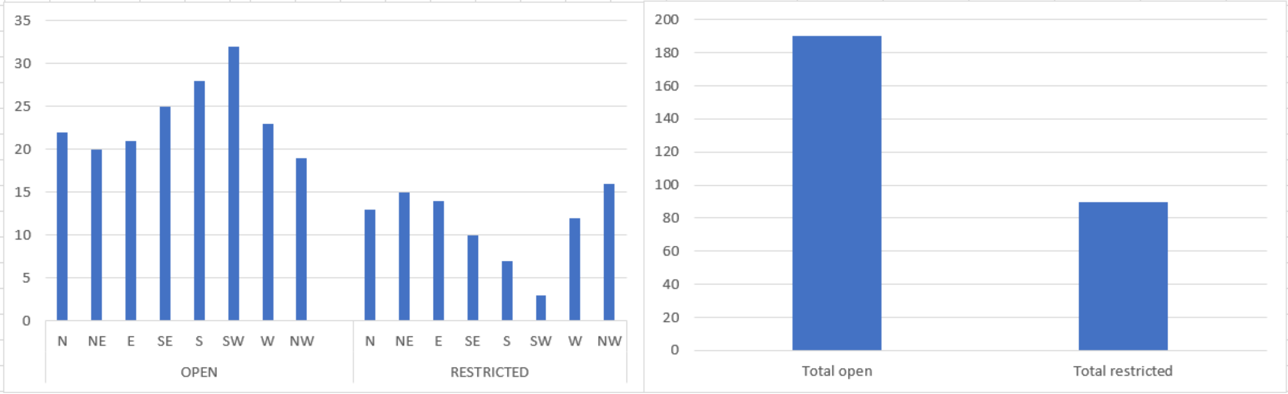
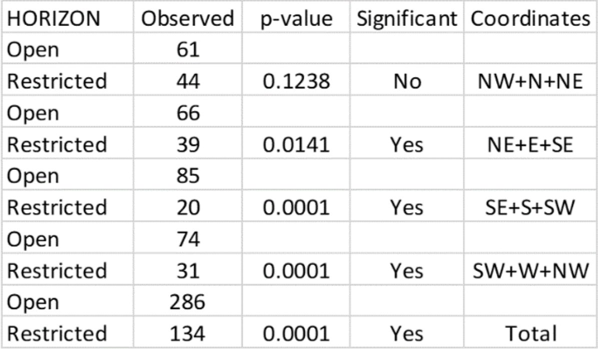


Figure 3.11. Chart open and restricted.
The chart on the left shows the hemispherical directions of open and restricted vistas indicating that SE, S, and SW have the highest number of open vitas. The chart on the right summarises grand total of octants with open (190) and restricted (90) vistas for all sites.

Table 3.4 presents the chi-square results based on the numbers of total temples for each category of coordinates in Table 3.3. The outcome of the chi-square is based on the H0 already noted with a threshold of 0.05 for a probability test of the p-value. On the left are the results of the tests done by looking at whether the horizon was open or restricted in and only in the specified cardinal and intercardinal directions. On the right the tests were done on aggregated quadrants, which was done by combining the data for the relevant directions. The sum or the total which represents the 360° circumference horizon shows a highly significant result with a p-value of 0.0001. This indicates that the distribution is not based on chance or randomness. The test also manifests that there are more significant observations towards the southern hemisphere, while the northern hemisphere has more non-significant value.

HORIZON	Observed	p-value	Significant	Coordinates
Open	22			
Restricted	13	0.2299	No	N
Open	20			
Restricted	15	0.6173	No	NE
Open	21			
Restricted	14	0.3959	No	E
Open	25			
Restricted	10	0.0248	Yes	SE
Open	28			
Restricted	7	0.0007	Yes	S
Open	32			
Restricted	3	0.0001	Yes	SW
Open	23			
Restricted	12	0.1279	No	W
Open	19			
Restricted	16	0.8586	No	NW
Open	190			
Restricted	90	0.0001	Yes	Total



HORIZON	Observed	p-value	Significant	Coordinates
Open	61			
Restricted	44	0.1238	No	NW+N+NE
Open	66			
Restricted	39	0.0141	Yes	NE+E+SE
Open	85			
Restricted	20	0.0001	Yes	SE+S+SW
Open	74			
Restricted	31	0.0001	Yes	SW+W+NW
Open	286			
Restricted	134	0.0001	Yes	Total

Table 3.4. Chi-square test horizon open and restricted.
The table displays both a detailed and a sum of the results from the chi-square test of open vs restricted vistas from a given temple site. The left side lists the number of open and restricted temples sites with its respective p-values and whether they are significant (Yes) or not (No) with its specific octant. Of the eight specific octants there are three Yes (SE, S, SW) and five No (N, NE, E, W, NW) results. The Total shows a highly significant Yes result. The right side of the table lists the number of open and restricted temple sites distributed around the four main cardinal directions, being north (NW, N, NE), east (NE, E, SE), south (SE, S, SW), and west (SW, W, NW). Except for the northern distribution all other cardinal distributions show a significant result (Yes), including the total. The implications of this result is discussed in 3.5.1.

3.4.2 Horizon astronomy

Table 3.5 shows the rising and setting of Sun and Moon at specific horizon features based on the methodology explained in 3.3.3. The table sums up in both absolute numbers and percentages the rising and setting of the major and minor lunar standstills and the Sun at the solstices and equinoxes. The highest values for rising or setting are on flat and slope land formations with a total of more than 80 % (84.28), nearly 9% (8.57%) on sea, and about 7% (7.14) on formations where land meets the sea or sea meets the land. Comparing the totals between rising and setting shows relatively small variations between the two when it comes to flat land, sloping land or the sea, but more distinct differences with respect to land meets the sea (5.3-0.8=4.5%) and sea meets the land (4.9-3.3=1.6%).

	RISING									SETTING									RISING/SETTING	
	nMjLXR	SSSR	nMnLXR	EQSR	sMnLXR	WSSR	sMjLXR	Total	%	sMjLXS	WSSS	sMnLXS	EQSS	nMnLXS	SSSS	nMjLXS	Total	%	Total	%
Mnajdra South	H	H	H	H	H	L/S	Se			Se	Se	Se	S/L	H	H	H				
Hagar Qim	F	F	F	F	L/S	Se	S/L			Se	Se	Se	Se	H	H	H				
Borg in-Nadur	F	F	F	F	L/S	Se	Se			H	H	H	H	H	H	H				
Tas-Silg	Se	Se	Se	S/L	F	F	F			F	F	F	F	F	F	F				
Hal Ginwi	F	F	F	H	H	H	H			F	F	F	H	H	H	H				
Xrobb-l-Ghagin	Se	Se	Se	Se	Se	Se	Se			H	H	H	H	H	H	H				
Tarxien	F	F	H	H	H	H	H			F	F	F	F	F	F	F				
Kordin I	H	H	H	H	H	H	H			F	F	F	F	F	F	F				
Kordin II	F	F	F	F	H	H	H			F	F	F	F	F	F	F				
Kordin III	F	F	F	F	F	F	F			F	F	F	F	F	F	F				
Il-Tumbata	S/L	F	F	S/L	F	F	F			F	F	F	F	F	F	F				
Id-Debdieba	S/L	S/L	F	F	F	F	F			F	F	F	F	F	F	F				
Hal Resqum	F	F	F	F	F	F	F			F	F	F	F	F	H	H				
Tar-Raddiena	H	H	H	F	F	F	F			F	F	F	H	H	H	H				
L-Iklin	F	F	F	S/L	S/L	S/L	S/L			F	F	F	F	F	F	F				
Ta' Hagrat	H	H	H	H	F	H	H			H	F	F	F	H	H	H				
Skorba	F	F	F	F	F	F	F			F	F	F	H	H	H	H				
Ras il-Pellegrin	F	F	F	F	H	H	H			Se	S/L	S/L	F	H	H	H				
Tal-Lippija	H	H	H	H	H	H	H			H	H	L/S	Se	Se	Se	Se				
Ras ir-Raheb	F	F	F	H	H	H	H			Se	Se	Se	Se	Se	Se	Se				
Koncizzjoni	F	F	F	H	H	H	H			F	F	F	F	Se	Se	Se				
Bugibba	F	F	F	H	H	F	F			H	H	F	F	F	F	F				
Tal-Qadi	H	H	H	H	H	H	H			H	H	H	H	H	F	F				
Xemxija Temple	H	H	H	S/L	F	F	F			F	F	F	F	H	H	H				
Ta 'Hammut	H	H	F	S/L	F	F	H			F	F	H	H	H	H	H				
Ghajn Zejtuna	Se	Se	Se	H	F	H	H			H	H	H	F	F	F	F				
Ggantija South	F	F	L/S	F	F	F	F			F	F	F	H	H	H	H				
Santa Verna	F	F	F	F	F	Se	F			S/L	S/L	S/L	F	F	S/L	F				
Borg Gharib South	H	H	F	F	L/S	L/S	F			F	F	F	H	H	H	H				
Borg Gharib North	H	H	F	F	L/S	L/S	F			F	F	F	F	F	F	F				
L-Imrejsbiet	H	H	F	F	L/S	L/S	F			F	F	F	F	F	H	H				
Xewkija	F	F	F	F	L/S	L/S	F			F	F	F	L/S	F	F	F				
Triq ix-Xabbata	F	F	F	F	H	H	H			H	H	H	H	F	F	F				
Ta' 'Marziena	F	F	F	F	L/S	F	F			F	F	S/L	F	F	F	F				
Borg L-Imramma	F	F	F	Se	Se	F	F			F	F	F	F	F	F	F				
Flat :F	19	20	23	17	13	13	17	122	49.8	22	23	22	20	18	16	17	138	56.3	260	53.06
Slope: H	11	11	8	11	12	12	13	78	31.8	8	7	6	10	14	15	15	75	30.6	153	31.22
Sea: Se	3	3	3	2	2	4	3	20	8.2	4	3	3	3	3	3	3	22	9.0	42	8.57
Land/sea: L/S	0	0	1	0	7	5	0	13	5.3	0	0	1	1	0	0	0	2	0.8	15	3.06
Sea/land: S/L	2	1	0	5	1	1	2	12	4.9	1	2	3	1	0	1	0	8	3.3	20	4.08
Total	35	35	35	35	35	35	35	245	100.0	35	35	35	35	35	35	35	245	100.0	490	100.00

Table 3.5. Horizon astronomy, Sun, and Moon rising and setting.
This table illustrates the rising and setting of the major and minor lunar standstills and the Sun at the solstices and equinoxes both individually and summarized in absolute numbers and percentages.

Figure 3.12. displays graphically the rising and setting of Sun and Moon at specific horizon features as summarized in Table 3.5. Indicated with a colour scheme, the chart to the left shows that the Sun and the Moon rising or setting have the highest observations on flat and slope horizon formations. The chart on the right illustrates a summary of total rising, setting, and a grand total on each of the four horizon features, being flat, slope, sea, land meets the sea, and where sea meets the land.

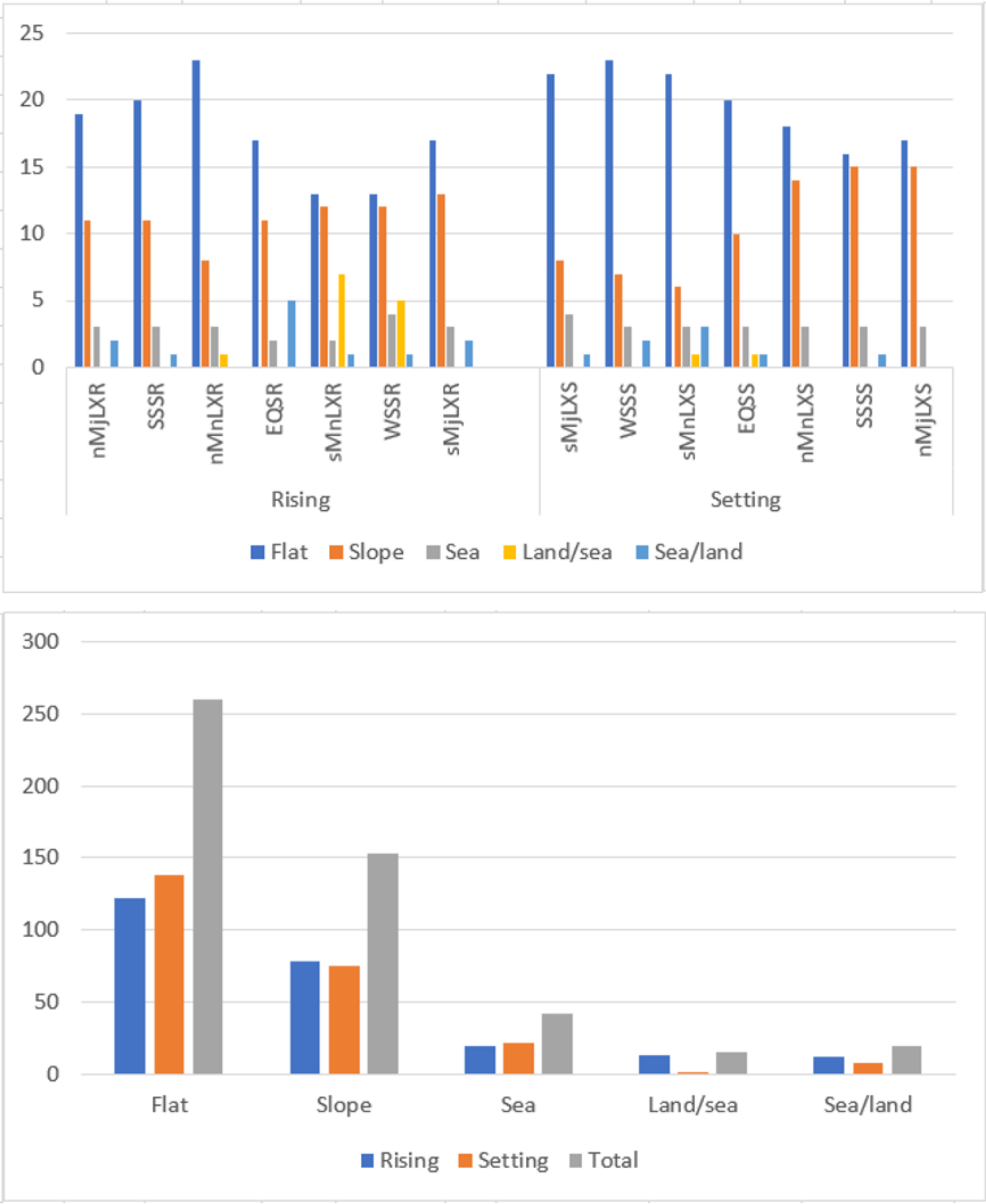
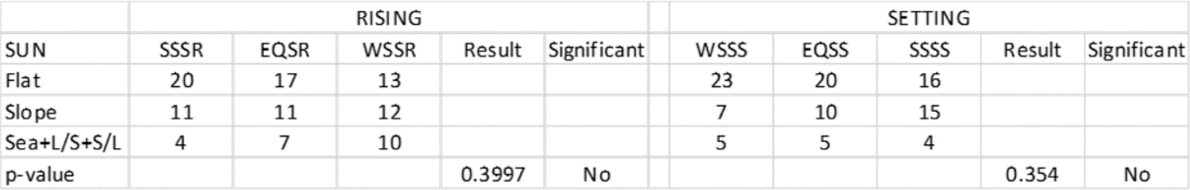
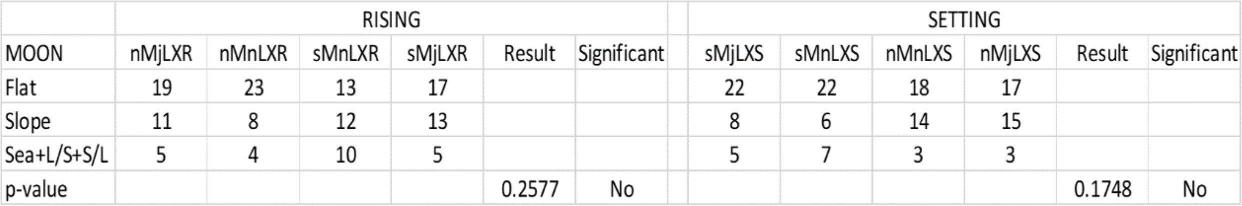


Figure 3.12. Illustration of where Sun and Moon rise and set.
Top: total of each of the rising and setting of minor and major lunar standstill and the Sun at solstices and equinox. Bottom: total rising, setting, and a grand total of each of the four types of horizon features.

Table 3.6 displays the results from the chi-square test grouped into four different observable categories, being the sums of the rising and setting of the Sun and the Moon on specific horizon features as listed in Table 3.5. For the features of the horizon, the values of the flat and slope land were left as two separate observations, but as the sea, ‘land meets sea’ (L/S) and ‘sea meets land’ (L/S) had each relative low observation, they were consequently grouped as one observation. The chi-square test is based on the null hypothesis noted earlier, for which a p-value threshold of 0.05 has been chosen. As all results of the p-value of the four categories are higher than the threshold, this concludes that the result of this analysis is non-significant and the H0 cannot be rejected, and that therefore it may be concluded that the temple builders had no preference for a location from where the Sun and Moon would appear to rise or set on particular landscape features of the apparent horizon.



	RISING						SETTING				
SUN	SSSR	EQSR	WSSR	Result	Significant		WSSS	EQSS	SSSS	Result	Significant
Flat	20	17	13				23	20	16		
Slope	11	11	12				7	10	15		
Sea+L/S+S/L	4	7	10				5	5	4		
p-value				0.3997	No					0.354	No



	RISING							SETTING					
MOON	nMjLXR	nMnLXR	sMnLXR	sMjLXR	Result	Significant		sMjLXS	sMnLXS	nMnLXS	nMjLXS	Result	Significant
Flat	19	23	13	17				22	22	18	17		
Slope	11	8	12	13				8	6	14	15		
Sea+L/S+S/L	5	4	10	5				5	7	3	3		
p-value					0.2577	No						0.1748	No

Table 3.6. Chi-square test horizon astronomy.
The rising and setting of the Sun and the Moon are divided into an upper part for the Sun and a lower part for the Moon with their representative feature groupings in relation to the coordinates of the horizon. The result of the p-value for each of these categories is properly listed as non-significant (No).

3.5 Disussion

Based on the research question of the chapter and the methodology, this section shall discuss and analyse the results presented in the Result section. This shall be done in context of the narrative on how the apparent horizon may have had an impact on the temple builders to choose a certain location in the landscape and to what extent this could be part of a wider cultural Temple Period’s cosmology. Questions of parallel research and new findings from this study program shall also be discussed.

3.5.1 Open vs restricted horizon

The results of this study show a highly significant southerly distribution of open vistas. The null hypothesis can therefore be rejected. This confirms a preference for locations with a specific type of open or restricted vista of the apparent horizon. More specifically, the results show that there was a significant preference for open vistas in a generally southerly direction.

The higher values of southerly distribution of open vistas may be correlated to other studies of temple locations. Grima (2004) identified a preference for locations with a southerly aspect, as also confirmed in this study (ref. 2.5.2) and Agius and Ventura (1981) demonstrated a preference for a southerly temple orientations. In relation to this, Fodera Serio *et al*. (1992: 116-117) maintain that the distribution of the temples was 'highly non-random' as a clear majority of the temple orientations lie within a band of 78.5°, which is less than a quadrant of a circle, towards the south. A chi-square test by Agius and Ventura (1980: 9) showed that the probability that this distribution of azimuths occurred by chance is less than 1 in a 1000. This is equivalent to the p-value obtained in this study, and also shows an interest towards the southern quadrant, despite being based on different methodologies.

The question of possible reasoning behind a temple location in the landscape has also been further explored in the previous chapter (ref. 2.5.2) where also the atmospheric conditions of protection from the harsh winter northern winds and a possible preference for the more friendly southern Sun, may also have influenced this distribution. The results from the statistical test shows that temples were not placed by chance in most inherently visible positions in the Maltese landscape (ref. 2.4.1) further underlining a wider possibility of non-randomness of temple locations.

3.5.2 Horizon astronomy

The result from this horizon astronomy study shows a non-significant distribution of temple locations as indicated in 3.4.2. The null hypothesis cannot be rejected, that is, the temple builders had no preference for a location from where the Sun and Moon would appear to rise or set on specific landscape features of the apparent horizon. Just because there is no evidence to reject H0 it doesn't mean that H0 is correct, only that it is more likely to be correct. In other words, the null hypothesis does not necessarily eliminate the possibility of the builders having had a preference.

Seemingly, this conclusion has a negatively deducted result. Nevertheless, it is essential to be aware that in statistical analysis a terminology of 'positive' or 'negative' results does not exist, but only that a result *is* significant or *not* significant (Wasserstein and Lazar 2016). In this case, the result allows us to infer a new and innovative finding of Maltese horizon astronomy, namely that the temple builders did not choose locations where the seasonal or periodical rising or setting of these two celestial objects took place over specific features on the apparent horizon. To rephrase this in other wording, this study did not test whether the builders had an interest in the Sun or the Moon, but whether they had an interest in matching Sun/Moon rise/set positions with horizon features. A negative result means that the builders did not have an interest in this matching, but could still be interested in Sun and Moon rising and setting, which other Maltese studies have indicated. On the other hand, a non reserached or verified possibility could be that the builders used postholes to mark and highlight a natural feature, such as the apparent horizon at Mnajdra (Ventura 2017, Ventura and Agius 2017, Ventura *et al.* 1993).

A surprising corollary to the results obtained here is that the sea forms such a small part of the apparent horizon of temple sites (13.1%), in contrast to landforms (86.1%). Considering that Malta is an island in the Mediterranean, the sea must have been of considerable importance for the prehistoric islanders for interrelations with the wider world and especially Sicily (Grima 2011, Robb 2001, Stoddart *et al.* 1993). When it comes to prehistoric sea navigation between Sicily and Malta, the use of celestial objects for that purpose has also been suggested (Cox 2001, Lomsdalen 2013c). Rare fish relief carving at the sea side Buġibba Temple has been found and molluscs and seashells were used for personal ornament and pendants, nevertheless indicating a certain interest for seascape and the sea elements even in a more cosmological context (Bonanno 1986b: 31, Grima 2016b: 41-42).

When it comes to the horizon astronomy in this case, a possible scenario could be that the society prioritised temple locations closer to natural water sources and to agricultural production (Grima 2016b, Grima and Vassallo 2008, Ruffell *et al.* 2018: 187, Stoddart *et al.* 1993: 6), more so than a general perspective of sky events on the apparent horizon. Grima (2005: 94-95, 131, 2016b: 28) suggests temples were located with an accessibility to the sea, but not necessarily a visual relationship to the coastline.

3.6 Conclusion

This study is innovative for Maltese landscape archaeology and horizon astronomy. It has adapted and developed its own research theories and methods, even while drawing on the work of others in comparable fields, to address a gap in knowledge, as explained in section 3.2.

The research question of this chapter was to investigate a possible purpose of how the apparent horizon may have influenced the temple builders to choose a certain location in the cultural landscape. This narrative was then dived into two parts. One investigated whether the vista of the apparent horizon was open or restricted seen from a temple site, while the other considered to what extent features on the apparent horizon and their relationship with astronomical phenomena, in this case the rising and setting of Sun and Moon, could have influenced the positioning of temples. Results and findings are listed as follows:

Horizon open and restricted
First finding:
The greater part of the apparent horizon from temple sites was found to be open rather than restricted, with a distribution of 190 octants (67.9%) to 90 octants (32.1%) respectively.

Second finding:

Chi-square test shows high significant values (p-value = 0.0001) for an open vs a restricted horizon vista from temple sites, where coordinate directions southeast, south, and southwest are significant, while the non-significant are north, northeast, east, west, and northwest (ref. Table 3.4). The results from the chi-square test show that the distribution of temple locations between open vs restricted vistas were not randomly chosen by their builders, meaning that locations were purposely chosen with respect to having open vistas towards the south.

A plausible but speculative explanation for why this direction was intentionally chosen could have been topographically and atmospherically conditioned based on heating energies from Sun and protection from the northern winds, or more cosmologically based to have an open vista and a viewscape towards the movements of celestial bodies in the southern hemisphere. An additional scenario could be a combination of these two possible explanations.

Horizon astronomy

Finding:

The statistical chi-square test shows non-significant values for the rising and setting of the Sun and the Moon on specific horizon features (ref. Table 3.6) consequently, the null hypothesis that the temple sites were randomly chosen cannot be rejected, meaning that it is possible that temples may have been randomly located with respect to horizon astronomy.

The GIS chapter, chapter 2, of this thesis has clearly demonstrated that when it comes to temple visibility in the landscape, the locations were not randomly chosen, and in the next Chapter 4, this study shall examine to what extent astronomical phenomena influenced the builders in orienting and aligning their temples.

An overall motivation behind this study was to bring in new and previously unverified perspectives of integrating landscape archaeology and archaeoastronomy. This was based on examining how Maltese prehistoric society may have perceived the interrelation between temple locations and the apparent horizon. An integrated analysis of this chapter’s results have suggested that a temple site location could have been selected on the following two criteria:

1. A cosmology of place and space with an open vista to the sky.
2. Access to life sustainable landscape resources.

To draw a final and definite conclusion on this topic, further studies should be undertaken.

4 Were temples built to allow the view out of their entrances to frame specific skyscape features?

This chapter is concerned with finding a possible answer to the research question:
Were Temples built to allow their entrances to frame specific skyscape features?
In search of an answer, the research methodology and the obtained results shall be fully discussed and finalised with some concluding thoughts.

4.1 Introduction

It is well recognized in archaeology that human cognitive ability to process spatial knowledge at complex levels goes back at least to the Upper Palaeolithic if not earlier (D'Errico 1998, Donald 1991, Renfrew and Scarre 1998). As argued elsewhere by the present author (Lomsdalen 2017: 106) 'According to Brown and Silva the sky is half the cosmos/world of any culture and yet it is rarely mentioned in Archaeology [(Brown 2013: 22) and (Silva 2014b)].' Campion (2015: 8) states that 'the sky is all around us and we would not be alive without it' and contends that the landscape does not exist without the skyscape. Based on these notions, it can be argued that early human societies could have had an appreciation not only related to the physical land and the environment they lived in, but also to the untouchable sky above them.

Pauketat (2013: 3) suggests that 'Beliefs have a form, a materiality, and happen in space and time, on the land, and in the sky'. Darvill (2008a: 111) defines cosmology as 'The world view and belief system of a community based upon their understanding of order in the universe', which implies a holistic worldview integrating the human element in the totality of the world one lives where the sky is an integrated part of daily life. Parker Pearson and Richards (1994: 11) state that a feature of all human societies has been to develop a cosmology through creation of order. This statement emphasises that a belief system is an integral part of the totality of the world where humans live, including structuring their daily activities, tasks, and lives. It is well documented in the literature that societies broadly contemporary with the Maltese Temple Period, like Mesopotamia and Babylon, and predynastic and old kingdom in Egypt, had awareness of movements of celestial objects as a part of their belief system and cosmology, and also applied it to more mundane purposes such as establishing yearly seasons and calendric time keeping (Rochberg 2004, Ruggels 2005, Shaltout and Belmonte 2009, White 2007).

The first known written source to connect Maltese prehistoric temples to celestial bodies was Vance (1842: 232) who suggested the temples were not roofed to be more appropriate for worshipping Sun, Moon, and stars. Zammit (1929b: 13) proposed a recumbent slab at Tarxien Temples represented the Southern Cross, and Ugolini (1934: 128) suggested the so-called Tal-Qadi stone to be a possible Neolithic ‘lastra astrologica’. Little further progress happened with regarding the skyscape investigation of Maltese temples until Formosa (1975: 19-21) discovered seemingly by pure chance, both rising and setting of summer solstice illuminating special areas inside Ħaġar Qim Temple. On an academic level Agius and Ventura (1980, 1981) in the 1980s started researching the astronomical alignments of Mnajdra Temple. Around the turn of the millennium, several archeoastronomy scholars and enthusiasts completed several studies of the megalithic temples in Malta (Albrecht 2004, Cox 2001, Mayrhofer 1995, Micallef 2000, Micallef 1990, Thomson Foster 1999, Vassallo 2000).

When it comes to archaeoastronomical topics like orientations and alignments to celestial bodies related to the Maltese temples, archaeologists in general have been slow to engage in the debate. However, regarding the more cosmological connotation to temple structures, archaeologists have shown an increasing interest in Maltese Temple Period cosmology since the turn of the century, where Grima (Grima 2001) and Robb (Robb 2001) seem to be the first ones to address the issue, followed by other publications and authors (Barratt *et al.* 2018b, Barratt 2018a, Grima 2001, 2003, 2005, 2007, 2016a, 2016b, Grima and Farrugia 2019, Malone 2007, Malone *et al.* 2007, Malone and Stoddart 2009, 2013, Morley 2007, Pace 2000, 2004d, Robb 2001, 2007, Ruffell *et al.* 2018, Skeates 2010, Stoddart and Malone 2008, Tilley 2007, Whitehouse 2007).

In order to answer the research question in this chapter, a methodology not previously used in archeoastronomy was employed. The approach was based on previous related studies, but developed its own specific methods of measuring alignments to celestial targets observable from inside a temple structure called '*temple entrance frame*', or simply '*entrance frame*'. In order to quantify research results, this study has also gone one step further than previous studies in Maltese prehistory, taking into consideration that all measurement, especially when dealing with remains of 5,000-year-old temple structures, has an element of uncertainty (Taylor 1997). To obtain reliable and significant test results, two completely different but complementary statistical approaches were adopted, being namely the Method of Maximum Likelihood and the Significance Test. The results from these statistical tests are then discussed in light of various scenarios and hypothesis as to why the temple builders constructed and oriented the temples the way they did, and how these may reflect chronological building phases, alignments to specific celestial bodies and cosmological perspectives.

4.2 Literature review

This section reviews published literature relevant to the research question at hand. It also looks at the broader concept of cosmology in connection with the integration of material culture, celestial bodies, and the human element.

According to Ruggles (2005: ix) the sight of a clear bright sky is always stunning, and human societies all over the world have for thousands of years recognized familiar pattern in the sky and tried to make sense of them. Cuneiform scrips from Sumerian, Mesopotamian, and Babylonian periods around 3,000 BCE are the first written evidence indicating human interest in an observable sky (Baigent 1994, Brady 2016, Brown 2000, Campion 2008, Kock-Westenholz 1995, Penprase 2011, Rochberg 2004, Woolley 1965). The physical structure of heaven and earth is described in Sumerian and Babylonian creation myths, where particular attention was devoted to the structure of the heavens (White 2007: 17). Day was born from night and the Sun and the Moon opened the gates of heaven and flooded the world with light and the gods' duty were to keep the stars of heaven on their predetermined course.

Human behaviour both individually and collectively may, according to Kelly and Milone (2005: 2), have been guided or driven by celestial happenings and the relative movements of heavenly bodies. Burial sites or monuments recognized in the archaeological record may shed some light on belief systems, worldviews, and a society's cosmology, as such monuments are frequently constructed to represent a partial model of the universe embodying a cosmological worldview (Kelly and Milone 2005: 2, Parker Pearson and Richards 1994: 11). Ruggles (2005: 115-116) proposes:

> Cosmology intimately involves astronomy, since the sky is an integral part of the world that people see around them. But cosmology is not restricted to astronomy. Objects and happenings in the sky are also seen as intimately connected with actions and occurrences in the realm of human relations. For many indigenous peoples, on the other hand, and (as we now suspect) for virtually every human community way back into prehistory, the sky is an important if not critical part of the world in which they lived, and it is crucial to keep human activity in harmony with it.

Tarnas (2006a: 16) on the other hand seems to hold a contrary view to Ruggles' of human sky inference, stating that the world is animated by the same psychologically resonant realities that humans experience within themselves, a continuum extending from the interior world of humans to the exterior world. In line with Tarnas' point of view, Mearleau-Ponty (1964: 186) describes vision as 'the means given me for being absent from myself'. Ingold (2016: 220) argues that the night sky is not homogeneous, but it swirls around and resonates the contours of the landscape from the light of the Moon where the pulsing stars are indefinitely distant and yet touch the soul. According to Sagan (1995: 12) thanks to science we understand the universe so much more than our ancestors, but we have also lost a profound sense of being part of that cosmos from which we are born and our fate is deeply connected. Silva (2014b) suggests that the sky is half the world in any society, implying that ever since human consciousness existed there may have been an awareness of the celestial sphere in as much as the earth itself. This statement is supported by Renfrew and Scarre (1998) and Donald (1991), who argue that advanced cognitive awareness goes back at least to the Palaeolithic, if not earlier.

In combination with the ever-changing phases of the Moon, the Sun could be used to establish a calendar which allowed leaders of a society to organize festivals and other types of events (Malville 2008: 11). Malville further argues that the sky was a region of wonder and power, sunlight and rain, danger and sustenance. One method used by ancient and primitive people according to Nilsson (1920: 5) to determine day of a solar year, was to '…indicate the exact interval of time between the culmination of the sun and that of one particular star…'. Aveni (2008b: 10) suggests that people all over the world have always managed to find star patterns which we today, '…call constellations and can trace their origin back to the very beginning of civilization'. Silva *et al.* (2019: 1) argue:

> The sky is filled with entities – the sun, the moon, the planets, individual stars, asterisms and constellations, the milky way – that are as much a part of the environment of a given society as the land, trees, animals, birds, mountains, rivers, lakes and the sea that surrounds them. As such, they are prone to feature in the world(s) conceived by such societies. The celestial objects can be conceived of as animate beings, with agency and social relations between themselves and the wider environment.

Nilsson (1920: 147-148) further maintains; '…as long as the human race has existed, man's attention must have been drawn to the moon', and further suggests that 'The observation of the moon is often said to be the oldest form of time-reckoning.' Iwaniszewski (2011: 30-31) suggests that though the universe is perceived by all humans, it is nevertheless understood and arranged variously and could be based on mythology, family affiliations, power and socio-economic considerations.

Marshack (1972: 27-32) made an observation that there were details to be observed in the incised marks on a Mesolithic bone, and that possibly the Ishango person used a system to describe lunar observations in some form of a calendric notation. These observations were criticised by D'Errico (1989, 1998: 20), as it was argued that Marshack never proposes a testable theoretical framework that may be validated experimentally. Hayden and Villeneuve (2011) also claim that Marshack's theories are controversial as it is impossible to establish the meaning of any single incision on an artefact from the distant past with any degree of certainty. On the other hand, Hayden and Villeneuve (2011: 336) argue that hunter-gatherer had some kind of astronomical system, being aware of solar movements in more general terms, however may have recognized that lunar cycles coincide with seasonal events. Pauketat (2013: Ch. 1) who integrates anthropology, archaeology, and cultural astronomy data from various ancient indigenous North American societies to seek to assess how 'beliefs' and religion influenced history and also how history has influenced religion and belief systems, defines the applicability of religion as 'the ritualized venerations of mystical cosmic power'. Morgan (2005: 8) notes that beliefs and religion happen 'in and through things that people do with them'. Beliefs have a form of materiality, and projected on the land and in the sky. The separation of earth and sky in Western cosmology happened, according to Aveni (2008c: 254), in the Medieval Period when maps of the world took on a religious connotation. Before that time, the connection between earth and heaven was needed to have knowledge of positioning the heavenly bodies in order to produce a faithful map of one's environment, being on land or at sea. According to Sagan (1995: 12) 'We have grown distant from the Cosmos', a statement he relates to that science has taken over the understanding of the vast universe and '…human affairs seem at first sight to be of little consequence'.

In the publication *Stonehenge Decoded*, Hawkins (1966) argued that Stonehenge was built as a Neolithic computer to predict solar eclipses. This idea was heavily criticised in mainstream archaeology. Atkinson (1966) who had excavated Stonehenge in the 1950s condemned *Stonehenge Decoded* as tendentious, arrogant, adopting bizarre interpretations and unconvincing results. The historian Hawkes (1967) described Hawkins' arguments as something as wishful thinking. About fifty years after the publication of *Stonehenge Decoded*, Parker Pearson (2012) in the Stonehenge Riverside Project, engaged Ruggles to validate the archeoastronomy data and its significance to Stonehenge. Ruggles (1999) has also in an earlier publication demonstrated an alignment at Stonehenge to the winter solstice sunset. The Irish archaeologist O'Kelly (1982) discovered winter solstice sunrise alignment inside the prehistoric site Newgrange in Ireland, as also noted by Prendergast (2011). Famous megalithic structures in many places around the world across various periods of time do indicate complex celestial alignments (Aveni 2008a, Hoskin 2001a, Magli 2009, Malville 2015d, Ruggles 2015, Thom 1971).

Ruggles (2005: xv) suggests that 'every oriented structure must point towards *some* point on the horizon, and in all likelihood to one or more identifiable astronomical targets', and that several entrances are periodically illuminated by sunlight during a solar year. In this respect Ruggles notes the need for caution, because apparent relationships between celestial bodies and prehistoric monuments need not have been intentional or meant something to the builders, rather than being the result of pure chance. To test for possible intentionality in these cases Ruggles (2005: xv) proposes two ways of action. One is to investigate a statistical evidence through identifying that a type of structure repeatedly shows the same pattern of astronomical alignments, or to find corroborating evidence in the archaeological record. Campion (2015: 11) also emphasises the importance of good archaeological dating to establish key features of solar, lunar or stellar phases to which a monument may be related. Already in his early work Thom (1971) applied statistical replications of some of his hundreds of surveys on alignments of megalithic monuments with a theodolite in Britain and Brittany (Ruggles 1988). Hoskin (2001a: 10-13) who surveyed literally thousands of megalithic monuments in the Mediterranean region, including Malta, mainly relied on a field methodology using compass and theodolite, finding the axis of orientation from the centre of the back stone to the centre of the entrance of the structure, which he named the 'axis of symmetry'. The results were further plotted into histograms and a visualization of the alignments into a circle illustrating the cardinal directions (Hoskin 2001a).

Silva (2014a: 27) introduces a new methodology called the '*window of visibility*' that combines both field studies and analyses. It consisted of not only taking the alignment of the central axis of the hundreds of dolmens he researched in northern Portugal, but also taking the azimuths of a minimum and a maximum value of an entrance frame, showing a visible horizon from inside a monument. As chambers inside a prehistoric monument have an inner depth and volume, the procedure requires some arbitrary decisions from where to take the measurements of the window of visibility, and a field survey must take all the alternative viewpoints into consideration and consequently works with a wide uncertainty (Silva 2019a: 9). Silva (2019a) then used ‘*the method of maximum likelihood’* (ML), which analyses measured orientations taking into account measurement uncertainty. The data is built into a statistical calculation of regions of maximum likelihood, to define where there is most likelihood to be able to view celestial objects from within those structures. The method of maximum likelihood that Silva refers to was first introduced by Fisher (1922: 310, 323-324, 1934: 11) and further advanced by Edwards (1992: 70-102). According to Silva (2017c: 101-102, 2019a: 1-12) the maximum likelihood method is frequently used as a statistical approach to estimate parameters of an empirical dataset, however archaeoastronomers have rarely engaged with it before. For statistical inference dealing with error analysis and pattern recognition Taylor (1997) is a relevant source.

For more accurate work on sky observations, the question of refraction in addition to atmospheric extinction also needs to be taken into consideration (Schaefer 1986, Tony and Creed 2008). In physics, refraction is according to Encyclopædia Britannica (2005: Vol 9, p. 997) ‘the change in direction of a wave passing from one medium to another or from a gradual change in the medium’. Ongoing changes in direction of surface waves may cause objects to be continuously refracted (Bullen 1975: 123-124). In astronomy an atmospheric refraction makes celestial bodies to visibly emerge higher over the horizon than they physically do (Ruggles 1999: 23, Ruggles and Hoskin 1997: 204, Schaefer 1993, Thom 1971: 28-35). An example of this is when the Sun at its rising and setting position is actually below the horizon, but appears to be above it as the Sun disk can still be seen by an observer on earth. According to Thom (1971: 33) both terrestrial and atmospheric refractions are subject to large unpredictable variations and states that ‘it is not surprising that authorities differ by several per cent in their values of astronomical refraction and at low altitude’. Adding to the uncertainty, both terrestrial and atmospheric refraction is affected by weather, wind, air pressure, temperature, time of day, and local terrain. The Stellarium astronomy software program has a function which allows inspection of how refraction may influence visibility and celestial objects by using ‘Toggle atmospheric effects’ making stars visible in the daytime (Zotti and Wolf 2019: 15).

4.2.1 The Maltese context

According to Grima (2008: 47) to affix a chronology of the megalithic monuments is at times controversial and rarely conclusive as older parts of buildings may have been destroyed or altered during episodes of rebuilding. Current understanding of the dating of different parts of the monuments often seem to be based as much on typology as on stratigraphic evidence. Evans (1959: 88-90) suggests the earliest monuments above ground were reproduction of rock-cut tombs. To quote Trump (1981a: 129-130), 'In the trefoil temples we see the first formalized plan, and can recognize the prototype of the later forms'. In this context, Trump further suggests temple construction starts with the more private and closed off areas, then came the more public and outer chambers, where also some areas could be closed off. Bonanno (2017: 16-17) brings in another view, that the temples started off as a combination of domestic huts into a single building without any specific overall shape at first. The more symmetrical and complex plans developed over time, adding more pairs of apses symmetrically laid around the main axis, following various stages of a linear development. Torpiano (2004: 360) argues that 'The first decision to be taken by the prehistoric builders would thus the orientation of the axis along which the portal structures would be erected.' Torpiano further proposes that only after that the portal was erected, the builders began to define the inner space of the temple.

Pace (2004b: 30) holds a similar view as Torpiano, suggesting the main corridor was probably the first element of the structure to be laid out in plan by the builders, and serving as the temples' main axis. Pace further emphasises that the entrance of the buildings was strategically placed in the middle of the façade and the doorways would have served engineering as well as functional needs. Even if the central axis were laid out first, Pace (2004b: 30) maintains that it appears that they started to build from the back and outwards along the established axis stating that 'the narrow entrances and inter-connecting interior doorways would have made it impossible for the temple builders to move megaliths and building materials within the structures'. Vassallo (2003) on the other hand proposes that the main doorway was carefully planned and constructed first, and the apses were added later. Vassallo's approach is based on the theory that the beams of the rising December solstice Sun illumination inside the temples through the main doorway was carefully planned, and the apses were added later. Vassallo (2000) notes that early temples consisted of three apses in a trefoil plan exemplified by Ta' Ħaġrat West, Skorba West and Kordin III West. Lomsdalen (2013a, 2014a, 2015b) holds a different view based on the archaeological record of Evans (1971: 103) and the building time-line of the Mnajdra Temple complex, maintaining that the back apses were first to be constructed. Lomsdalen further suggests that the builders of Mnajdra not only retained the central axis along the corridor when adding new apses and chambers, but also preserved the orientation in the direction of the rising of the Sun at cardinal points on the apparent horizon. According to Grima (2008: 35) the buildings do not appear to follow a single master plan, nor do they appear to have been conceived at a single moment, but rather to be a product of extensions and modifications over a longer period of time.

The first suggestion of a potential analogy between temples and astronomical phenomena was Vance (1842: 232-233) who especially studying Ħaġar Qim, but also attributing Mnajdra, indicating the temples were built '…to pay homage to the sun, moon, and stars…' and further referring to the highest eastern pillar at Ħaġar Qim that it '…serves also to strengthen the idea that I have conceived', and brings up that the temples were not roofed. As discussed elsewhere by this author (Lomsdalen 2013c: 97-98) referring to Zammit (1929b: 13):

> Zammit related the temples to astronomy when, in 1929, he suggested that the pits dug out of a horizontally positioned slab at the entrance to the Tarxien Temple represented an image of the stars of Crux (Southern Cross), a constellation clearly visible from Malta in that period.

Ugolini (1934: 128, 138) also mentions a potential affiliation among temple orientations and celestial bodies. He proposed that the Tal-Qadi Stone was possibly a Neolithic 'lastra astrologica', presumably suggesting a chart of astrology or astronomy. This was also when the Maltese megalithic structures were frequently referred to as sanctuaries, temples or sites for religious performance by excavators and scholars (Ashby *et al.* 1913, Bradley

1912, Caruana 1882, Mayr 1901). The megalithic monuments were first recognized as prehistoric monuments predating the Phoenicians by Mayr (1901: 86) [translated from German by this author], and were attributed to the Neolithic by Tagliaferro (1911) and Zammit (1910, 1916).

From the 1950s Maltese archaeology was also influenced by New Archaeology and Processualism. Two British archaeologists, John Evans (1959, 1971) and his successor David Trump (1961, 1966a, 1972) conducted the first fully scientific and professional excavations of the prehistoric sites. Quoting Evans (1959: 125), declaring that he is fully aware of that '…mostly the entrances face in some direction between south/east and south/west', but argues that '…it seems that orientation was not important', where celestial targets had no distinct significance to the builders. Agius and Ventura's (1981) statistical work confirmed that the majority of the temples have a southeast and southwest temple central axis orientation, and contrary to Evans, they used a chi-square test to argue that '…some factor has influenced the choice of orientation of the temples'. Astronomically, today as in the Temple Period the Sun rises in the southeast and sets in the southwest around the time of the winter solstice, though there is a variation in declination from about +/- 24.1° in Temple Period to about +/- 23. 36° today (Agius and Ventura 1980: 13).

Before 1975 little work had been conducted on the archaeoastronomy front in Malta until the photographer Formosa (1975: 17-21) who in 1974 identified the summer solstice sunrise illumination traversing the so-called 'oracle hole' in Ħaġar Qim. Some years later Agius and Ventura (1980) published their first work on scholarly astronomical research on Maltese megalithic sites. A decade later Micallef (1990) published a more popularised version of the solar alignments of the Mnajdra South Temple, calling it a '*Calendar in Stone'*. However, it was not before the turn of the millennium that both Maltese and international scholars as well as amateurs showed increasing interest in celestial influence of the Maltese prehistoric monuments. The INSAP (Inspiration of Astronomical Phenomena) 1999 conference in Malta organised by Prof. Ventura, University of Malta, may have contributed to this increased interest. Nevertheless, mainstream Maltese archaeology has been reluctant to accept the idea of any possible celestial orientations of the Maltese prehistoric temples (Bonanno 2004: 273, Evans 1959: 125, Stoddart *et al.* 1993: 16, Trump 2002: 151, Turnbull 2002: 131).

There is nevertheless a growing body of literature concerning Maltese temple orientations and the alignments to celestial bodies; Agius and Ventura (1980), Micallef, P. I. (1990), Ventura *et al.* (1993), Thomson Foster (1999), Mayrhofer (1995), Ventura (2002, 2004), Vassallo (2000, 2003, 2007, 2011a, 2011b), Cox (2001, 2009), Micallef, C. (2000, 2001), Albrect (2007), Cox and Lomsdalen (2010), Lomsdalen (2013a, 2013c, 2014a, 2014b, 2015a, 2016). In more recent work Malone, Stoddart and collaborators (Barratt *et al.* 2018b, 2009: 376, 2011:768) have begun to embrace the possibility that the Maltese prehistoric society had an interest in skyscape in connection with their monuments. In a personal communication in March 2018, Professor Anthony Bonanno also indicated that he has now a more open view towards the possibility of astronomical alignments on the Maltese temples. An engaging refined revision substantiated by statistical analysis of previous research of the 5,000-year- old Tally stone at the Mnajdra temple site in Malta by Ventura and collaborators from the 1990s (Ventura *et al.* 1993) has been published in 2021 again by Ventura but in this case with new collaborators (Agius *et al.* 2021). Though it cannot be ‘proven’ an actual reasoning behind these tally marks, but their new study provides a strong support to that the drilled holes are not just a random series without any meaning.

4.3 Methodology

This chapter describes the steps taken to address the question of whether the Temples were built to allow their entrance to frame specific skyscape features. The methodology is based on data collection through fieldwork, and estimating and quantifying the uncertainty level of measurements by statistical inference and patterning using the Method of Maximum Likelihood. It then examines potential celestial objects utilising astronomy programmes such as Horizon and Stellarium, and finally conducts significance testing of all the resulting data. Before describing the methodology, the relevant astronomical terminology will be explained, and the appropriate measuring equipment used for this field survey will be reported.

4.3.1 Astronomical terminology

The previous Chapter 3, has explained the astronomical terminology also used in this chapter, besides the one listed down below.

Heliacal and acronychal rising and setting

Heliacal rising is referred to when a star or a planet, after a period of invisibility and as it is close to the rising of the Sun becomes visible before the sunrise, while *heliacal setting* is when a star or a planet is visible setting in the west after the sunset, and ends its period of circumpolar visibility (Brady 2015: 82-83, Kelly and Milone 2005: 40). *Acronychal rising* refers to when a star or a planet, after a period of invisibility in the sky, rises in the east as the Sun sets in the west, while *acronychal setting* is when a celestial object sets at sunset and begins its period of invisibility (Brady 2015: 82-83, Kelly and Milone 2005: 40). According to Schaefer (1987: S19) heliacal phenomena were an important element in the pattern of the sky for ancient cultures, and '…ancient Egypt based the calendar on heliacal rising of Sirius'. Schaefer (Schaefer 1987: S19) further suggests that the Maya assigned their calendar '…into four intervals based on heliacal phenomena of Venus, and the first day of the Islamic lunar month is defined by the heliacal rising of the Moon'. The Greek used the heliacal and acronychal rising and setting of Pleiades as a calendric marker for the beginning of agricultural seasons (Dicks 1970: 36). Related to Maltese Prehistory, Ventura *et al.* (1993: 176-178) suggest that the Mnajdra South Temple was not oriented towards sunrise at equinox, but towards the rising of Pleiades with a declination around 0° during the Temple Period, as the position of equinox sunrise would be difficult to interpolate between the summer and winter solstices without mathematical calculations.

4.3.2 Measuring equipment

The following surveying equipment was used.

Global Positioning System (GPS)

To measure a site location or a specific point inside or outside a temple site in geographical longitude and latitude, a hand-held GPS Garmin eTrex 30 was used (2012).The resulting data from this device was verified against the GeoServer from the Maltese Planning Authority (2016) and found to be satisfactory. This is a device to be used in open-air conditions, but the protective membrane shelters covering the sites Mnajdra, Ħaġar Qim, and Tarxien did not negatively influence the survey data. Repeat measurements were taken of the same point at different calendar dates and showed consistency.

Total Station (TotS)

The Total Station used is a SOKKIA SET5, D20B16 Electronic Total Station (SOKKIA 1994). Contrary to normal procedure when using a Total Station in archaeological fieldwork using intersection and triangulation to find the geographical coordinates based on Geodetic markers (Betts 1992: 60-66, Hogg 2015-120, Howard 2007: 12-26), this research used Ruggles' (1999: 166) 'sun sight method' also known as sun-azimuth calibration. For this method there are two vital things to take into consideration. One is that the horizon profiles of interest must be clearly visible during the survey. The other condition is that there is clear sky and sunshine for about ten minutes to permit the sun-azimuth calibration to be made. The 'sun sight method' consist of pointing the TotS directly at the Sun to register a theoretical and preliminary azimuth with an absolute correct time when the reading was taken. As looking directly at the sun through the eyepiece of the TotS will cause blindness, and sun filters are unsafe as they can fracture under the intensity of the light, a sheet of paper was used to capture the projection of the solar orb through the eyepieces of the TotS. When the entire orb is visible then the TotS is aligned with the sun and its azimuth can be taken. To convert the Sun's theoretical azimuth to actual azimuth the astronomy program Stellarium (Chéreau 2019, Zotti and Wolf 2019) was used, by computing the location of the site and the exact time of the reading. Actually, all azimuth readings with the TotS on site are theoretical and only through data reduction work can the theoretical azimuths be converted to true azimuths (Ruggles 1999: 168-171).

Compass and clinometer

When a measurement with the TotS was not possible due to internal layout of a site or a site being inaccessible, the survey used a SUUNTO Tandem/360PC/360R G Clino/Compass (SUUNTO 2019) for registering azimuth and altitude values. The Suunto Tandem is a combined precision compass and clinometer, and according to the Finnish producer SUUNTO (2019), the compass has an accuracy of 1/3° and the clinometer an accuracy of 1/4°. To get the True North Azimuth from a compass, the local Maltese magnetic north was taken into consideration by adding the difference of 3° to the magnetic declination to get the true north. The value of 3.21° East ± 0.31° changing by 0.12° East per year with an uncertainty of 0.31°, represents the present Magnetic declination (MagDec) for Malta and was retrieved from the website of the National Centre for Environmental Information (2019: accessed 06 March 2019).

To avoid magnetic anomalies influencing the compass readings, a standard practice was introduced. It consisted of taking all measurements from both sides of an alignment, namely inside/out and again outside/in, and then the two readings were averaged. This is a standard to follow for all compass readings of megalithic sites where magnetic anomalies may occur (Ruggles 1999: 166-168). However, as Malta and Gozo are formed of Coralline and Globigerina Limestone, any magnetic anomalies should not have a major influence on compass readings (Foderà Serio *et al.* 1992: 116). Magnetic anomalies were mainly noticed when readings took place close to modern railings of tourist walkways inside the temples.

Survey rods and measuring tapes

Interconnecting archaeological survey rods, each 0.80 m in length and divided into 20 cm bands of white and red colours, were used. The rods were mainly used for two purposes. One was to establish a front and back alignment position of an azimuth reading when using a compass or a total station. Another reason was when they were positioned at a threshold where the megaliths of the side wall were destroyed or no longer in their original positions. The survey rods were also used to indicate scale in photographic records.

For this particular survey the measuring tape in metres was used to measure the height, the width, and the centre of an entrance doorway. The size of the entrance doorway has no significance for azimuth measurements, but more for a general registration of the size of a temple entrance. On the other hand, the measurement of the centre threshold point of the entrance is highly significant to establish the central axis of the temple. The same applies to establish the central point of the back apse.

As some back chambers or back apses are not quite symmetrical, or have been poorly preserved, the central point was taken by taking the middle point of the total width of the back apse. When a back apse was difficult to recognize on the ground, two rods were placed at the entrance window frame, one on the outer and one on the inner sides of the entrance window frame. A piece of string was then laid on the ground perpendicular to the line joining the two inner rods. Measuring Maltese Prehistory Temples due to their deformation or reconstruction over the years does create a certain level of uncertainty and possibility of errors. This will be taken into account and explained later in this section.

4.3.3 Data collection

According to Taylor (1997: 3) error analysis is the study of evaluation of uncertainty in measurements. Taylor maintains that errors in science are not necessarily mistakes or blunders that can be eliminated. Even carefully taken measurements cannot be completely free of uncertainties. In accordance with Taylor, Silva (2019a: 59) states that the actual uncertainty cannot be estimated from an instrument, and suggests that it is up to the surveyor to evaluate all areas of potential uncertainties and consider methods to reduce each one to its minimum.

Measuring prehistoric monuments has mainly been concerned with establishing the central axis of the monument and the altitude of its local horizon in degrees (Agius and Ventura 1980, Aveni 1982, Cox 2001, Foderà Serio *et al.* 1992, Heggie 1982, Hoskin 2001a, Ruggles 1999, Thom 1971). This is all valid and important work for establishing a possible pattern of temple orientations, which has also been inspirational literature for the present research. What Hoskin (2001a: 12) calls ‘axis of symmetry’, measuring from the centre of the back of the megalith to the centre of its entrance, has also been employed here. However, this study went one step further than the more traditional measuring and data gathering methodologies. The methodology developed by Silva (2014a, 2015a, 2017c, 2019a) named ‘window of visibility’, which defines the topographic region of the horizon that can be seen through the entrance frame from a chamber of a megalithic monument, was a key methodology in gathering measurement data for the present work. Regarding Silva’s window of visibility, this study adapted a more defined methodology of the window of visibility applying a specific predetermined point being the centre of the back of a temple, rather than considering any potential point inside the temple that has a view through the window of visibility (Silva 2015a: 124-125).

To be more specific, this study combines key elements from both Hoskin and Silva and applies them to a new methodology that would be more suitable to answer the present research question. That consists of using only the back point of Hoskin’s axis of symmetry and the front part of Silva’s maximum window of visibility. The combination of these two approaches frames the data capture and the key measuring area of this study, being the view from the central point of the central back apse through the entrance of a temple. That method will hereafter be referred to as the ‘*entrance frame’* of a given temple, a site, or the entrance of a temple apse.

A schematic plan view of this is shown in Figure 4.1 below, indicating the area of temple orientation. In addition to measuring the azimuths of the temple entrance window frames, the altitude of the visible apparent horizon seen from the back of the temple is also registered. This is done to convert the azimuths of the entrance window frame into declination in order to search for celestial bodies in the sky.

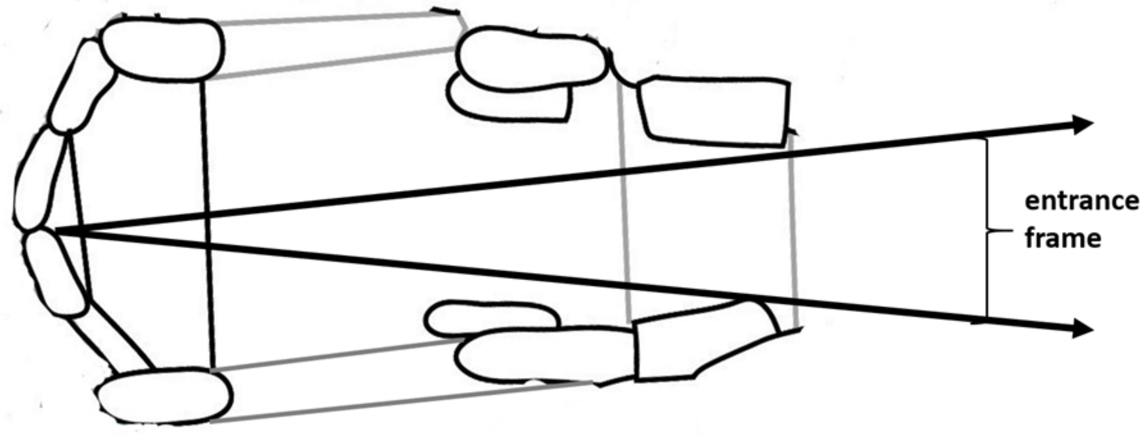


Figure 4.1. Plan showing method used to define entrance frame.
The area outside a temple falling within the entrance frame was defined by projecting cross-jamb lines from the central point of the innermost apse on the same axis as the entrance.

According to Torpiano (2004: 360) ‘The first decision to be taken by the prehistoric builders would thus be the orientation of the axis…’ to where the entrance should be built. This was followed by putting the threshold in place, and then the megaliths for the portal structure would be erected. How Torpiano describes this constructional sequence of Maltese prehistoric temples, is a fundamental component of Hoskin’s (2001a: 12) concept ‘axis of symmetry’ and the method of ‘entrance frame’ used in this study. Evans (1959: 86) refers to a symmetrical temple construction, suggesting that the architectural unit of the Maltese temples is ‘centring about a central spine composed of courts and corridors’. Both Trump (1981b: 129-130) and Bonanno (1999b: 105-106) also describe how the evolution of the temples from a trefoil to a five, six, or even seven apse temples basically followed the further planning along the established central axis. Grima (2005: 192-193) suggests that when the builders intended to construct larger temples or expand the extant ones, they generally achieved this by grouping more circular chambers together rather than creating chambers of larger sizes, and so sizes of individual chambers remain less variable. For this study, in the cases were the lintel is still in place over a temple entrance, the four corners of the entrance frame were also registered. The four corners of the entrance frame or the central axis measurement are not used in this study as it is the width of the entrance and the altitude of the apparent horizon which are the essential measurements.

There are various reasons why this specific method of entrance frame was chosen based on a combination of elements from both Hoskin's *axis of symmetry* and Silva's *window of visibility,* and not applying entirely only one of them. One is that Hoskin's axis of symmetry would narrow the visibility through a temple entrance down to 1° or 2°. The other is that Silva's method is not necessarily measured from the centre of the back apse of a structure which is the case in this study. The reason for combining these two methods is that, firstly, the width of the Maltese temple entrances seen from the back central axis can be from around 6° to 12° (ref. Appendix 7.4) which is considerably larger than what Hoskin's method allows for and, secondly, the horizon as seen through the temple entrances is not always flat but can be curved from one side to the other. For establishing a temple's geographical or celestial orientation, Hoskin's method is suitable, but not when it comes to searching for potential celestial targets that may rise or set within the scope of an entrance frame.

Another reason for applying the entrance frame method is that a methodology similar to Silva's window of visibility would in this case, create difficulties in establishing inside the temples a reliable patterning with positions of similar features or characteristics. According to Anderson and Stoddart, (2007: 42) Maltese temples display comparable layout when it comes to access and movements, but for single temple structures, each temple arranges its own inner visual distribution of spatial appearance with regard to specific elements and details. Silva's method is beneficial for establishing cross-jamb alignments from inside a structure through its window of visibility. However as earlier outlined, that is a methodology which is not applicable to this study. Once a temple was constructed, assumingly a prehistoric person could take a number of positions inside the structure for possible observations of celestial objects through the entrance frame. Nevertheless, based on the above-mentioned arguments, this research is using a methodology that engages with the central orientation of a temple based upon its structural building sequences (Torpiano 2004: 360). This methodology is sustained by a temple's orientation confined to its central axis and its threshold which forms the basic structure for the entrance frame. The measurements are not an aim *per se*, but a means to explore, using statistical patterning and significance testing, why the temple builders may have oriented and built the structures the way they did.

4.3.4 Fieldwork

Fieldwork consisted of visiting all extant prehistoric temple sites either where a window entrance frame still exists with a lintel, or temple sites where the entrance window frame itself was destroyed, but the threshold was detectable or a width of the entrance could be established when seen from the back apse. This meant that only 14 temple sites, out of the 35 previously considered, could be researched in this way. In the case of Xrobb I-Għaġin, where the back apse and the threshold where not fully detectable due to modern vegetation or destruction, archaeological plans were used to complement the site survey. The methodology involved measuring a total of 32 temples or temple apses listed in Table 4.1 with their respective phases of construction, being Ġgantija Phase, Tarxien Phase or Uncertain Phase. Two temples sites are listed in an Uncertain Phase, due to that it was not possible to establish if they belonged to either the Ġgantija or the Tarxien Phase. Appendix 7.2 shows the temples and their chronological phases indicating relevant reference to the archaeological record.

Temple Name	Phase
Mnajdra South	Ġgantija
Mnajdra Central	Tarxien
Mnajdra East	Ġgantija
Ħaġar Qim East	Ġgantija
Ħaġar Qim West	Ġgantija
Ħaġar Qim Room 10	Ġgantija
Ħaġar Qim Room 11	Ġgantija
Ħaġar Qim Room 12	Ġgantija
Ħaġar Qim Room 13	Ġgantija
Ħaġar Qim North	Tarxien
Borg in-Nadur West	Tarxien
Borg in-Nadur East	Tarxien
Tas-Silġ East	Tarxien
Tas-Silġ West	Tarxien
Xrobb l-Għaġin	Ġgantija
Tarxien South	Tarxien
Tarxien Central	Tarxien
Tarxien Room 10	Tarxien
Tarxien East	Uncertain
Tarxien Far East	Ġgantija
Kordin III West	Ġgantija
Kordin III East	Ġgantija
Ta' Ħaġrat West	Ġgantija
Ta' Ħaġrat East	Ġgantija
Skorba West	Ġgantija
Skorba East	Tarxien
Konċizzjoni	Tarxien
Buġibba	Tarxien
Tal-Qadi	Tarxien
Xemxija Temple	Uncertain
Ġgantija South	Ġgantija
Ġgantija North	Ġgantija

Table 4.1. Tempe entrance names with their respective phase of construction.
The table lists each temple or site entrance used in this study.

The field survey consisted of measuring the left, centre, and right part of the temple entrance frame in azimuths seen from the centre of the back apse, and the altitude in degrees of the apparent horizon seen through the entrance window frame. Where the apparent horizon had a hill formation, the horizon altitudes were also measured from the left, middle, and right side of the temple entrance window frame. When the apparent horizon could not be seen due to modern construction or vegetation, the Horizon program was used to detect the horizon altitude in degrees. The reason behind taking the azimuth and altitude measurements was to convert them into declinations during post-fieldwork data processing.

To take measurements of the entrance frame, the total station was positioned at the centre of the back apse inside the temple. Whenever a temple had a complete window entrance frame the azimuths and altitudes of the four corners of the window frame were recorded. However in such cases the azimuth of the ground corners was used as they seem to be more reliable as the top ones either had more erosion, had been replaced, or adjusted over the years. The height of the total station was put to approximate 1.60 metres which was the estimated hight of a prehistoric person (Brothwell and Blake 1966, Stoddart *et al.* 2009: 325). The same position and about the same height were also used when manually measuring the entrance window frame with a compass or a clinometer. When using a total station, the same readings were also taken by a compass and a clinometer. The purpose of this exercise was for a simple verification of the two data sets. The data from the readings and measurements were registered on a survey sheet for later data processing.

Traversal calibration

Three of the sites surveyed have today a protective membrane shelter, being Mnajdra, Ħaġar Qim, and Tarxien. This shelter does not allow a direct view to the Sun for a sun-azimuth calibration as explained above. In these cases a so-called 'Traversal' with the total station is necessary to ensure the set-up of the reference system is maintained when moving the total station from outside to under the shelter (Ruggles 1999: 167). A control point outside the shelter was established for the sun-azimuth calibration, then moved into a new control position under the shelter for measuring the azimuths back to the first control point. The total station was also used to measure the altitude in degrees of the apparent horizon which is an actual or true measurement and does not need to be converted. These corrected data were then inserted into another Excel spreadsheet for calculating the actual azimuth taking into consideration the Sun calibration technique, as shall be further explained in the following paragraph.

4.3.5 Post-field data processing

The post-field data processing consisted of transforming the theoretical data measured from the total station during the field survey to actual data.

Data reduction

The method of data reduction from Ruggles (1999: 166-171) has been applied for transforming theoretical Sun position in the sky and theoretical azimuths of the structure into actual ones. These calculations were done for all surveyed temple sites regardless of whether a Traversal calibration technique was used or not (Ruggles 1999: 166).

The actual data reduction consists of two steps. The first is to convert the position of the Sun in the sky at the exact time it was registered with the total station. This Sun calibration is done using Stellarium (Chéreau 2019, Zotti and Wolf 2019). By plotting the geographical location of the total station in longitude and latitude into Stellarium and then searching for the Sun's position at the registered time when the reading from the total station took place, Stellarium will provide the actual potion of the Sun in the sky in azimuth degrees. The next step is to convert the registered azimuths of the structure from the total station reading into actual azimuths. This is done with the help of a method named 'Calculate the (PB-Az) correction' (Ruggles 1999: 168). According to Ruggles (1999: 168) it consists of calculating the total station's 'plate bearing (PB) errors from pairs of horizontal circle reading on both faces taken before, after and throughout a period of fieldwork', and is a method used in high-precision work.

Atmospheric extinction and refraction

A part of the methodology is to estimate to what extent atmospheric extinction and refraction could have affected the visibility of celestial objects seen from Malta during the Temple Period.

Atmospheric extinction and refraction describe when the light of a celestial object passes through the atmosphere and reduces its apparent brightness, and is influenced by three factors; clarity or transparency of air, the observer's elevation above sea level, and the celestial object's altitude above sea level (Schaefer 1986, 1993, Tony and Creed 2008). The closer a celestial target is to the horizon, the more atmospheric air an observer has to look through and the more degraded the visibility becomes. The Stellarium astronomy programme makes it possible to inspect how refraction influences visibility and celestial objects by using 'Toggle atmospheric effects' making stars visible in the daytime (Zotti and Wolf 2019: 15). Horizon v. 0.13.b offers a new tool to explore and compare the apparent brightness of bright stars, taking atmospheric extinction into account (Smith 2020).

When searching for skyscape features and celestial objects going back about 5,000 years in time, there are other limitations or uncertainties to take into consideration. One is whether the celestial object in question was actual visible at all due to atmospheric pressure and temperature. Stellarium has a built-in tool called 'Extinction/Refraction settings' and it was adjusted by using this application to an estimated atmospheric situation for Malta during the Temple Period. However, data obtained from the Maltese Metrology Office of daily temperature and air pressure during 2016 to 2018 will be examined and used within Stellarium and Horizon.

4.3.6 Statistical analysis

This section explains the two statistical inference methods applied in the methodology; method of maximum likelihood and significance test.

Statistical inference

Statistical inference deals with error analysis and pattern recognition (Taylor 1997). In archaeology and archeoastronomy both qualitative (Cummings *et al.* 2002, Sims 2009b, Tilley 1994) and quantitative (Agius and Ventura 1980, Grima 2004, Pimenta *et al.* 2015, Ruggles 1999, Silva 2019a) methods have been applied in measuring prehistoric megalithic monuments. This study shall use a quantitative approach in searching for patterning of the orientation of Maltese prehistoric temple structures, using Silva's (2017c: 94, 2019a: 69-71, 2020) methodology. Statistical inference is relevant for evaluating structural orientation data, especially for prehistoric structures, as the complete dataset is seldom present due to partial preservation (Silva 2017c: 94-98).

For this analysis two independent but complementary inferential statistical approaches shall be applied; namely, the method of maximum likelihood and significance testing. Independent, as they are two completely different statistical methods, and complementary as they both infer patterns from measured data which can reinforce each other. As further explained down below, method of maximum likelihood is as its name indicates, *likelihood based,* while significance testing is *probability based*. Likelihood is testing a hypothesis of empirical data, while probability is testing the outcome of empirical data against a null hypothesis. For both methods, the open source R Statistical Computing Environment (R Core Team 2019) was applied, as done by Silva (2019a, 2020).

Method of Maximum Likelihood (ML)

Fisher (1922: 310, 323-324), the first to introduce the '*Method of Maximum Likelihood*', later defined '*Likelihood*' as 'the mathematical quantity which appears to be appropriate for measuring our order of preference among different possible populations', which is to say among different possible hypotheses (Fisher 1934: 11). Edwards (1992: 3) claims '*likelihood*' to be a numerical expression of the likelihood of rival hypothesis, or in other words, how likely it is for a particular hypothesis to be true given some empirical data. Edwards (1992: 9, 70) in line with Fisher, describes the *method of maximum likelihood* to be a method based on the premises that the best supported targets are those for which the likelihood of their occurrence is maximised. Silva (2017c: 93) states that ML is not very commonly used in archaeoastronomy, yet largely popularised in other academic fields.

What ML does in archaeoastronomy based on data capture and statistical inference, according to Silva (2019a: 68), is to establish overlapping regions of orientations to identify potential patterning suggesting an interest in the same target, being celestial or otherwise, for two or more structures. Silva (2019a: 68) names the overlapping region or the patterning as '*region of maximum likelihood'*, which is technically a more correct terminology than '*pattern'* when being used in likelihood statistics. Silva further argues that the strength of this method is that it can be used for any number of structures, from two upwards. ML discloses an overlapping patterning, identifying where the best estimation of the measurement shows the region for which the likelihood of its occurrence is greatest (Silva 2019a: 66-69). The concept of likelihood relating to archaeoastronomy and to the present study is that it makes it possible to examine overlapping patterning in orientation of temple entrance frames in order to identify potential celestial targets, using ML to calculate the region of maximum likelihood. The following step in using the region of maximum likelihood to identify a potential celestial object was done through Stellarium.

Silva (2017c, 2019a), being the first to introduce the ML method to archaeoastronomy maintains that the traditional accepted measurement errors of 2-3° makes it impossible to find patterning. Silva (2019a: 69) refers to Hoskin's (2001a: 11, 213-216) work using the method of '*axis of symmetry'* when measuring thousands of prehistoric megalithic sites, with the result that many regions had 'loose orientations to the rising or climbing Sun on seemingly arbitrary dates'.

Silva's (2014a, 2017c, 2019a) work has been an inspirational source for this study. The ML method has not previously been applied to archaeoastronomy research on Maltese megalithic prehistoric structures. The methodology of data collection used in this study is described in Section 4.3.3. The input data used for ML statistical calculations is based on three parameters (see Appendix 7.4). In this study the uncertainty range for each site is highlighted in a blue rectangle, and the black dot represents the centre of the measurement. The region of maximum likelihood, or patterning, is represented by a vertical highlighted coloured line in Figure 4.4 page 246.

Significance Test (ST)

Silva (2020: 2) refers to Neyman and Pearson (1933) and Neyman (1950) on hypothesis testing methods which compare two opposing hypothesis where one is excluded to the advantage of the other. Silva (2020: 2) further argues that the purpose of a ST is 'to measure the evidence against a single hypothesis – the *null hypothesis*', and that the result of the ST is a *p-value*, which estimates how strong the evidences are against the H0. According to Wasserstein and Lazar (2016: 9) researchers often want to use a p-value as the truth of a H0, or on the other hand, argue that the probability of the data is a result of chance and randomness. Wasserstein and Lazar (2016: 9) argue that a p-value is not 'a statement about data in relation to a specified hypothetical explanation, and is not a statement about the explanation itself', and a statistical outcome is not automatically 'true' or 'false'. Researchers should apply scientific inferential analyses into their methodology, such as uncertainty in data distribution, external events influencing the study, as well as legitimacy on what the data analysis is based (Wasserstein and Lazar 2016: 9).

For the present study, the significance test developed by Silva (2020) will be used, as it is appropriate to the study of structural orientations. This method simulates a random dataset with the same attributes as the empirical data, and then compares the result of those random simulations to the empirical data in order to determine whether the empirical data is random or not, by calculating a p-value (Silva 2020: 2). To calculate the p-value the method of North *et al.* (2002) is followed. Furthermore, the process also applied a *global p-value* in accordance with Shennan *et al*. (2013) as a measurement for an overall significance. According to Silva (2020: 2) the global p-value illustrates the statistical significance of the entire empirical dataset. As this procedure will be applied with a 95% confidence level, this may indicate that a 5% of false positives may lay outside the confidence envelope. This will further demonstrate that if a global p-value will be equal or less than 0.05, one can follow an interpretation of high probability and intentionality behind the way the temples were oriented, nevertheless, a margin of 5% has to be left open to other possibilities.

Silva (2017c: 56, 2019a: 95) maintains that in archaeoastronomy inferential use of ST has been predominantly ignored. The field has relied on qualitative assessments of measurements in search of patterning, being measuring structures or alignments to celestial targets. The approach has mainly been descriptive and not inferential, and has generally neglected inferring uncertainty values in statistical testing (Silva 2017c). In statistics, descriptive relates to establishing a number that describes an empirical distribution. It is usually visually represented as a histogram, curvigram, or a plot chart. An inferential method is used when the measurement itself is applied to infer or derive some other quantity, which can either be based on computer simulations, or purely a mathematical calculation, or both (Silva 2019a: 56). Bothe descriptive and inferential methods have been applied in this study.

In archaeoastronomy, quantitative statistical methods first gained attention through the works of Thom (1971) and Ruggles (1999: 160-161, 2015b: 418-419) who named the visualization method *curved histogram* or in short *curvigram*. The method used in the curvigram consist of finding a possible distribution of each assessment and consequently construct a probability distribution of all the empirical data (Silva 2017c: 100). Pimenta *et al.* (2009) went one step further than the curvigram methods using Bayesian inference in researching orientations of 12 megalithic enclosures in the Alentejo region of southern Portugal, but did not engage in quantifying any uncertainty. Silva (2020: 2) states that in order to test for significance, the first fundamental principle in measurement analysis is to establish which H0 the data shall be tested against. Relating Silva's statement to this study, the H0 is the following: The builders had no preference in orienting their temple structures, and temple orientations were purely randomly selected.

The level of statistical significance was set to 0.05, a commonly used threshold to make a claim for a scientific finding, nevertheless a level that can also be open to discussion (Wasserstein and Lazar 2016). In other words, the conceptual framework of the methodology was not based on any predetermined search result, or 'wishful' expectations, but fully conditional to if a pattern shall emerge. If no pattern would be found, that would not be regarded as a 'failure' or a 'negative' result, but a manifestation that the builder showed no interest or intentionality in orienting their temples towards celestial objects. The same analytical conclusion would also be valid if significant patterning would emerge without disclosing any celestial objects within that pattern.

Beside data uncertainty, it is of relevance of the ST for this study that the actual data collection is relatively limited, as it consists of measuring 'only' 32 temples. Therefore, 15.000 computer simulations are used to replace the effect of lacking a large quantity of similar data (Barcelò 2009, Lake 2014, Pimenta *et al.* 2015).

4.3.7 Celestial targets

A part of the methodology of this study is designed to search for celestial targets and objects in combination with measurement of orientations of temple entrance frames. Measuring celestial orientations is an essential part of the methodology to find celestial targets, but the measurements *per se* are not of interest in this case. Measurements are of interest for inferential purpose to find alignments of orientations. The measurement is a means to an end to infer possible alignment of celestial targets through measuring azimuths, horizon altitudes, and convert them into declinations in search of celestial targets (Silva 2019a: 58).

When it comes to celestial targets the most obvious first choices are the two luminaries: Sun and Moon. However, these objects move around the sky over the course of the year quite considerably. The most commonly looked for events are their extreme rising and setting positions, which have been suggested as targets for a variety of structures across a number of cultures worldwide (Aveni 2008a, 2008b, Belmonte and Shaltout 2009, Kelly and Milone 2005, MacKie 1977, Magli 2009, Malville 2008, North 1996, O'Kelly 1982, Ruggles 1988, 1999, Thom 1971).

Apart from the Sun and Moon, stars are also possible celestial targets. A consideration when searching and selecting stars based on declinations is, that they should not have an apparent or visual magnitude of more than +2.0, as these are the brightest and most obvious celestial targets in the sky (Smith 2019). A star catalogue from IAU, the International Astronomical Union (2020) was used for this classification. To search for stars in the sky Stellarium (2019) was used. To be more specific, Stellarium was used for computing any range of patterning that would result from statistical testing in searching for any potential celestial target within that range. To identify celestial objects in 3,000 BCE the Plug-in Tool ‘ArchaeoLines’ in Stellarium was used (Zotti and Wolf 2019: 27). The other question that arises is how reliable Stellarium is to bring celestial observations back to the years of the Maltese Temple Period. According to Stellarium User Guide (Zotti and Wolf 2019: 320-321), reliable dating goes back 13,000 years, meaning that the astronomical data for Maltese Temple Period should be solid. Known stars that were visible in prehistory but have since exploded in a nova or supernova, have also been considered. This was done using Stellarium using the *Bright Novae* and *Historical Supernovae* plugins that display such stars (Zotti and Wolf 2021: 135-139).

Another issue to take into account when considering alignments to celestial objects close To the horizon is atmospheric refraction (Schaefer 1993: 314-315). When the light of a celestial object travels through the atmosphere it is bent by refraction. When this happens, the objects will appear to be in a different position from where it actually is. This shift in position needs to be taken into account when considering alignments. Schaefer (1993) gives formulas to calculate this shift based on the altitude of the celestial object, the atmospheric temperature, and air pressure.

According to Schembri (2019: 11) there are four different air masses that influence the climate of the Mediterranean in general and Malta in particular. The Maltese summer months, usually recognised as dry, warm with long-term climate stability, and clear sky, are also associated with prominent heat and humidity. The summer climate is influenced by the Continental Tropical Air Mass originated in Africa and the Maritime Tropical Air Mass with its origin in the mid-Atlantic Ocean (Schembri 2019). The intensified autumn and winter precipitation and the assembly of warm and cool air masses during winter and spring months, is caused by Continental Polar Air Mass from the continent of Asia and the Maritime Polar Air Mass from the northern Atlantic region (Schembri 2019: 11).

Fenech (2007: 114) suggests that the biggest environmental changes in the Maltese Neolithic period due to extreme weather and climate changes, which seem to be the prime agent of the continuous degradation of the environment and/or erosion since the Neolithic. How forested Malta was in the Neolithic is still debatable. However there are indications of a steppe environment and open landscape with similarities to today's landscape (Fenech 2007: 113-114, Gambin *et al.* 2016: 273). At present, the average annual rainfall is 529.6 mm and has a marked seasonal occurrence with a total of 70% falling from October to March (Marriner *et al.* 2012: 2, Ruffella *et al.* 2018: 186). The most common wind direction today is the north-westerly one, experienced on average 20.7% a year (Gambin *et al.* 2016: 276). According to Gambin *et al.* (2016: 274), in the early to mid-

Holocene (7,280-5,000 BP) the environmental changes were dominated by natural atmospheric weather conditions, while human impact dominated in the late Holocene (4,500-3,700 BP) with dryer and warmer weather conditions. Between *c*. 7,000 and 4,800 cal BP, a time span that includes the Maltese Temple Period, the temperature according to Gambin *et al.* (2016: 282) was considerably stable at around 11°C. However after 4,800 BP, the temperature developed into higher changeable weather with a minimum of 7°C and a maximum of 14°C. Winter rainfall seems to show strong variations, though from 7,000-4,600 BP both summer and winter have generally high precipitation which seems to decrease from 6,000 BP, and Bronze Age Malta seems to experience a dry period with low winter precipitation (Gambin *et al.* 2016: 282).

Data provided by the Met Office (2019) at Luqa Aiport (Figure 4.2 and Table 4.2) shows the variation of maximum and minimum daily temperatures as well as daily air pressure over the period 2016-2018. From these, one can find the minimum and maximum values and use them to assess the maximum refraction effects (see Table 4.3).

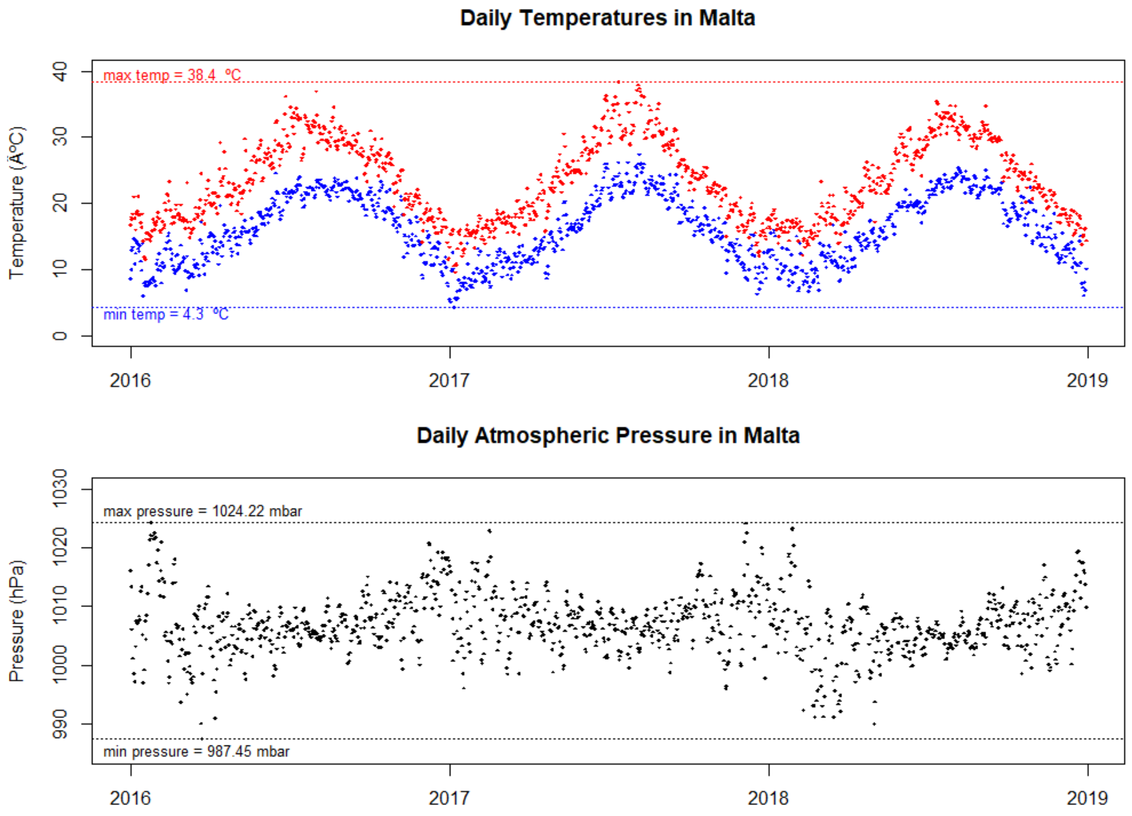


Figure 4.2. Daily temperature and atmospheric pressure in Malta.
The figure illustrates the maximum (red colour) and minimum (blue colour) daily temperature and atmospheric pressure in Malta from 2016 to 2019. As indicated in top part of the figure, the temperature is highest at the mid-year, during summer (38.4°C), and lowest (4.3°C) at the turn of the yearly cycles, being winter season. The atmospheric pressure follows a kind of opposite pattern to the temperature with maximum pressure (1024.22mbar) during the winter and a minimum pressure (987.45mbar) in the summer season.

Minimum Temperature	4.3 °C
Maximum Temperature	38.4 °C
Minimum Pressure	987.45 mbar
Maximum Pressure	1024.22 mbar

Table 4.2. Temperature and atmospheric pressure in Malta.
The table shows the minimum and maximum temperatures and atmospheric pressure in Malta for the period of 2016 to 2019.

Putting these numbers into Schaefer’s (1993: 314) equations one gets that the maximum change in the apparent altitude of a celestial object at a horizon with 0° altitude is of 0.5° (see Table 4.3). This value is not significantly different from the standard one of 0.5°, which is used in most astronomical software including the ones used in this study (Stellarium, Horizon and skyscapeR).

Temperature	**Pressure**	**Refraction at 10º altitude (in degrees)**	**Refraction at 0º altitude (in degrees)**
4.3	987.45	0.09	0.57
4.3	1024.22	0.09	0.57
38.4	987.45	0.08	0.57
38.4	1024.22	0.08	0.57
		This column uses equation (1a) in Schaefer 1993 (page 314)	This column uses equation (1b) in Schaefer 1993 (page 314)

Table 4.3. Calculation of atmospheric refraction at ten- and zero-degrees altitude. Based on minimum and maximum temperature and air pressure in Malta from 2016 to 2019 using Schaefer's (1993: 314) equations, showing that the refraction values are not significantly different from the standard 0.5° used in the astronomy programs Stellarium, Horizon, or SkyscapeR.

4.3.8 Limitations

An essential application in field measurements is to evaluate the validity of the collected data at hand. Taylor's (1997: 3) claim that 'even carefully taken measurements cannot be completely free of uncertainties', is an important consideration when field surveying 5,000 year old Maltese Prehistoric Temples which have undergone various alterations either due to human exposure, physical deterioration, or atmospheric conditions. It is paramount that the surveyor is not only aware of this, but whenever possible all measurements should be double checked. This can be done by measuring an alignment from both ends of the temple structure. This method would not be possible when measuring alignments towards a distant apparent horizon, and the surveyor must then rely on the measurements taken from the site itself if a total station or a compass have been used.

Hoskin (2001a: 11) emphasises that few prehistoric megalithic monuments have an axis that can be defined better than within two or three degrees. Based on this, a general rule in archaeoastronomy allows a measurement uncertainty margin of +/- 2°, which in itself is debatable. Ruggles (1999: 165) suggests that using a theodolite is often the only way to obtain demonstrably reliable readings where a minute-of-arc or better is easily possible.

Hoskin (2001a: 11) on the other hand argues that measurements taken by a theodolite are not immune to mistakes. He refers to a case where three experienced professors of astronomy measuring the same poles with two different theodolites, obtained a difference of more than one degree. For measuring azimuths and altitude to a precision of about one degree, prismatic hand held compass and clinometer may be sufficient, but should be calibrated with observations of visible landmarks (Ruggles 1999: 165). According to Fodera Serio *et al*. (1992: 116), the use of a theodolite is not that advantageous as one might think, as positioning of pole and survey rods is not an exact science.

Further limitations and uncertainties in scientific field survey work used in this methodology could be influenced by a consistency in positioning the total station and establishing the exact 'axis of symmetry' for a temple or an apse entrance. This uncertainty is not only due to possible human error, but could also be due to lack of preservation of the megalithic structure. In some cases, an axis of symmetry may have never existed, because the structure does not respect a single axis, and at best the researcher can only achieve an approximation. Using inferential statistical data for calculating these types of uncertainties will reduce a potential margin of error in measurements. Another aspect is when taking measurements on Maltese prehistoric megalithic temples, the awareness of potential limitations creates a higher degree of concentration in searching for justified results, which has also been a major objective during field surveys.

A potential limitation could be introduced when using a handheld compass or a clinometer instead of the total station. To quantify such uncertainty a calibration was made showing a standard deviation of 0.8 degrees (ref. Table 3.1 page 186). Another similar possible limitation exists when using a total station and the astronomy programme Horizon when used for specific points or features on the apparent horizon both in azimuths and altitudes in degrees seen from a temple location. In this case ground-truthing calibration was used indicating the mean error of Horizon and total Station used in this fieldwork. The mentioned table shows that the Mean Error (standard deviation of mean (SDOM)) in degrees of both the azimuth and altitude is less than one degree and is thus considered acceptable.

Another more predtermined methlogical limitation to this study which shall not be explored in this reserach question, is the aspect of celestial bodies influence and temple orientations which is the effect of the ilumination and alignments to the sunrise at cardinal points throughout a solar year. As previously mentioned (ref. 4.2.1 page 216), several related studies have been carried out, but not directly statistically quantified or verified when it comes to patterning. Neither has this study evaluated to what influence the major lunar extreme may have had on the temples and their orientations similar to a study done by Cox (2010). All these areas could be subjects for futher reserach based on statistical infernecial methodology.

4.4 Results

This section presents the results of the field survey of 32 temple entrance frames as explained in the Methodology section. The aim of this section is to present results of the investigation as to whether temple entrance frames were oriented towards specific skyscape features. The results obtained are based on two means of statistical inference using the Method of Maximum Likelihood and Significance Testing. In addition, Stellarium was used to identify potential celestial objects, as explained in the Discussion section.

4.4.1 Orientation of temple entrances

The data collection is listed in Appendix 7.4 and is the basic working sheet for all further results presented in this section, where the azimuths have been converted based on the previous exercise of Sun calculations into declinations following the formula of Ruggles (1999: 22).

4.4.2 Statistical analyses of temple entrance frames

Statistical analyses of the temple entrance frames are inferred from the results of the temple orientations. The results here are based on two independent statistical methods. One is the Method of Maximum Likelihood (ML), and the other is a Significance Test (ST) as already described in 4.3.6 page 231.

Method of Maximum Likelihood

For this specific study the method of maximum likelihood consists of two statistical data compilations. One is a calculation based on the temple entrance frame in azimuths, while the other is based on declinations. The rationale in analysing both azimuths and declinations is that azimuths relate to orientations in the landscape while declinations, on the other hand, are associated with skyscape observations. In other words, the azimuth tells if a structure is oriented north, east, south, or west, while the declination indicates an orientation towards the southern or northern sphere of the celestial equator or if it is aligned to the celestial equator itself.

Maximum Likelihood in azimuth

Figure 4.3 left, is not intended to calculate or infer any region of maximum likelihood, but lists temple entrance frames in order of orientations. It shows the orientation of the temple entrance frames in azimuth listed from lowest to highest degree of azimuth. The result shows that all sites involved have an orientation between 72.1° and 307.6°, which covers the spherical area from north-east to north-west. There are no structures oriented due north. The dashed lines indicate three cardinal directions. The first to the left shows 90° East, the one in the middle 180° South, and the one on the right 270° West. What this illustrates is that out of 32 temple sites, 28 (or 87.5%) fall inside an orientation towards the southerly geographical hemisphere from east to west. A further orientation towards the southern hemisphere shows that there are 18 (or 56.3%) axes that have an orientation between 135° (due south-east) and 225° (due southwest).

Figure 4.3 right, shows temple orientations in azimuths and are chronologically sorted according to their Temple Phases. It calculates an inferential statistical region based on the total data at hand of method of maximum likelihood. The region of maximum likelihood which is represented by the width of the red vertical line covers an azimuth area of 128.9° to 131.4°. The following six temple entrances fall in the region of maximum likelihood of which they all belong to the Ġgantija Phase: Xrobb l-Għaġin, Ħaġar Qim East, Ġgantija South, Ta' Ħaġrat West, Ġgantija North, and Skorba West (ref. Table 4.4). None of the temples from Tarxien or Uncertain Phase fall in this region of maximum likelihood.

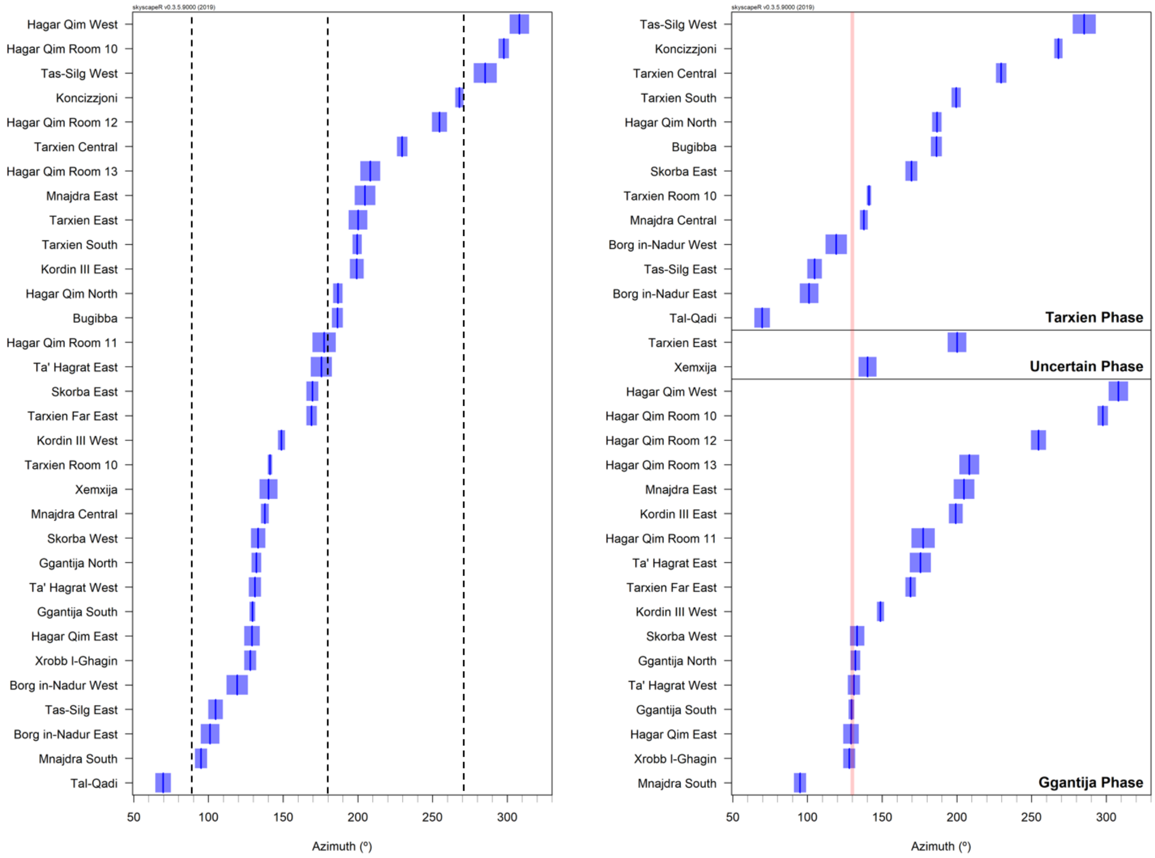
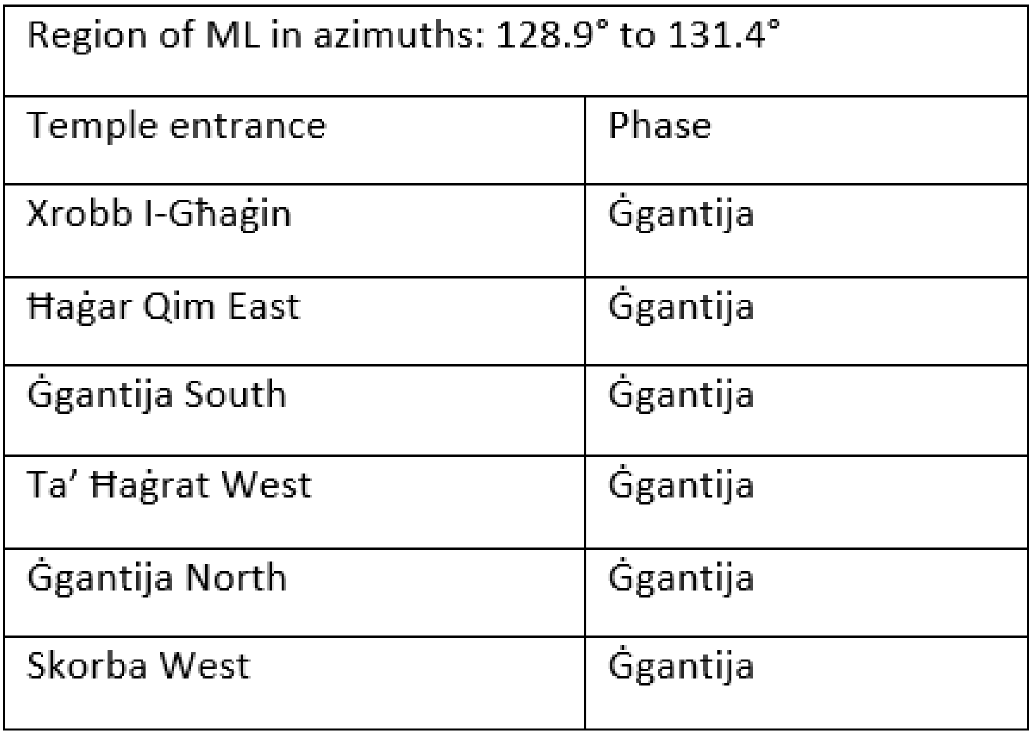


Figure 4.3. Maximum likelihood in azimuths.
The left figure shows the orientations of the temple entrance window frames in azimuth listed from lowest to highest degrees of their azimuths of orientation. The dashed lines indicate the cardinal directions in order, from left to right; 90° East, 180° South and 270° West. On the right, temple entrances are ordered by orientation and chronologically split by Temple Phases. The region of maximum likelihood is represented by the width of the red vertical line. In both figures the blue boxes indicate the width of the entrance frames of the temples and the vertical line inside the blue box is showing the centre of the entrance frame.



Region of ML in azimuths: 128.9° to 131.4°	
Temple entrance	Phase
Xrobb l-Għaġin	Ġgantija
Ħaġar Qim East	Ġgantija
Ġgantija South	Ġgantija
Ta' Ħaġrat West	Ġgantija
Ġgantija North	Ġgantija
Skorba West	Ġgantija

Table 4.4. Region of maximum likelihood in azimuths.
The six temple entrances that fall within the region of maximum likelihood in azimuths with their respective temple phases.

Maximum Likelihood in declination

As Figure 4.4 left illustrates, it is not meant to calculate or infer any region of maximum likelihood, but lists the temple entrance frames in order of declinations from south to north. It shows the orientations of the temple entrance frames in declination degrees. The result shows that all sites have a declination between – 53.9° and + 54.1°. This figure also shows that out of a total of 32 temple axes, 27 (or 84.4%) have a southerly celestial orientation, as they are located either on, or south of the 0° declination divide.

Figure 4.4 right, indicates which region and which temple phase the 14 temple entrances out of a total of 32 (or 43.8%) belong to one of the two regions of maximum likelihood. Of the 14 temple entrances, regardless if they belong to Region of ML 1 or 2, ten (or 71.4%) of 14 belong to Ġgantija Phase whereas three temple entrances belong to Tarxien, and one to Uncertain Phase. Taking the Regions of ML into consideration, four (or 57.1%) of seven temple sites belong to Ġgantija Phase in Region of ML 1. The equivalent for Region of ML 2 is six (85.7%) out of seven sites belonging to the Ġgantija Phase. This temple entrance distribution is schematically illustrated in Table 4.5.

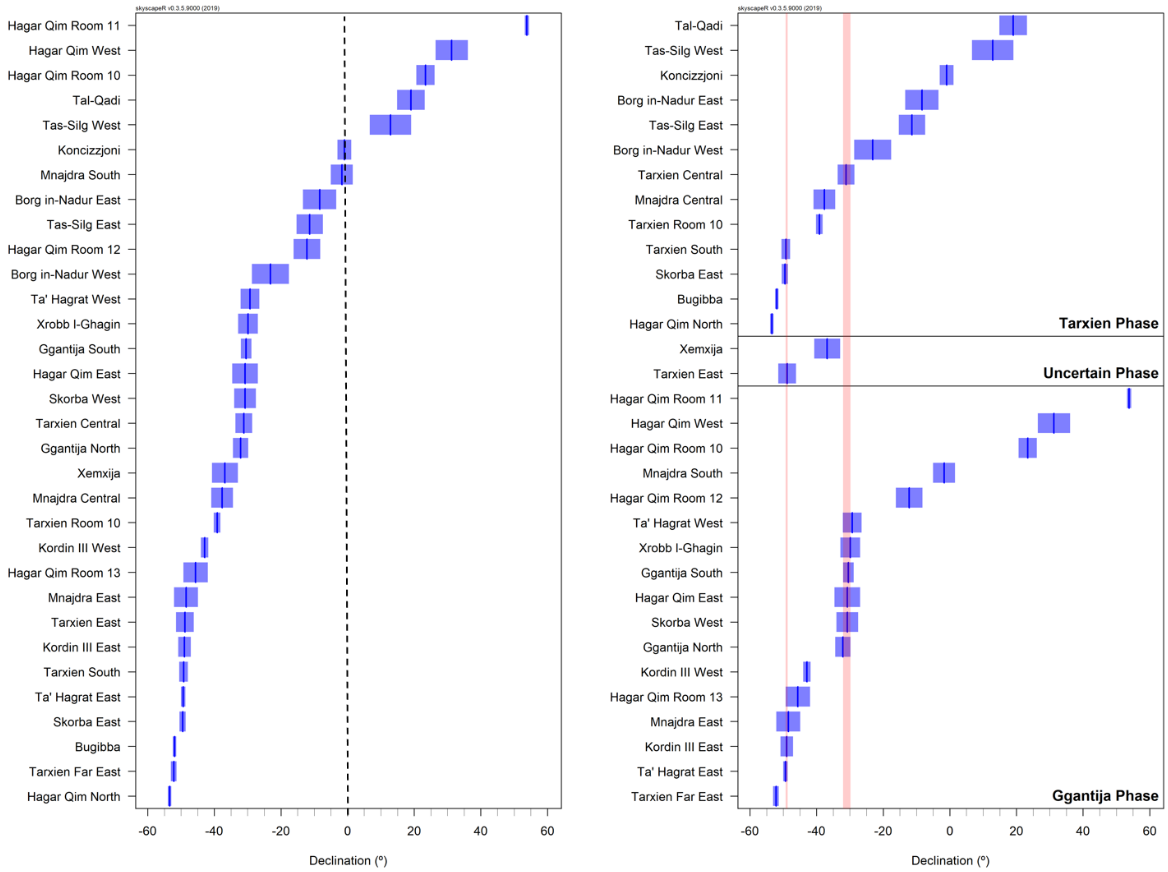


Figure 4.4. Maximum likelihood in declination.
The figure on the left lists the temple entrance frames in order of declinations from south to north orientation. The dashed line is set at 0° declination. The figure on the right also lists the temple entrance window frames in order of declinations but following a south to north orientation and listed according to their chronology. In addition, the figure on the right shows the result of the maximum likelihood statistical test with the respective region of maximum likelihood marked with a red line. Region of ML 1 is the narrower red line to the left and Region of ML 2 is the wider red line to the right. In both figures the blue boxes indicate the width of the entrance frames and the line inside the box shows the centre of the entrance frame.

Region ML 1 Dec. -49.5 to – 48.7			Region ML 2 Dec. -32.0 to -29.8	
Temple entrance	Phase		Temple entrance	Phase
Mnajdra East	Ġgantija		Ħaġar Qim East	Ġgantija
Ħaġar Qim Room 13	Ġgantija		Xrobb l-Għaġin	Ġgantija
Tarxien South	Tarxien		Tarxien Central	Tarxien
Tarxien East	Uncertain		Ta’ Ħaġrat West	Ġgantija
Kordin III East	Ġgantija		Skorba West	Ġgantija
Ta’ Ħaġrat East	Ġgantija		Ġgantija South	Ġgantija
Skorba East	Tarxien		Ġgantija North	Ġgantija

Table 4.5. Region ML 1 & 2 with Temple Phases.
This table illustrates which region of ML a temple entrance falls within, and its relevant Temple Phase. Out of the 14 sites listed, 10 date to Ġgantija Phase, 3 to Tarxien Phase and 1 to Uncertain Phase. Region ML 1 has 4 Ġgantija, 2 Tarxien and 1 Uncertain Phase. For Region ML 2, 6 belong to Ġgantija and 1 to Tarxien.

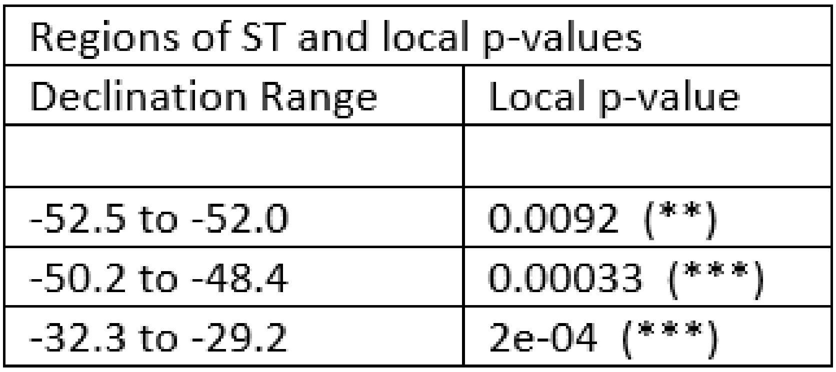
4.4.3 Significance Test

This section shows the results of the curvigram method summing up the probability distribution of each measurement and creates a curvigram that represents all the empirical data. The calculations are based on 15,000 simulations and with a 95% confidence level, meaning 5% is open to uncertainty.

Significance Test for all sites

As indicted in Figure 4.5, the global p-value is 0.01973. This implies that the data is significantly deviating from the null hypothesis (H0). As the global p-value is lower than the established H0 level, the random distribution shows significant patterning of distribution, meaning the entrances are not oriented by chance. Some factors have affected this distribution. The grey area is the confidence envelope of the H0 which indicates that temple entrances falling inside the envelope are based on a random distribution, meaning the orientation of these sites is by pure chance only.

There are three blue peaks reaching above the confidence envelope. Table 4.6 illustrates the declination ranges and local p-values for each of the three blue peaks and their significance values.



Regions of ST and local p-values	
Declination Range	Local p-value
-52.5 to -52.0	0.0092 (**)
-50.2 to -48.4	0.00033 (***)
-32.3 to -29.2	2e-04 (***)

Table 4.6. Regions of significance test and local p-values.
The first row represents the blue peak to the left classified as 'false positive'. The second represents the middle blue peak and the third row the blue peak to the right. The number of stars of the local p-value indicates the level of significance in p-value. The more stars a p-value has, the more significant its p-value is.

As the significance value in the first row which represent the left peak in Figure 4.5 is so much less significant than the other two, and since it lies so close to the extreme of the null hypothesis, it is likely to be a false positive, meaning that the significance test has erroneously identified it as significant (Silva 2020). However, the middle and the right peaks are definitely significant, namely:

- Region of ST 1: The blue middle peak has a declination range from -50.2 to -48.1.
- Region of ST 2: The blue peak to the right has a declination range from -32.3 to -29.2.

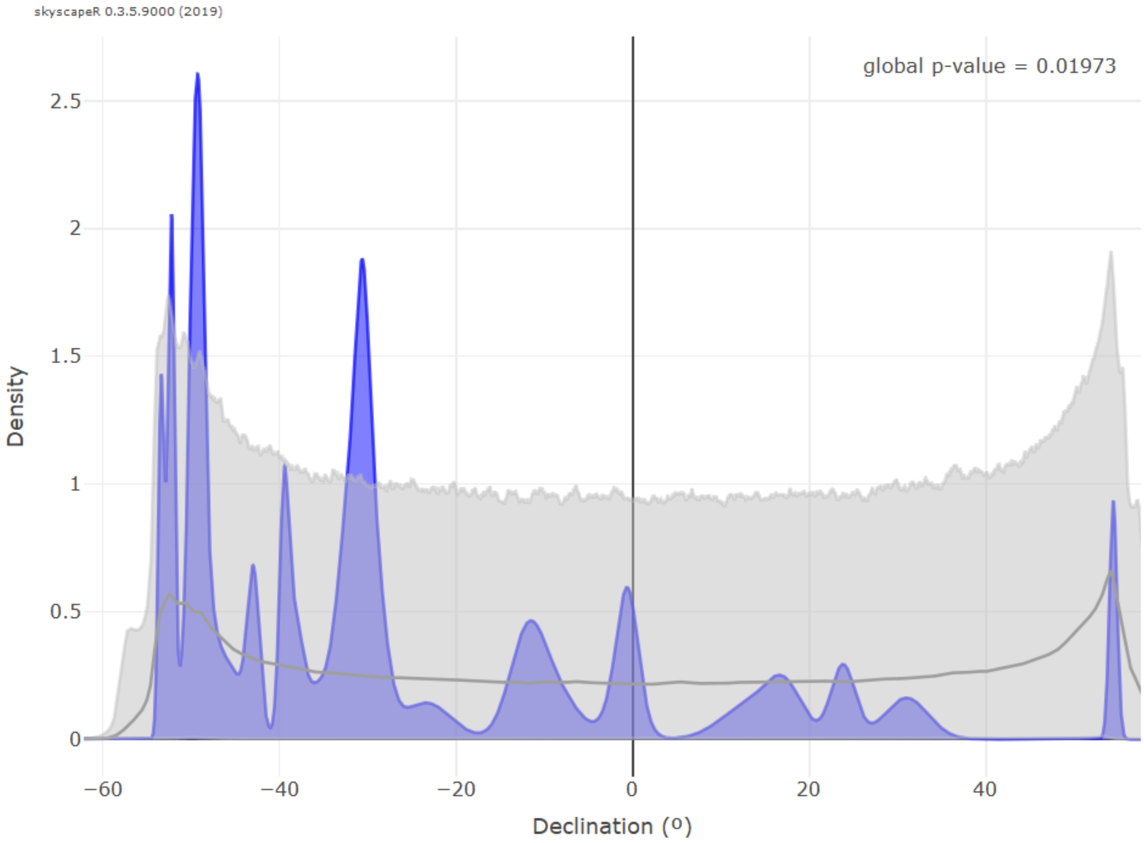


Figure 4.5. Significance Test for all sites and phases.
The Global p-value is 0.01973, indicating the data implied is significantly deviating from the H0. The horizontal x-axis in the curvigram shows declinations. The vertical y-axis indicates the statistical density. Density is related to frequency; the higher a curve is, the more frequent is the distribution. The blue coloured area and the curves across the chart represent the various temple entrances and their distribution ranges based on entrance frame measurements. The grey area is the confidence envelope of the H0 which represents the ranges of possibilities consistent with the H0. This means that if all sites are ordered at random, the curvigram in blue should be completely inside the confidence envelope (the grey area). However, this specific significance test results in three peaks (though the first to the left is a so-called 'false positive') that are higher than what would be expected if the temple entrances were randomly oriented, as they are outside the confidence envelope. Statistically that implies that their distribution ranges are not random or due to chance. The grey line in the lower part of the chart indicates the mean value of the randomness of the hypotheses.

Table 4.7 illustrates which temple entrance frames fall inside Region ST 1 or 2, with respective Temple Phases. Fourteen (43.8%) out of a total of 32 sites fit either to Region of ST 1 or 2. Out of the 14 temple entrances regardless if they belong to Region ST 1 or 2, ten (or 71.4%) of 14 belong to Ġgantija Phase. Three temple entrances belong to Tarxien and one to Uncertain Phase. Taking the Region ST into account, four (or 57.1%) of seven temple sites belong to Ġgantija Phase in Region ST 1. The equivalent for Region ST 2 is six (85.7%) out of seven sites belonging to the Ġgantija Phase.

Region ST 1 Dec. -50.2 to -48.4			Region of ST 2 Dec. -32.3 to -29.2	
Temple entrance	Phase		Temple entrance	Phase
Mnajdra East	Ġgantija		Ħaġar Qim East	Ġgantija
Ħaġar Qim Room 13	Ġgantija		Xrobb l-Għaġin	Ġgantija
Tarxien South	Tarxien		Tarxien Central	Tarxien
Tarxien East	Uncertain		Ta' Ħaġrat West	Ġgantija
Kordin III East	Ġgantija		Skorba West	Ġgantija
Ta' Ħaġrat East	Ġgantija		Ġgantija South	Ġgantija
Skorba East	Tarxien		Ġgantija North	Ġgantija

Table 4.7. Region ST 1 & ST 2 and Temple Phases.
The table shows which Region of ST a temple entrance belongs to and its Temple Phase.Out of the 14 sites listed, ten belong to Ġgantija, three to Tarxien and one to Uncertain Phase. Region ST 1 has four Ġgantija, two Tarxien, and one Uncertain Phase sites. For Region ST 2, six belong to Ġgantija and one to Tarxien Phase.

Significance Test for each Temple Phase

The significance tests for Ġgantija, Tarxien, and Uncertain phases are listed as follows:

Ġgantija Phase

Significance test for Ġgantija Phase results in a global p-value of 0.01953, which is lower than the H0=0.05, showing a significant result that is not due to chance or randomness. As can be seen in Figure 4.6 (top one), there are two blue peaks that rise above the confidence envelope (the grey area). The left peak represents a declination range from -49.5 to -48.5 and the right one, -32.7 to -28.9, respectively representing Region of ST 3 & 4. For this phase, there are a total of four temple entrances that fit into Region of ST 3 and six for Region of ST 4 with their corresponding names listed in Table 4.8.

Ġgantija Phase		
Region ST 3 Dec. -49.5 to -48.5		Region ST 4 Dec. -32.7 to -28.9
Temple entrance		Temple entrance
Mnajdra East		Ħaġar Qim East
Ħaġar Qim Room 13		Xrobb l-Għaġin
Kordin III East		Ta' Ħaġrat West
Ta' Ħaġrat East		Skorba West
		Ġgantija South
		Ġgantija North

Table 4.8. Region ST 3 & 4, Ġgantija Phase.
The table lists the various temple entrance site names of the Ġgantija Phase with their respective Region of ST.

Tarxien Phase

The outcome of the significance test for Tarxien Phase indicates a global p-value of 0.77776, which is above the H0=0.05. This result shows that there is no significant temple entrance frame distribution or patterning in the Tarxien Phase, though Tarxien South and Skorba East would fit into a Region ST 1, and Tarxien Central in a Region ST 2 patterning. This is indicated in Figure 4.6 (lower left), where some of the blue peaks rise slightly above the confidence envelope (the grey area), however not high enough to conclude on significance. This result implies that temples belonging to the Tarxien Phase are randomly oriented.

Uncertain Phase

The result of the significance test for Uncertain Phase is similar to the one of Tarxien Phase, that is that the distribution of the temples is not significant, and orientations are by chance and randomly chosen. The global p-value of 0.22832 is considerably higher than the H0=0.05. Although one of the two blue peaks, where Tarxien East would fit, does slightly penetrate the confidence envelope (the grey area), nevertheless the test implies conformity with the H0 that the temple orientations were randomly chosen (ref. Figure 4.6 lower right).

To facilitate visual comparison between results of significance tests of Ġgantija, Tarxien, and Uncertain phases, the results for these three categories are shown side by side in Figure 4.6.

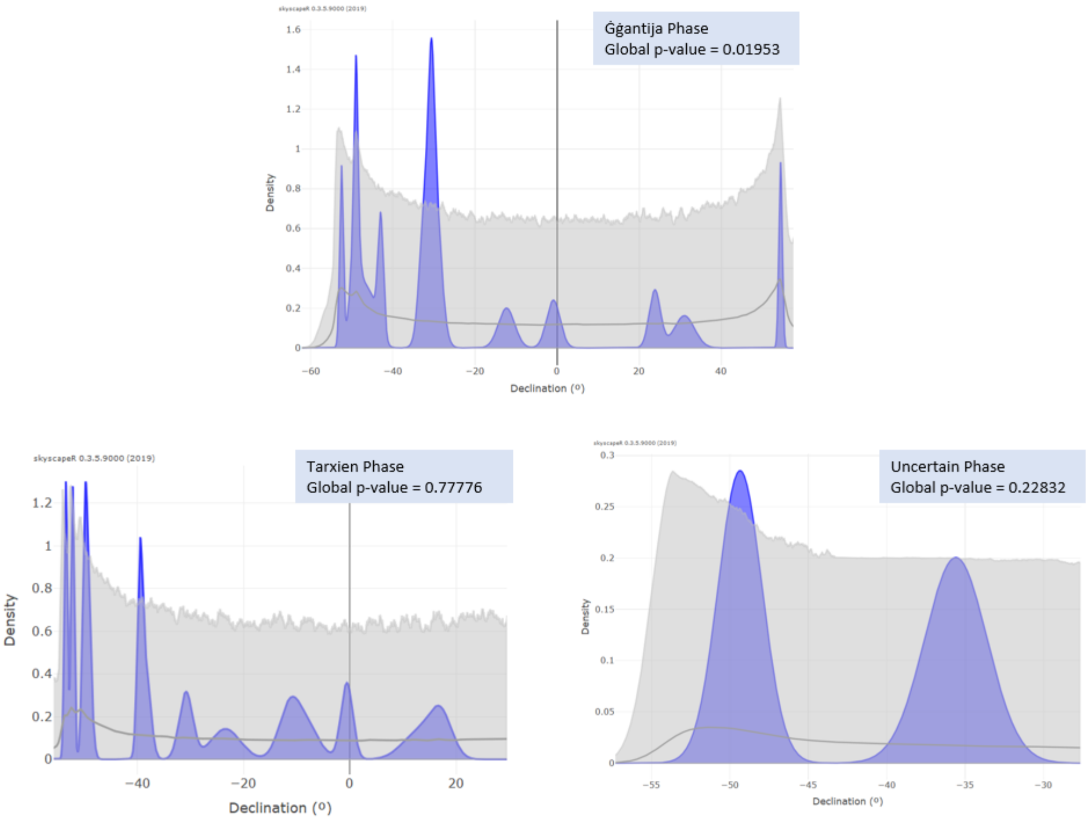


Figure 4.6. Significance test for each Temple Phase.
Ġgantija Phase is on the centre top, while Tarxien Phase is at the lower left and Uncertain Phase on the lower right. Of the three Temple Phases in question, only Ġgantija Phase has a global p-value implying a significant result. This distribution is not due to chance or randomness.

4.4.4 Celestial targets

This section shows the results of celestial targets identified using the methodologies from two statistical tests as explained above, method of maximum likelihood and significance test, and the astronomy program Stellarium.

Method of Maximum Likelihood (ML)

As already identified through the statistical method of maximum likelihood (ref. Figure 4.5 and Table 4.5) two patterns emerge, named as Region ML 1 and Region ML 2. In Figure 4.7, the Region ML 1 is the left red vertical column and Region ML 2 the right (pink) column. Based on the criteria established in the Methodology (ref. 4.3.7 page 236). in searching for celestial objects, the result shows that there are two stars in the sky that fit into this patterning:

- Region ML 1 (-49.5 to -48.7): Avior with declination -49.0 at 3,250 BCE.
- Region ML 2 (-32.0 to-29.8): Gacrux with declination –30.6 at 3,250 BCE.

Except for southern major lunar extreme with a declination of -29.2 being slightly attached to the Region of ML 2 with a black line, no other lunar or solar events fit into this patterning.

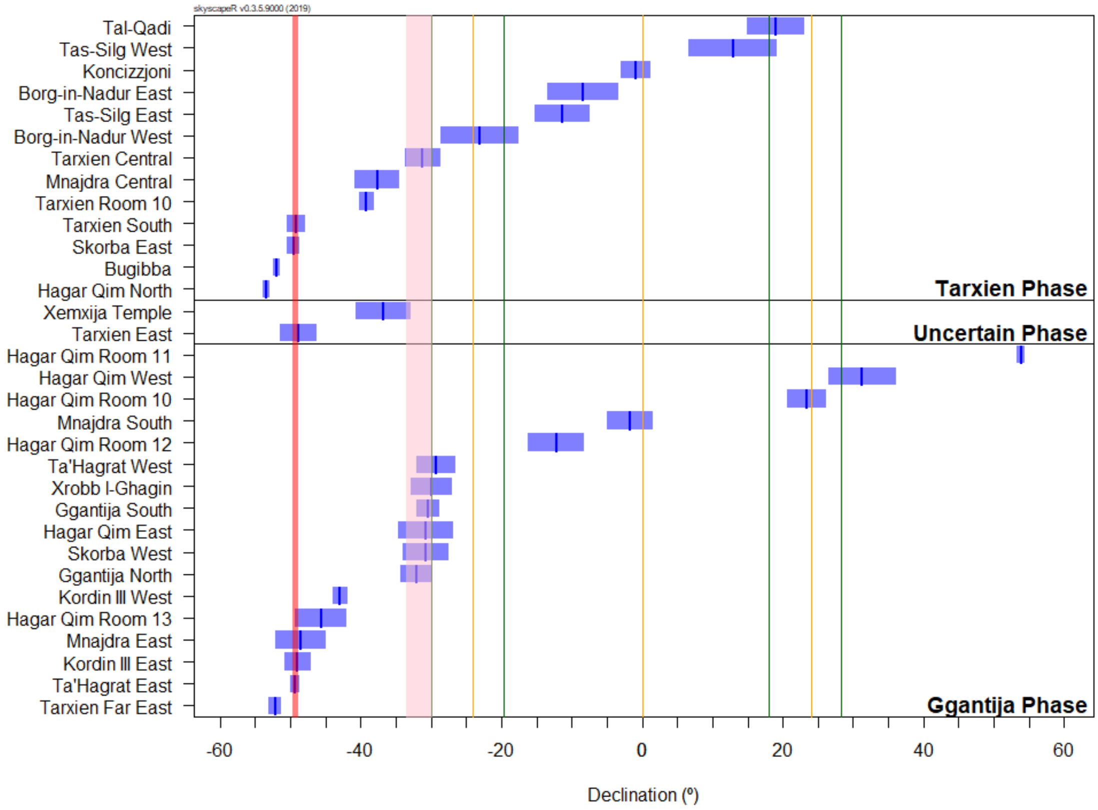


Figure 4.7. Celestial Targets, Maximum Likelihood.
Avior is part of Region ML 1 which is the red column. The pink column is Region LM 2, where Gacrux is located. The black line which is attached to Region ML 2, indicates the southern major lunar extreme. The following order from left to right, the other lines represent the winter solstice, the southern minor lunar extreme, the equinox (dec. 0°), the northern minor lunar extreme, the summer solstice, and the last one, the northern major lunar extreme. Except for the southern major lunar extreme, no other lunar or solar events fall inside any pattern of this study.

Significance Test (ST)

The Region of ST 1 and Region of ST 2 are already identified through calculation of the significance test (ref. Figure 4.5 and Table 4.7). In Figure 4.8 Region ST 1 is represented by the yellow column and Region ST 2, by the green column. Built on the criteria established in the Methodology in searching for celestial objects, the result confirms that there are two stars in the sky that fit into these regions:

- Region ST 1 (-50.2 to -48.4): Avior with declination -49.0 at 3,250 BCE.

- Region ST 2 (-32.3 to -29.2: Gacrux with declination -30.6 at 3,250 BCE.

Beside the Southern Major Lunar Extreme with a declination of -29.2 being slightly attached to the Region of ST 2 with a black line, no other lunar or solar events fit into this patterning.

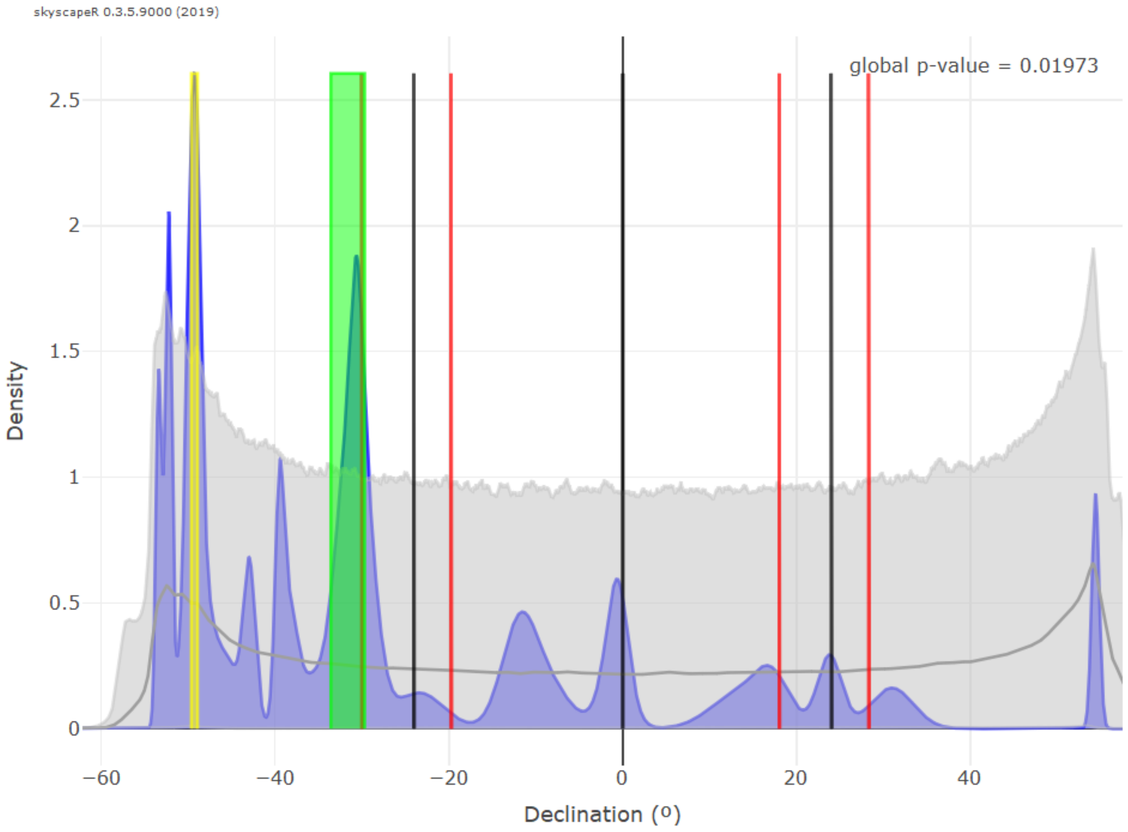


Figure 4.8. Celestial Targets, Significant Test.
The yellow column shows Region ST 1 and where Avior is positioned in the sky. Region ST 2 is represented by the green column where Gacrux is positioned in the sky. The black line which is attached to Region ST 2, indicates the southern major lunar extreme. In the following order from left to right, the other lines represent the winter solstice, the southern minor lunar extreme, the equinox (dec. 0°), the northern minor lunar extreme, the summer solstice, and the last one the northern major lunar extreme. Beside the southern major lunar extreme, no other lunar or solar events fall in any pattern of this study.

4.5 Discussion

This section offers a discussion and interpretation of the findings presented in the Result section. It shall analyse the wider debate concerning the Maltese Prehistoric Temples' orientations and alignments to celestial bodies and specifically the new results of the skyscape events that have been obtained by applying the concept of temple entrance frame. It shall further discuss to what extent skyscape events may have influenced the Temple Period’s culture and cosmology in combination with viewscape.

4.5.1 Relationship to previous Maltese Temple Period studies

As referenced in the Section Literature Review, the prehistoric Maltese temples have been subject to a variety of research and interest from both scholars and enthusiasts when it comes to their orientation and alignments towards celestial events. Most of these publications have been valid contributions in shedding light on the concept of celestial involvement in Maltese prehistoric temples. However, they have mainly been concerned with the Sun’s movements through a calendric year. The questions of the Moon, stars, star groups, and constellations have largely been left untouched, except for the work of a few more astronomy-oriented scholars such as Agius and Ventura (1980, 1981), Ventura *et al.* (1993), Ventura (2004), Cox (2001), Cox and Lomsdalen (2010), Lomsdalen (2014a), Ventura and Agius (2017), and Agius *et al*. (2021).

From the early 1980s Agius and Ventura (1980, 1981) were the first to present results of statistical patterning of celestial objects in relation to central axis of the Maltese prehistoric temples. Their research was further followed up in the early 1990s (Foderà Serio *et al.* 1992, Ventura *et al.* 1993) and in the publication Malta before History (Ventura 2004: 307-326). Ventura (2004: 307-326) presented here an extensive visualisation based on his and the collaborators’ research programs on temple orientations, and statistical testing on how the so-called *tally stone* at Mnajdra could illustrate a sequence of stars and star groups rising based on the total of depicted markings in each row in the stone. Ventura *et al.* (1993: 179-181) list in Table 1 with dates of heliacal rising of stars, limited to magnitude 6.0 or higher, seen from the latitude of Malta. Their Table 2 shows a proposed sequence of heliacal rising of stars marked on the tally stone at Mnajdra. They further claim that the heliacal rising of the Pleiades at equinox could have been an astronomical motivation for Mnajdra South’s orientation, and not necessarily the equinox sunrise as generally suggested (Ventura *et al.* 1993: 176). Ventura *et al.* (1993: 179) also mention Gacrux as a star that can be seen in the southern sky from Malta, but not restricted to a certain temple site. Fodera Serio *et al.* (1992: 118) suggest that the temples were intended to face the brightest stars in Southern Centaurus, and state that they '…would be well above the horizon when they transited the axis of the temples'. A revised statistical based research of the Mnajdra tally stone (Agius *et al.* 2021) from Ventura *et al*. (1993) original study, reveals a support to that the drilled tally holes are not randomly placed which does imply that series of subsequent periodical heliacal risings of bright stars were significant.

The earliest innovative research on stellar alignments was done by Agius and Ventura (1981) identifying that six temples had their central axis corresponding to star alignments with a mean declination of -49.7° with a standard deviation of only 0.54°. This result is highly similar to the independent result obtained in this study with Pattern 1 of -49.28° to -48.65°, corresponding to the star alignment with Avior. In their 1981 paper, Agius and Ventura did not identify any celestial targets corresponding to their declination. It is only now, nearly 40 years later, that the potential celestial target star of Avior has been identified.

Another significant comparison between Agius and Ventura (1981: 17) and this present study is that they list the same six temples as in this study (except Xrobb l-Għaġin and Xemxija) belonging to Pattern 2 (-32.03° to -29.82°), with an average declination in axes of -31.3°, which corresponds to Gacrux with a declination of -31.52°. Agius and Ventura did not mention the star Gacrux by name, but nevertheless state that this axis 'corresponds to the declination of the brightest star of the constellation Crux'. These revelations of star arrangements in the southern sky by Agius and Ventura back in the 1980s and the results from this study 40 years later where different research methods have been applied, do bring forth a certain validity of both studies and above all, a credibility that both Gacrux and Avior could have been two highly significant stars for the temple builders.

According to Stellarium, the brightest star in the constellation of the Southern Cross is Acrux with a declination in 3,000 BCE of -37.9° (Ridpath 2019, Zotti and Wolf 2019), meaning that the brightest star in Crux which is Acrux could not fall into Agius and Ventura's proposed span, being from -29.4° to -33.5°. On the other hand, this span does fit very well the result presented in this study for Pattern 2 which would fit the second brightest star in the constellation of the Southern Cross, namely Gacrux (Ridpath 2019). In a personal communication with Ventura (2019), it was suggested that the mistake of identifying Acrux instead of Gacrux could be due to the manual use of a star catalogue dated 1967 (Hawkins and Rosenthal 1967).

In the first decade of the 21st century, Cox (2001, 2009) also published papers on how the various temples' orientations were correlated to the passage of the Sun, Moon, and stars. Cox (2001: 32 Fig. 9, 33, Fig. 10) presents a schematic representation of the path of various stars of the temples facing southward orientation. These figures show the Sun, the Moon and bright southern stars, and where they would rise and set at epoch -3.000 in azimuths in relation to the south-facing temples. Cox's (2001: 32-33) results are based on the criterion that the celestial objects could be seen from the far back of a temple and what he describes as a 'strict approach'. The strict approach is only applied to what Cox (2001: 32-33) concludes as 'the only three primary structures, Ġgantija N, Skorba W, and Mnjadra NW, that can be drawn into a Centaurus hypothesis'.

Cox (2001: 32, Fig. 9) also lists Gacrux and the schematic illustration indicates that it rose in azimuths at about 130°, has its maximum height at about altitude + 20° and sets close to 230°. The corresponding results from this research are: 130.2°, +22.5° and 229.9°, which broadly agree with the ones from Cox. Cox (2001: 33) suggests that the bright star Fomalhaut could be an potential candidate as it was visible in the southern sky about midnight in the middle of June during the Temple Period. Cox's suggestion is highly valid and Fomalhaut had an azimuth of 180° with a max altitude of +10° at that time, but having a declination of -44° excludes it from becoming a candidate for the temple frame concept of this study.

On the other hand, there are no indications that Cox actually has used an entrance frame concept, contrary to what this reserach has done, as the dimensions of the temple window frame are missing. Furthermore, both Ġgantija North and Skorba West, which Cox refers to in a 'Centaurus hypothesis', do fall inside Region of ML 2 and Region of ST 2 (ref. Table 4.5 page 247 and Table 4.7 page 250). Contrary to what Cox lists, that also

Mnajdra NW (Central) belongs to a '…Centaurus hypothesis '… does not correspond to Region of ML 2 and Region of ST 2 of this study. The results of this study are also based on an extremely low p-value and a high significance level as explained in the Result section. They show that actually a total of six temples aligned to Gacrux's rising, on the apparent horizon, consequently are part of what Cox names as a 'Centaurus hypothesis'. Cox seems to use azimuths for celestial alignments, while this research uses declinations. Cox (2001: 33) includes Avior (ε Carina) and Peacock (α Pavonis) as far-southern candidates for Tarxien East, Ta' Ħaġrat East, Haġar Qim North, and Buġibba, but excludes them as astronomical targets as they were so low-lying and inconspicuous due to atmospheric extinction. Cox does not apply any statistical testing to the results, but his research has been both an inspiration and a validity for this study program.

Actually, few other studies on temple orientation if any, except Agius and Ventura (1980, 1981), present results based on statistical testing. Agius and Venture also made an explanatory chi-square test of the distribution of temple orientations in azimuths, indicating that the alignments were not done by chance. The results from Agius and Ventura and their collaborators and the ones from Cox are highly significant in their own context and compelling for comparison with the results obtained here. However, there is a difference in approaches and results. The present research program is more specific in the sense that it concerns only what celestial objects a person in prehistory could possibly see through the entrance window frame standing at the centre of the very back of the temple. Ventura and collaborators and Cox's results are based on the central temple axis and shows a more general perception of star involvements seen from a named temple site. To be more precise, Ventura (2004: 232-234) bases his observations from the Mnajdra Temple compound, but also measured the central axes both in azimuths and declinations from all extant temples (Agius and Ventura 1980, 1981, Foderà Serio *et al.* 1992).

4.5.2 Temple phases

Evans (1971: 34) argues that dating Maltese megalithic monuments can be very challenging as they are sometimes built on older sites and have a continuous use through the various phases of Maltese prehistory. According to Grima (2008: 47): 'The dating of all these structures is at times controversial, and rarely conclusive'. Grima's statement is based on that the temples appear not to follow a specific plan and were not instantaneously completed, but were extended, modified and altered over a long time period. When it comes to the constructional time period of the Mnajdra Temple complex, Lomsdalen (2013a) proposes that it could have taken around a millennium to fully complete the site. Some of the early excavations were not carried out with the same precise methodology that is now standard practice in modern archaeology. This of course creates a certain uncertainty when it comes to date a site and especially the various buildings within the totality of a temple complex.

As mentioned in Chapter 1 the timeline for this study is based on the chronology established by the *FRAGSUS Project* (McLaughlin *et al.* 2020a), and the two core phases, Ġgantija and Tarxien, which all the temples applied in this study are a part of. That said, there is also a third phase, the Uncertain Phase where two temples are listed. The reason behind the Uncertain Phase is that it was not possible to establish based on the archaeological record, if they belonged specifically to the Ġgantija or the Tarxien Phase, however all archaeological indications show that they do belong to one of these two phases (see Table 4.1 page 228). Trump (1997: 21) makes a distinction in temple architecture between Ġgantija and Tarxien Phases, as the Ġgantija Phase shows a great variety and originality in temple architecture while in the Tarxien Phase the temples constructed along the older lines stop, and now follows a more standardised pattern and form.

Trump (1972: 21) suggests that it is conceivable that there may have been a change in the Maltese prehistoric society's worldview and belief systems between these two phases. The changes could also have influenced the temple builders' cosmological approach to the celestial sphere as this study suggests. Specific celestial interest and events could have been more significant during one phase that influenced the builders to orient the temples the way they did. Such a theory is sustained by Agius and Ventura (1980: 8, 1981: 14) underlining and graphically illustrating that Ġgantija Phase temples mainly have a south-east orientation and the temples from the Tarxien Phase have a south-west orientation.

Cox (2001: 28) also suggests that temples of the Ġgantija Phase were commonly directed towards the south-east, while the ones from the Tarxien Phase had a south-west orientation.

The chronology of the Maltese temples can only be based on the archaeological record and not on astronomy or archaeoastronomy. It is essential to bear in mind that orientation of structures is an element of the archaeological record, regardless of any alignments. When it comes to Temple Phases, the most important findings and results from this study is not skyscape related, but more about the presence of statistically significant patterning in orientation which occurs only in the Ġgantija Phase, and not in the Tarxien Phase (ref. Table 4.5 page 247). These findings stand independently of any astronomical interpretation, though skyscape is integral to the interpretation and discussion presented here regarding the star patterning in Ġgantija vs. Tarxien Phase (ref. Table 4.11 page 279). The presence of statistically different ways of orienting structures in the two phases is based on the archaeological record. In analysing and discussing which entrance frames of the temples fall under which pattern and Temple Phase will be results of a significance test. This test cannot replace the archaeological debate on chronology, but hopefully may shed light on some new aspects to it. This will be a central part of the following discussion in this section.

4.5.3 Intentionality

This section shall discuss a potential explanation for the results of the patterning in orientation of entrance frames. Though the results listed in 4.4.4 page 252 are indisputably statistically significant, nevertheless other targets than celestial bodies should also be considered as possible explanations of the rationale why the builders oriented the entrance frames the way they did. The reasoning for temple orientation by their builders may not necessarily be related to celestial bodies alone or at all for that sake of the matter. Therefore, other hypothetical non-sky objects ought also to be considered and evaluated as a plausible cause for temple orientations as; bird migrating, terrain and topological considerations, wind, weather and climate, and temple orientations and geographical knowledge, as further explained down-below.

Bird migration

According to Sultana and Borg (2015: 313-314) Pleistocene deposits in the Maltese Archipelago were primarily found inside caves, rich of palaeontological bones from various animals including avian species. Excavations during the first half of the 20th century in the quaternary Pleistocene Għar Dalam cave discovered 31 different avian species (Sultana and Borg 2015: 316-320). Maltese Temple Period representation of birds appear on various artefacts including pottery, figurines, a terracotta model, pendants, personal ornaments, and engravings on limestone blocks. Bird bones have also been retrieved from archaeological sites indicating prehistoric use of birds (Fenech 2010: 3-4, Zammit Maempel 2001: 24-25). One of the most illustrative representations of bird a flying was found at Ġgantija Temples on a pottery shard (Fenech 2010: 3, Trump 2019: 50-51). Zammit Maempel (2001: 35-36) suggests that based on high number of avian illustrations found in archaeological sites it could be presumed that bird representation could have a symbolic significance for the Temple Period society as an artistic decorative purpose, serving as a votive offering, but also for personal ornamentation used as protective amulets or talismans. In other words, a cosmological significance for the Temple Period society. Evans (1959: 157) likewise maintains that there are representations of birds and that bird-bones have also been retrieved in the temples.

Trump (2010: 6) suggests that the present-day resident bird population is not rich in Malta, however bird migration is widely augmented during spring and autumn with birds passing through on their migration routes between Africa and Europe. Though Malta is a natural staging post for bird seasonal migration between Africa and Europe, Fenech (2010: 143-146) maintains that there is no evidences that the Maltese islands receive more than a representative cross-section of the totality of around the 5,000 million birds in a migration pattern between Africa and Europe. The number of bird ringing in Malta is conditioned by fine weather and convenient wind directions. The spring migration has a south-westerly route via Tunisia or more southernly as from Libya and Central Africa, while the autumn migrant birds originates mainly form countries in north-east and eastern Europe (Fenech 2010: 143).

Though birds in general and regular seasonal migration patterns to and from Africa and Europe could have been an important element in Temple Period society, this is largely untestable since, on the one hand, present-day migration patterns may be dramatically different from those of the Temple Period due to changing climate as well as because of hunting. On the other hand, it is rather far-fetched to suggest that the builders would be able to follow birds' migration patterns on the apparent horizon or in the sky as being a constant target for temple orientation. It is not clear to what extent birds were a part of a nutritional program, or used as symbolic or stylish representations, however as Zammit Maempe (2001: 37) concludes, birds could have been a significant ingredient in the Temple Period's culture.

Terrain and topological considerations

According to Grima (2005: 191) to have a better understanding of temple orientations, it is important to take into consideration the topography of the landscape where they are built. Grima (2004: 337-243, 2005: 191-192) suggests that there is no eminence to place temple sites on higher or lower ground or on steeper or shallower slopes. When it comes to the third topographical variable aspect (direction faced by a slope on the ground), both Malta and Gozo have a patterning of temple locations facing south emerging strongly with a secondary preference for locations facing west (Grima 2004: 340).

As Grima (2004: 341, 2005: 191) concludes, aspect alone does not explain the reasoning behind temple locations, and to search for further reasons one needs to look into the wider landscape, but there is no particular patterning showing preference in locating sites with visual connection to the sea. Another apparent pattern is that the temple entrances are aligned with the aspect, facing southward and downhill. Whether this orientation was influenced by the Sun's path through the southerly hemisphere, remains an open question. The archaeological record shows that some sites have been used as settlements prior to becoming a temple site (McLaughlin *et al.* 2020b, Trump 1966a). According to Grima (2005: 191), in these cases the prehistoric community chose dwelling location on slopes with preference to exposure to the Sun and shelter from the prevailing northerly winds. This factor of light and shelter is then an element the temple builder could have taken into consideration in locating and orienting their structures. Light and shelter are plausible considerations in the layout of any building. According to Turnbull (2002: 132) the southern orientation is due to that the builder wanted to maximise the sunlight entering the temples.

Wind, weather, and climate

The wind, weather, and climate in Malta are conditioned by the southerly continental tropical dry, warm air mases from Africa in the summer and the northern dry and cold continental polar air masses lowering the temperature and increasing autumn and winter rainfall (Schembri 2019: 11). Dominant winds arrive from the north-west and the west and facing the coast with high energy winds during the winter season, with waves reaching up to 7 m in height (Zammit Pace *et al.* 2019: 213-214). The northeast shores of the Maltese archipelago due to extreme wind conditions have not only been struck by storm waves, but also tsunami waves arriving from northeast direction (Mottershead *et al.* 2019: 273, 283-285). According to Gambin *et al.* (2016: 276) the most frequent wind direction is from north-east, while Marriner *et al.* (2012: 2) suggest that the predominant wind comes from west-north-west and severe winter storms from north-east.

Protection from the harsh northern wind direction was a reasoning for building the temples in the landscape aspect towards a southern orientation is a possibility that should not be disregard. The Maltese corbelled stone huts, the *Girna*, used for protection and as a resting area for farmers working in the fields had mainly a southeast or south oriented door entrance (Fsadni 1999). Even if the girna and the prehistoric temples are conceptually not comparable in structure, usage or chronology, it can be argued that the fundamental idea of protection from harsh northern winds and shelter in an open landscape environment could have been a plausible cause why the builders chose a southernly orientation of their temple entrances.

Temple orientations and geographical knowledge

The fact that façade and temple entrance orientations predominantly face geographically southeast or southwest has been discussed in Sections 1.2.1 and 1.5.1. An alternative hypothesis has been put forward by Stoddart *et al.* (1993) reversing the line of sight of astronomical phenomena form inside the temples, to the direction faced from the outside to the inside of the temples during congregational gatherings in the outside temple forecourt. This proposal is based on that even though the majority of the temples are facing a south-east orientation, the opposite hemispheric direction would be north-west towards Sicily, Lipari, and Pantelleria, where the islanders have their ancestral origin and from where they imported exotic products (Stoddart *et al.* 1993: 16-17).

An intriguing aspect of argument of Stoddart *et al.*'s (1993) theories of temple orientations would be to take temple phases into consideration. Based on analysis done by Agius and Ventura (1980: 8, 1981: 14) and Cox (2001: 28) that the temples in Ġgantija Phase had a predominant southeast orientation while the one in Tarxien Phase a south-west one, could imply that the Ġgantija Phase society was more concerned with their ancestral roots than the later Tarxien people. Trump (2010: 9) suggests a cultural change between the two phases, as the Tarxien society lost the experimental spontaneity and imagination in both pottery making and architecture which was particular to the Ġgantija people. In the Tarxien Phase the temple builders followed the same repeatable standard form, though initiated a fresh artistic development generating figures from 2.75 meters high down to elaborate heads of less than a couple of centimetres, contemporary with an expanding priesthood society (Trump 1997: 21). An increase of a priestly class together with focus on artistic human representations even of anthropomorphic form, could indicate a Tarxien society developed a more human centred based cosmology. Regardless the reasoning behind the shift in temple orientation, Stoddard *et al.* (1993: 17) conclude that 'alternative interpretations of orientation, although geometrically opposed, are not necessarily mutually exclusive'.

Sun, Moon, and star observations

According to Kelley and Milone (2005: 71) pre-telescopic ancient observations of the Sun were used for time reckoning as a seasonal calendar for agriculture or linked to ritual purposes, while the Moon with its nightly illumination to facilitate traveling during the night, for tide warnings or religious celebrations, and the stars for navigations. The prehistoric seafarers used stars for navigation between Sicily and Malta has been suggested (Cox 2001, Lomsdalen 2013c). It is also documented that specific stars are observable in the southern sky from Malta and temple sites (Agius and Ventura 1981, Cox 2001).

In Malta the celestial body that has created the most interest, is the passage of the Sun between summer and winter sunrise along the apparent horizon. These regular extreme tuning points of the Sun's position would give ancient astronomers a convenient calendar (Malville 2008: 37). As explained in 4.2.1 page 216 and 4.5.7 page 293, the Sun in relation to temple sites have been extensively studied, but mostly in respect of sunlight illumination inside temples at sunrise, as well as a device to keep track of time. The Maltese archaeological record has only one artefact retrieved at Ħaġar Qim that has been suggested to represent the 'solar wheel' or a 'compass rose' (Ventura 2004: 312).

The Moon on the other hand has created less attraction for astronomical or archaeoastronomical studies in Malta probably due to more difficulties in following its faster and more irregular cyclical path when compared to the Sun. In one month the Moon makes the same cyclic movements as the Sun makes in a year, nevertheless enthusiasts in the study of lunar cycles tend to focus on the Moon's most extreme positions in the sky (Silva and Pimenta 2012, Sims 2016a). The Moon's extreme positions in the sky which happens every 18.6 years (the major lunar extreme) has been documented so far related to Maltese temples by Agius and Ventura (1980, 1981), Cox (2009) and Cox and Lomsdalen (2010). A fragment of a limestone retrieved at Tal-Qadi Temple has been suggested by Micallef (2001) to represent stars and the crescent Moon. However, how significant and illustrative this piece may be, it is difficult, if not unattainable at the present stage, to verify if this decorating actually has an astronomical representation.

Concluding remarks

All the areas mentioned here could to a more or less degree be a part of a hypothesis related to temple orientations. Bird migration and ancestral connections to Sicily seem to be the least plausible based on lack of empirical evidences. On a more general level, location of temples on southern slopes due to topographical and atmospheric conditions, do carry a statically significance when it comes to more a general geographical directional orientation of temples (Grima 2004: 338-341). As already exposed and explained on several occasions in this chapter, the Sun, Moon, and stars do seem to have a considerable importance to temple orientations, and one study also concludes statistically on south-east and south-west temple orientations (Agius and Ventura 1981: 13-14). Moon and star involvement related to temple orientations are more based on empirical observations.

The results of this study do carry an indisputable statistical significance based on two different but complementary calculations, the method of maximum likelihood and the significance test, as explained in the Result section. Based on the measurement of 32 temple entrance frames, both statistical tests show that the same 14 temple entrance frames do all fall inside one of four regions (Region ML 1 and 2, and Region ST 1 and2). Region of ML 1 and 2 are the specific areas with a patterning where there is a maximum likelihood to find a celestial target. The result of this finding is that Avior falls in Region ML 1 and Gacrux in Region ML 2. The span of Region ML 1 is less than one (0.8°) degree in declination and Region ML 2 is just over two (2.2°) degrees in declination as shown in Table 4.9 below). The equivalent for Region ST 1 is 1.8° and Region ST 2 with 3.1°. Region St 1 and 2 are statistical retrieved areas after 15,000 simulations, where also Avior and Gacrux happen to be located respectively.

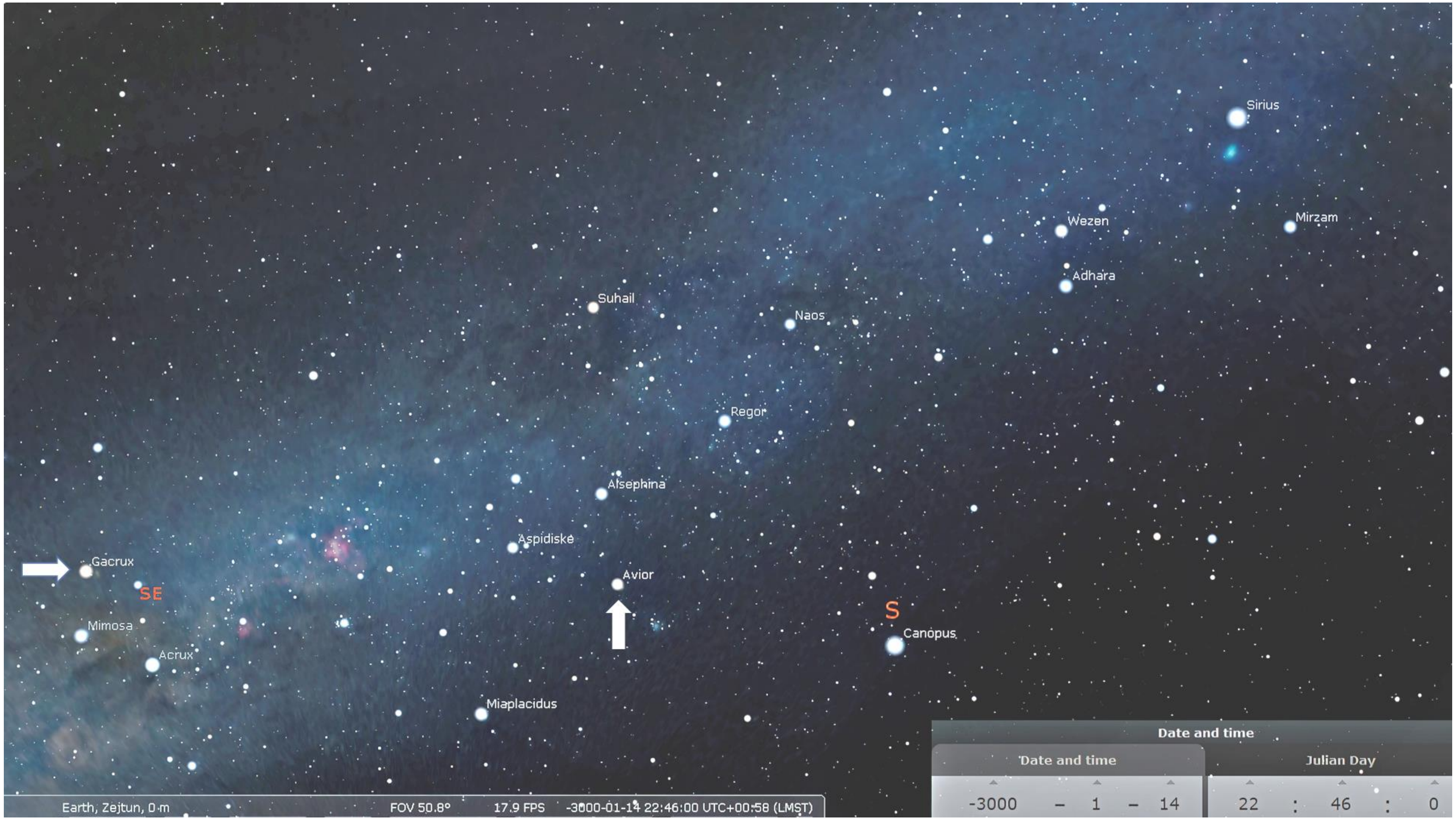
Based on the star search criteria (see Section 4.3.7 page 236) only stars with a visual magnitude less than +2 would be considered. That means that out of thousands of stars observable from Earth, no more than 50 stars would qualify (AstroPixcel 2020). Since only two stars, Avior and Gacrux, are possible targets falling inside the two identified statistical regions, it stands to reason that the orientation of these temple entrance is not due to chance or randomness. Based on the above argumentation of intentionality and considering the various possible targets or reasoning for an intentional temple orientation by the builders, we are left with one compelling explanation, namely Avior and Gacrux.

Region	Declination	Span
Region ML 1	-49.5 to -48.7	0.8
Region ML 2	-32.0 to -29.8	2.2
Region ST 1	-50.2 to -48.4	1.8
Region ST 2	-32.3 to -29.2	3.1

Table 4.9. Summary of region size.
This table shows a summary of the actual size of the regions in declinations based on the statistical calculations of Region ML 1, Region ML 2, Region ST 1, and Region ST 2 (ref. Table 4.5 page 247 and Table 4.7 page 250). The width for each region in declination is listed, as well as the difference in span for each of the regions.

4.5.4 Celestial targets

This section shall look at the two celestial objects, Avior and Gacrux, that appear to have been a target for Maltese Temple builders. The section shall also assess whether or not the two celestial objects would have any potential significance or meaning to the builders, and hence assess the possible intentionality of these alignments. Figure 4.9 from Stellarium shows Avior and Gacrux in the southern sky seen from Malta in 3,000 BCE where Gacrux is indicated with a horizonal white arrow on the left, visibly being a part of the Milky Way, and Avior with a vertical white arrow in the middle. Canopus and Sirius are also clearly visible in the southern night sky. Figure 4.10 also from Stellarium illustrates Gacrux and Avior in their respective constellations seen from Malta at 3,000 BCE. To the left in this figure, the Southern Cross is indicated in the constellation Centaurus placed in the southeaster part of the sky with Gacrux at the top of the cross. In the middle, the False Cross is seen residing in the constellations of Carina and Vela with Avior at the bottom of the cross. To the bottom right with an inserted arrow is Canopus, the brightest star in the constellation Carina, and positioned at the keel of Argo Navis, about due South. Sirius is indicated with a white arrow top right.



Earth, Zejtun, 0 m FOV 50.8° 17.9 FPS -3000-01-14 22:46:00 UTC+00:58 (LMST)

Date and time

Date and time: -3000 – 1 – 14

Julian Day: 22 : 46 : 0

Figure 4.9. Southern sky seen from Malta in 3,000 BCE.

Earth, Zejtun, 0 m FOV 50.8° 17.8 FPS -3000-01-14 22:46:00 UTC+00:58 (LMST)

Date and time

Date and time -3000 – 1 – 14

Julian Day 22 : 46 : 0

Figure 4.10. Gacrux and Avior in constellations 3,000 BCE.

Avior

The star Epsilon Carinae (ε Carinae, abbreviated Epsilon Car, ε Car) is officially named Avior and has an apparent magnitude of +1.86 and is listed among the 40 brightest stars in the sky (IAU 2016). Avior is the bottom star in an asterism named the ‘False Cross’ (Moore 2015: 185). The name False Cross has been given to it because in astronavigation it is easily mistaken from the Southern Cross, though it is larger and less brilliant than the Southern Cross. Its members are Delta Velorum, Kappa Velorum, Iota Carinae and ε Carinae, residing in the constellations of Carina and Vela, largely a part of the Milky Way.

The constellation Carina belonged until 1763 to a much larger Southern figure named Argo Navis (the Ship Cargo), but was then dived into three sections; Carina (the Keel), Puppis (the Stern), and Vela (the Sail). These three constellations takes up most of the space between Crux and Sirius (Allen 1963: 64, Moore 2015: 185), see Figure 4.10 above. According to Cornelius (1997: 58-59) and his concept of ‘Star lore’, Argo Navis was already in ancient times associated with the prototype of a great ship which ‘crosses the waters of the Deluge, as in the Biblical tale of Noah’s Ark’. Argo Navis is further related to how the gods choose to extinguish the Earth in the Babylonian Creation Epic, and in Greek mythology it was the ship of the hero Jason and his crew, the Argonauts, as described by Ptolemy in the 2nd century CE (Cornelius 1997: 58-59).

Ptolemy’s star catalogue was one of the most outstanding achievements in ancient astronomy, but giving proper names to individual stars was not very advanced in Ptolemy (Pedersen 1974: 249-251). Cornelius’ claim that ‘Argo Navis was first described by Ptolemy’ is not really in conformity with Ptolemy, as Ptolemy in Almagest does not mention ‘Argo Navis’ by name (Ptolemy 1952). More correctly is Pedersen’s (1974: 251) version that Ptolemy only identified the star Canopus (the second brightest star in the sky after Sirius), which today belongs to the constellation of Carina and is positioned at the keel of Argo Navis. Sirius was clearly visible in the southern sky from Malta during the Temple Period (Ventura 2004: 323), which it still is today. The statement of Pedersen is in accordance with the Almagest where Ptolemy (1952: 254-255) thoroughly describes the positions of various unnamed stars (expect Canopus as already mentioned) located on an unspecified skip in the Constellation of Argus (ref. Figure 4.10).

Gacrux

The star Gamma Crucis (γ Crucis, abbreviated Gamma Cru, γ Cru) officially named Gacrux, has an apparent magnitude of +1.6 and is listed among the 25 brightest stars in the sky (IAU 2016). Crux, commonly known as the Southern Cross, is one of the smallest constellations in the sky (see Figure 4.10). It is surrounded by the Centaurus and until 1679 was also considered as part of this constellation (Moore 2015: 182). Acrux (Alpha Crucis) is brightest and the most southerly member of the Southern Cross, pursued by four other dominant stars: Mimosa (Beta Crucis), Gacrux (Gamma Crucis), Imai (Delta Crucis), and Ginan (Epsilon Crucis), (Cornelius 1997: 72, Moore 2015: 182).

According to Cornelius (1997: 72-73), the name Gacrux was probably composed by the American cartographer Elijah Hinsdale Burritt around 1835 and is the top positioned star of the asterisms (a group of stars smaller than a constellation) Southern Cross making a striking cross-like figure pointing towards the South Pole. Allen (1963: 184-191) argues that the Southern Cross was not known to ancients by its present name, however it was noted by Ptolemy that it was a part of the constellation Centaurus. Authors around the world from classical to more modern times have described it in astronomical, poetic, and romantic literature. In contrast to both Cornelius and Allen on the origin of the name of the Southern Cross, Kanas (2012: 118-119) maintains that even though the ancient Greeks were aware of the stars in the Southern Cross, they included them in the legs of the constellation of Centaurus. It was the Italian navigator Andreas Corsali who gave a clear description of the stars as a separate constellation in the early 16th century. However, it was not until the Dutch Calvinist theologian Petrus Plancius (1552-1662) engaged the chief pilot and navigator Pieter Dirkszoon Keyer (1540-1596) to chart the southern skies on a trading expedition to East Indies in 1595 that the correct position of Crux was registered (Kanas 2012: 199).

The Southern Cross is positioned across the Milky Way and is a brilliant but narrow stream of stars, recognisable by its form with the upper star (Gacrux) clear orange in colour, and the others white, and as Allen (1963: 185-189) further suggests, its general effect is more like a badly made kite than a cross, though astronomers and sky watchers have for millennia engaged in discovering crosses also in other places of the sky. Allen (1963: 189) accredits Von Humboldt (1769-1859), a German scientist who refers to the two great stars in the Cross, the summit (Gacrux) and the foot (Acrux) having nearly same Right Ascension, and that it was a time piece that advanced regularly almost four minutes a day, whereupon Von Humboldt concludes that 'no other group of stars affords to the naked eye an observation of time so easily made'. Ptolemy (1952: 256257) describes the various stars in the Constellation of Centaurus without giving them a name and not without some uncertainty, the Southern Cross is identifiable without the 'Cross' itself being named. The star catalogue in the Almagest is based on what is today known as the classical Greek constellations and contains 1.022 stars arranged into 48 constellations with an assigned location of each star (usually without a name) within the respective constellation (Kanas 2012: 110, Ptolemy 2014).

According to Ruggles and Hoskin (1997: 18-19) in prehistoric times the Southern Cross was visible from the Mediterranean and could have been related to cult in the sanctuaries of Menorca contemporary to the Maltese Temple Period. It has also been suggested that the Southern Cross may have been a significant object for navigation by the stars, and contrary to the Pole Star in the north, the Southern Cross indicates a south direction (Kanas 2012: 117, Ruggles and Hoskin 1997: 19). The Italian navigator Cellarius (1660: 211) suggests that the Southern Cross was used by Spanish and Portuguese sailors for determining the position of the South Pole and described the Southern Cross to be 'so fair and beautiful that no other heavenly sign may be compared to it'.

In the context of Maltese seafaring and navigation, a question arises if the prehistoric seafarers also navigated the crossing from Sicily to Malta by the Southern Cross as Malta is geographically due south of Sicily. Cox (2001: 33) suggests that for navigation from Sicily to Malta during the summer period the bright southern star Fomalhaut, as Centaurus (Southern Cross) would not be an attractive candidate for summer navigation. Lomsdalen (2013c: 87-92) also analyses prehistoric non-instrumental navigations in the Central Mediterranean, also suggesting Fomalhaut to be a strong candidate, although making no mention of the Southern Cross. With the results now acquired about Gacrux and the Southern Cross, a plausible hypothesis of celestial navigation could be that the seafarers used Fomalhaut during the summer, as it was not visible during the winter, and the

Southern Cross during the winter, as it was not visible during the summer. As Malta is positioned South of Sicily, another candidate for prehistoric navigation from Sicily to Malta could be the second brightest star in the sky, Canopus, as it was basically positioned due South in the sky (ref. Figure 4.10). It should be noted that the period when Gacrux and Avior are visible includes the winter months, less favourable for open-water navigation. During late spring and early autumn, these stars may nevertheless have been used for navigation during long-distance journeys to or from the Maltese archipelago. They may also have been observed and celebrated for their symbolic associations with maritime travel and the outside world. Nevertheless, based on these new findings of celestial targets a possible future study of Maltese seafaring could be undertaken. Not only from Sicily to Malta, but also the seafaring from Malta to Sicily by star navigation after that period's northern circumpolar stars.

Zammit (1929b: 13) suggests the horizontal slab at the entrance to the Tarxien Temples to be a representation of the Southern Cross. Comparing the so-called Southern Cross slab at Tarxien to a NASA (2019) photography (see Figure 4.11) the similarities can be detected. However whether the temple builders had in mind to make a replica of the Southern Cross, remains an open question. Nevertheless, in light of the strong statistical significance, Gacrux has in temple entrance frame alignments, and it is difficult to imagine that the Southern Cross would have been completely irrelevant and completely ignored to the prehistoric temple builders and seafarers.

Figure 4.11. Tarxien megalith and NASA Southern Cross, comparison.
This figure compares a NASA photo of the Southern Cross (right) with the Tarxien Temple horizontal slab as suggested by Zammit. The photo from NASA also shows the very distinctible orange-redish colour of the top star in the the cross, which is Gacrux. Photo of Tarxien slab by Daniel Cilia.

Commonalities between the two stars

One of the possible reasons why the prehistoric Maltese temple builders showed interest in Avior and Gacrux could be based on certain similarities between them, such as:
- both stars are part of a cross shaped asterism, one is the top star, Gacrux, and the other the bottom one, Avior (see Figure 4.12).
- both stars are orange-red, a colour most stars do not have.
- they have similar seasonality (ref. Table 4.14 page 291 and Figure 4.16 page 291).

It is unlikely that they would be targeting two stars with that similarity by chance. In addition, the result shows by using two independent statistical tests, Method of Maximum Likelihood and Significance Test, that these two patterns, Pattern 1 and Pattern 2, are highly significant and not random (see Result section). The results of the tests give two patterns of orientation that are statistically significant pointing at the two stars in question, namely Avior and Gacrux.

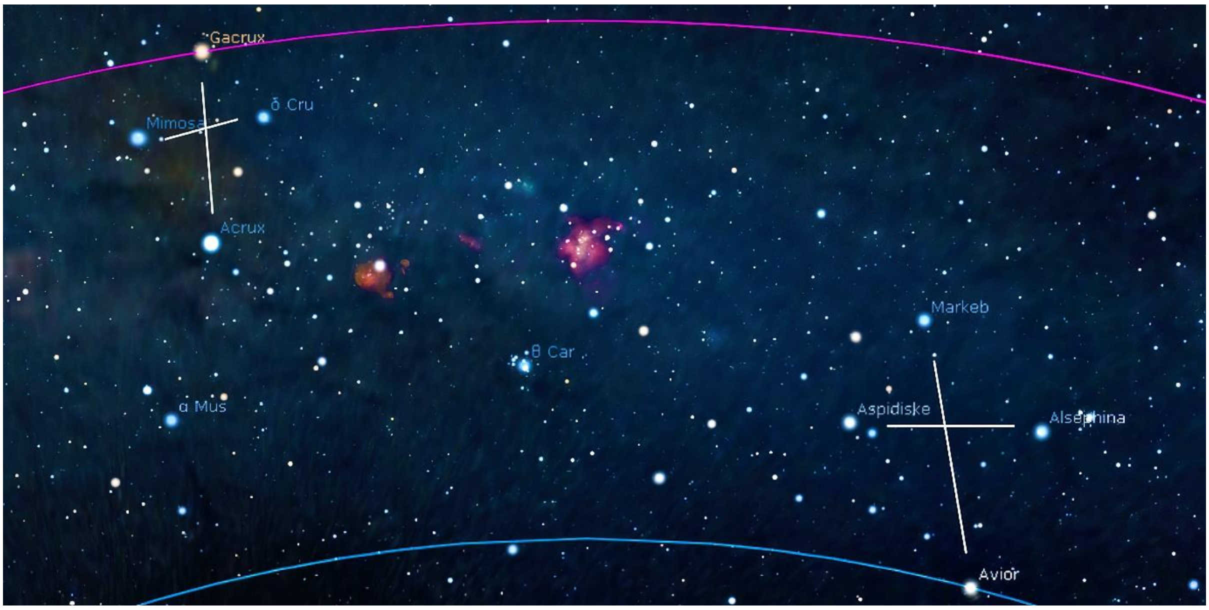


Figure 4.12. Gacrux and Avior as a cross-shaped asterism in the sky.
Gacrux is the top star in the Southern Cross (top left) and Avior is the bottom star in the False Cross (bottom right). The curved lines indicate the declination and the path through the southern sky of the respective stars. (Stellarium).

Visibility

Any discussion of stellar alignments must carefully consider the question of visibility. According to Schaefer (1986) who did visual fields surveys both in Chile and the US, the problem is that stars are not always visible close to the horizon because of an effect known as atmospheric extinction, which dims their brightness. The lower they are in the sky, the more difficult or impossible they are to observe. Under ideal conditions atmospheric extinction is about 0.16 magnitudes per airmass, and near the horizon the light of these stars will be passing through the equivalent of about 10 airmasses which means that their light will be dimmed by 1.6 magnitudes (Schaefer 1986). Based on Schaefer's (1986) equation, the result of stellar visibility of this study is shown in Table 4.10.

	Extincted Magnitudes			
	Avior		Gacrux	
	Dry Night (k = 0.20)	Humid Night (k = 0.30)	Dry Night (k = 0.20)	Humid Night (k = 0.30)
At 10º altitude	2.99	3.55	2.68	3.24
At 5º altiude	3.93	4.96	3.62	4.65
At 4º altiude	4.32	5.55	4.01	5.24
At 3º altitude	4.87	6.38	4.56	6.07
At 2º altiude	5.71	7.64	5.40	7.33
At 1º altitude	7.11	9.74	6.80	9.43
At 0º altitude	9.86	13.86	9.55	13.55

Table 4.10. Extinct Magnitudes.
For the extinction there are two columns for each star: one for a good night (dry) and one for a bad night (humid). The magnitudes below six are in red, meaning those stars are not likely to be seen at those altitudes. It's clear that both stars become visible at 2-3° of altitude, depending on atmospheric conditions.

A normal human eye can see down to about magnitude 6 in a dark sky (Kelly and Milone 2005: 56, Schaefer 1986: S33). Therefore, from Table 4.10 we can see that these two stars would be within the limits of naked eye visibility around 0° of altitude. However, by the time they reach an altitude of 3° they are well within the visible range and should be noticeable in the sky. For some temples, such as Skorba and Ta' Haġrat, the apparent horizon already provides the necessary elevation to ensure that the stars would be visible when they rise. In other cases, however, the horizons are low. Though, it is still possible that the stars and their alignments would be seen minutes later when the stars rise above 3° to become visible. Although it has been impossible to assess the height of all temple entrances due to missing stones, it is clear that in most, if not all cases, a significant portion of the sky would be visible from them. It is therefore likely that they would allow for these later alignments when the stars have climbed up a couple of degrees.

4.5.5 Chronological considerations

As already noted the chronological dating of the Temple Period is based on the *FRAGSUS Project* (McLaughlin *et al.* 2020a). In this section, more specific dating alternative sources may be applied, but these will still be inside the timelines established by the *FRAGSUS Project.* After this more general introduction of temple phases, celestial targets, and orientations, it is relevant to analyse closer the implications of temple phases and temples' geographical orientation of the two stars, Avior and Gacrux. This shall be considered in relation to the rising and setting positions of the two stars at 3,000 BCE which are as follows:

- Avior rises at an azimuth of 159° and setts on 201°.
- Gacrux rises at an azimuth of 130° and setts on 230°.

Temple phases with Avior and Gacrux rising and setting

The rising and setting paths of the two stars in azimuth manifest that they rise in the southeast and set in the southwest. This follows up on the suggestions made by Cox (2001: 28) and by Agius and Ventura (1980: 8, 1981: 14) about temple phases and orientations, which implied that temples with an alignment towards Avior and Gacrux rising should theoretically belong to the Ġgantija Phase, and the ones aligned to the setting should date from the Tarxien Phase. To bring this topic more closely into discussion, Table 4.11 shows which temples and phases each of the two stars would rise or set in relation to their patterning. The rising or setting sequence of Avior or Gacrux would consequently be observable from the back of their respective temples through the entrance frames. The rising and setting of Avior and Gacrux as well as to which temples they apply, and to which phase the respective temples belong shall now be discussed.

Table 4.12 shows the results from Table 4.11 illustrating the number of sites belonging to Avior and Gacrux rising and setting, with their respective Temple Phases.

AVIOR	Phase	Rising/ Setting		GACRUX	Rising/ Setting	Phase
Mnajdra East	Ġgantija	Setting		Ħaġar Qim East	Rising	Ġgantija
Ħaġar Qim Room 13	Ġgantija	Setting		Xrobb l-Għaġin	Rising	Ġgantija
Tarxien South	Tarxien	Setting		Tarxien Central	Setting	Tarxien
Tarxien East	Uncertain	Setting		Ta' Ħaġrat West	Rising	Ġgantija
Kordin III East	Ġgantija	Setting		Skorba West	Rising	Ġgantija
Ta' Ħaġrat East	Ġgantija	Setting		Ġgantija South	Rising	Ġgantija
Skorba East	Tarxien	Setting		Ġgantija North	Rising	Ġgantija

Table 4.11. Avior and Gacrux rising and setting.
This table shows which temples and phases each of the two stars would rise or set in relation to their patterns.

	AVIOR		GACRUX		
Phases	Rising	Setting	Rising	Setting	Sum
Ġgantija	0	4	6	0	10
Tarxien	0	2	0	1	3
Uncertain	0	1	0	0	1
Sum	0	7	6	1	14

Table 4.12. Avior and Gacrux rising and setting quantified.
The table indicates the total numbers of temple sites aligned to Avior and Gacrux rising or setting with their respective Temple Phases. The asymmetry here is that out of seven sights aligned to Gacrux, six are aligned to Gacrux rising in Ġgantija Phase rising, and one to Gacrux setting which is dated to Tarxien Phase.

As seen in Table 4.11, Avior is setting in all temple entrance frames, without exceptions. When it comes to phases of the Avior pattern, out of a total of seven temples four of them belongs to the Ġgantija Phase, two to the Tarxien Phase, and one to the Uncertain Phase. A similar analysis of the Gacrux pattern shows that out of seven sites, six have Gacrux rising and one setting. All the temples that have Gacrux rising belong to the Ġgantija Phase, except the one setting that belongs to the Tarxien Phase. The analysis of the totality of this exercise shows that the temple builders probably considered Avior more meaningful as a setting star, while Gacrux was more influential as a rising star. Avior always sets during the dark nights, while Gacrux being so high in the sky, could also set after sunrise and obviously no longer visible. The question of extinction and refraction may also have been an aspect, as Avior was relatively low in the sky and could be inconspicuous at certain times. However as already discussed in the sub-section *Visibility*, it is difficult to estimate to what extent this would influence the visibility of risings and settings of the stars.

Another reason for this phenomenon of the rising patterning of Gacrux could also be influenced by the fact that the entrance frames in question are also aligned towards the southern major lunar extreme (ref. Figure 4.7 page 254). Even though the southern major lunar extreme happens only every 18.6 years, it has been a paramount event in many ancient societies connected to a generational social memory of celestial observation (Aveni 1997: 33, Malville 2008: 38-42, Ruggels 2005: 272-274, Ruggles 1999: 36-37, Sims 2016b, Thom 1971). In Malta so far, Agius and Ventura (1980, 1981), Cox (2009) and Cox and Lomsdalen (2010) have looked into temple alignments towards the southern major lunar extreme. The next time this celestial event shall become observable from Malta will be in the years 2023 to 2025, an event to be considered for a potential future research program.

Reflecting the temple phases in relation to rising or setting of the two stars, the following patterning emerges (ref. Table 4.11):
The Ġgantija Phase has six temples aligned to rising and four to setting, while the Tarxien Phase has three setting and Uncertain Phase has one setting. Based on these 14 temples, this patterning seems to confirm the arguments of Cox (2001: 28) and Agius and Ventura (1980: 8, 1981: 14) that the Ġgantija Phase temples mainly have a southeast orientation while the temples from the Tarxien Phase have a south-west orientation.

To confront this suggestion with the archaeological record, Tarxien Temples are as a temple complex listed to Tarxien Phase, except Tarxien Far East which is dated to Ġgantija Phase (Pace 2004a: 64, Trump 1966b: 47). According to Trump (1966b: 47) Tarxien East and Tarxien South are from an early Tarxien Phase, a time dating that Trump calls Saflieni Phase an intermediate phase between Ġgantija and Tarxien phases, and Tarxien Central from Tarxien Phase. Tarxien Central was then constructed between Tarxien East and Tarxien South in the Tarxien Phase (Pace 2004a: 64). The reasoning behind listing Tarxien East to Uncertain Phase is built on the fact that Evans (1971: 88-90) brings in uncertainty whether this part belongs to Ġgantija or Tarxien Phase.

Temple phases and stellar patterning

The next patterning to discuss will be the distribution of which temples with their respective phases are aligned to Avior and Gacrux. Again, based on the method of maximum likelihood (see Table 4.5 page 247) and not considering the rising or setting of the stars but only the phases, the following patterns emerges:

Avior in Region ML 1 is aligned with four sites belonging to the Ġgantija Phase, two in Tarxien and one in Uncertain Phase. Gacrux in Region of ML 2 is aligned with six sites in Ġgantija one in Tarxien Phase. Based on the significance test (see Table 4.7page 250) the same patterning emerges as in the method of maximum likelihood. From a statistical methodological point of view, having the exact same result using two completely different statistical methods, does underline the validity of the obtained results.

As ten out of 14 sites are oriented either to Avior or Gacrux in Ġgantija Phase, it seems the temple builders were more interested in star alignments in Ġgantija Phase and less so in Tarxien Phase. This argument is also statistically confirmed, which proves that these two orientations are not done by chance (ref. Result section). If the temple builders had selected celestial alignments completely randomly or just by chance, they could get any star in the sky. However, that does not seem to be the case. The significance test clearly shows that it is highly probable they selected orientations that pointed at these two stars with certain similarities. This patterning does suggest intentionality. Another aspect to consider is that the margins of Region ML 1 and 2, and Region of ST 1 and 2 go from minimum 0.7 to maximum 3.1 degrees in declination, also underlining the extremely narrow visual field of skyscape observations.

Further than that, although several stars do have striking colours, most are not orange-reddish, neither do they appear in cross-shaped asterisms recognisable by several cultures worldwide, and in addition not many stars, if any, have a similar pattern of seasonality during the Maltese Temple Period. Another aspect to consider is that none of the statistical patterning (see 4.4.4 page 252) matches any solar targets. This again could indicate that for the Ġgantija Phase, the temple builders' orientation to the stars at night was more important than the Sun at daytime (the Sun is actually the only star a human eye can see at full daylight). Another element that emphasises the night observations of the sky is, as mentioned above, that Region of ML 2 and Region of ST 2 (ref. Table 4.5 page 247 and Table 4.7 page 250) do have a lunar alignment to southern major lunar extreme. As the orientation to this lunar event has the same statistical significance as Gacrux, but based on its 18.6 years cycle, it is probably more likely that the star Gacrux would be the temple builders' primary celestial target, and that the lunar event with similarities in declination happened to become an additional supplement for skyscape observations. However, taking generational and social memory into account, it cannot be excluded that both celestial events could have influenced this specific alignment.

A different factor to consider is not only the visibility of Avior and Gacrux from Malta during the Temple Period which they both had, but also whether they would be visible inside the temple entrance frame. Table 4.13 below illustrates which time frame Gacrux would be and not be visible. Gacrux would be visible inside both entrance frames during the whole Ġgantija Phase, but would start to lose visibility in late Saflieni and early Tarxien Phase from about 2,900 BCE onwards. To build an argument on more Ġgantija interest in stars than in Tarxien Phase, due to the disappearance of Gacrux, is not really valid, even though the statistics do sustain such an argument. The core of the matter is that temple people society would most likely not know *a priori* when Gacrux would become inconspicuous, though by generational observations over time, they could observe it moving slowly but surely out of a temple entrance frame alignment. As Gacrux ceased to be an interesting candidate for stellar alignments, one possibility could be that the Tarxien temple people became more solar than star concerned. Left with only Avior as a celestial target candidate in the Tarxien Phase, could cause the Temple society gradually looking for other substitutes than the rising and setting of stars for keeping track of time. The regular movements of the Sun disk on the apparent horizon could become a more 'familiar' candidate.

Year BCE	Gacrux Dec.	Region ML 2 Dec. -32.0 to -29.8	Region ST 2 Dec.-32.3 to -29.2
3,600	-29.3	Visible	Visible
3,000	-31.5	Visible	Visible
2,900	-31.9	Visible	Visible
2,800	-32.3	Not visible	Visible
2,750	-32.5	Not visible	Not visible
2,500	-33.6	Not visible	Not visible

Table 4.13. Gacrux Temple Period declinations.
The table indicates which years BCE Gacrux would have been aligned to the entrance frames of Region ML 2 and ST 2. Up to 2,900 BCE Gacrux would be visible, but from 2,800 BCE Gacrux would be borderline visible from Region ST 2.

A related question to consider here, though highly difficult to find an answer to, may be if the seeming shift in interest of celestial observations was caused by a cosmological change in the Temple Period society from one phase to the other. One argument, as previously touched upon earlier, could be that the movements of the Sun throughout a solar year became more influential in the Tarxien Phase than movements of the stars. This could be based on shift in belief systems, worldviews, cosmology, or a more practical implementation of using the Sun as a device to keep track of time through the year as would be more reliable than heliacal rising and settings of star observations.

An alternative explanation to this change could be that rather than that the temple builders lost interest in stars; their needs of aligning temples to the stars was already met by the existing structures inherited from the Ġgantija Phase. The builders were now doing other things with their buildings and alignments with other priorities, without losing interest in those phenomena related to those stars and their rising and setting. These practises could well have continued in Tarxien Phase using the infrastructure inherited from centuries before. Here again a change in temple orientations from southeast to southwest could be a potential driving factor (Cox 2001, Foderà Serio *et al.* 1992). The settings of celestial bodies which happen in the western sector of the globe, could become more useful or compelling than their risings in the east. If this would have been a plausible cause, this could indicate a cosmological shift from Ġgantija Phase to Tarxien Phase.

It is also suggested that due to the fact that the Sun rises in the east it is symbolically connected to life and the beginning of a life cycle, while the west relates to death and ending the life cycle (Campion 2008: 5, Eliade 1959: 157). The two main mass burials Hypogea in Malta, Xagħra Circle and Ħal Saflieni, are also dated to Tarxien Phase (Malone *et al.* 2009, Pace 2004c). Malone and Stoddart (2009: 376) bring the burials into a cosmological level through cycles of life and celestial alignments. In this case, Malone and Stoddart do not specify which sky targets are in the celestial alignments, but they may assume the target was the Sun and not stars. The Ġgantija Phase does carry more evidence of smaller individualised burial sites as rock-cut tombs (Grima and Farrugia 2019, Trump 2002: 162-163).

To sum up the above-mentioned scenarios, a hypothetical consideration for the change in temple orientations from southeast to southwest could be an increased focus on celestial bodies setting in the west (end of life) than to the rising in the east (beginning of life). A plausible reason for this could be a change in the islanders' cosmology. Contrary to the Ġgantija Phase, the Tarxien Phase seems to have a more aimed sustainable relationship to the dead. The Tarxien society initiated mass burials in hypogea with figurines, statues, ornaments, decorations in sophisticated underground temple structures indicating a ritualised belief system from the living to the dead and afterlife. A plausible cause for these changes could be that the start of the Tarxien Phase saw the initiation of a more holistic worldview, whereas the Ġgantija Phase had a cosmology more centred around the living and life sustainability. The Tarxien Phase developed a new sophisticated and refined temple structure than the more rudimentary Ġgantija Phase, where Evans (1971: 116) maintains that 'The Tarxien temples are the most elaborate group of megalithic remains on the Maltese islands, both architecturally and in their internal decorations'.

Temple phases and temple layout

An illustrative view of temple layout and the window frame orientations is presented in Figure 4.13 with each of the relevant sites and apses with their indicative orientations.

Another aspect of a possible patterning of Avior and Gacrux visibility is not only to consider the temple's entrance frame itself which has been quantitively manifested (see Result section), but also if the physical layout of the totality of a temple complex have been influenced by alignments to Avior or Gacrux. Some of the temples like Tarxien Temples and Ħaġar Qim have attached several apses or integrated temples into the totality of one temple complex. To analyse this aspect and try to bring some clarification why some temples or temples' apses were aligned to Gacrux and others towards Avior, may shed some new light and thoughts on why a temple entrance or an apse had an alignment to one particular star and not to the other. In other words, could a chronological or an architectural evaluation from the builder's side help explain why one part of a temple complex falls within an Avior or a Gacrux pattern?

By considering again Table 4.11, patterns seems to emerge with temple complexes having other temples' entrances or apses inside the main structure, like Tarxien and Ħaġar Qim, or temples with separate but more secondary structures within the temple compounds, like Ta' Ħaġrat and Skorba. A likely pattern here seems to be that the majority of temples or apses inside the totality of a complex are aligned to Avior and its setting, while the main structures seem to be aligned with Gacrux and its rising. This patterning seems to be consistent when it comes to single temple sites with a single unit or a secondary temple added to the main structure like Ta' Ħaġrat West, Skorba West, Ġgantija South, and Ġgantija North, having an alignment to Gacrux and Gacrux rising. Incidentally, all of these belong to the Ġgantija Phase.

The pattern of the secondary or smaller temple in the temple complex as Mnajdra East, Kordin III East, Ta' Ħaġrat East and Skorba East also shows a consistent pattern with an alignment to Avior and Avior setting, but there is a difference in temple phases. Regarding Skorba East it is clearly dated to Tarxien Phase (Trump 1966a: 47). When it comes to Ta' Ħaġrat East the chronology seems to be less straight forward and clear. Trump (1966a: 18, 47) claims the dating of Ta' Ħaġrat East to be more complicated than dating the west temple, and seems to move from late Ġgantija to Saflieni and early Tarxien Phase. Evans (1971: 34) also admits that there is not really a satisfactory explanation to the exact dating of Ta' Ħaġrat East, and suggests that a thorough investigation of all deposits left intact at

Ta’ Ħaġrat could help to a better understanding of its chronology. Subject to a certain non-conformity of Ta’ Ħaġrat East’s clear chronology and based on the illustration of Table 4.11, Ta’ Ħaġrat East would qualify for a Ġgantija Phase classification. Based on a theory that Ta’ Ħaġrat East was built after the larger west temple, the question if Avior would at all be visible arises. From a site visit and today’s temple structure, the apparent horizon is visible standing in the back of the smaller east temple, however if this was the case in Temple Period, remains an open question. Nevertheless, an interesting fact remains, namely that both of the main temple unites of Ta’ Ħaġrat and Skorba are aligned to Gacrux rising and both of the more secondary units have Avior setting. Whatever chronology archaeoastronomy may suggest, revelations in the archaeological record shall have priority when it comes to dating.

A more complexed picture appears considering patterning with the temple sites as Tarxien Temples and Ħaġar Qim. For the chronology and building sequence of the various structures inside these two, temples Evans (1971) has been the primary source. Especially when it comes to the Tarxien Temples, Evans (1971: 135-137) seems to raise some questions on chronological building sequence as sherds of Żebbuġ, Mġarr, and Ġgantija type of pottery were also found inside some of the apses. Again, referring to Table 4.11, the table indicates that all three temples within the Tarxien complex are aligned to either Avior and Gacrux setting. In other words, based on this scenario they all have a western orientation which fits into a general Tarxien Phase of temple orientations as previously discussed and referenced to Cox (2001: 28) and Agius and Ventura (1980: 8, 1981: 14).

Figure 4.13 and Figure 4.14 show an illustration of temple plans and central axis of respective entrance frames from the back apse by a black coloured arrow. The entrance frame axis are imposed on temple plans from Cilia (2004). Figure 4.15 found on basemap of the Planning Authority (2016) illustrating temple plans and central axis of respective entrance frames indicated by a black coloured arrow from the back apse measured by this author as there are no archaeological excavation of these two sites. All the temple measurements are listed in Appendix 7.4.

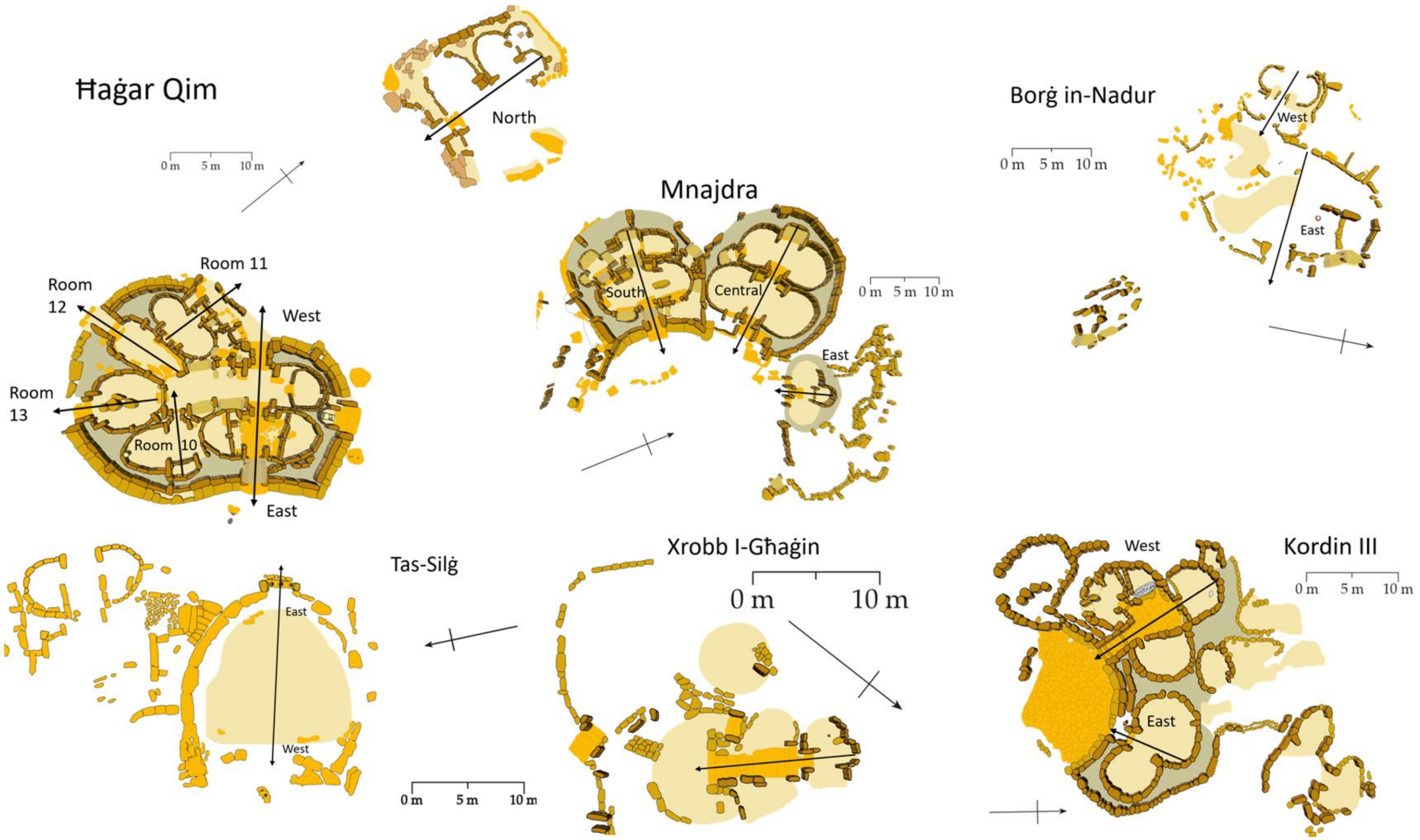


Figure 4.13. Temple plans, after Cilia (2004), showing central axis of entrance frame.
Top row from left to right, Ħaġar Qim, Mnajdra, Borġ in-Nadur.
Bottom row from left to right, Tas-Silg, Xrobb I-Għaġin, Kordin III.

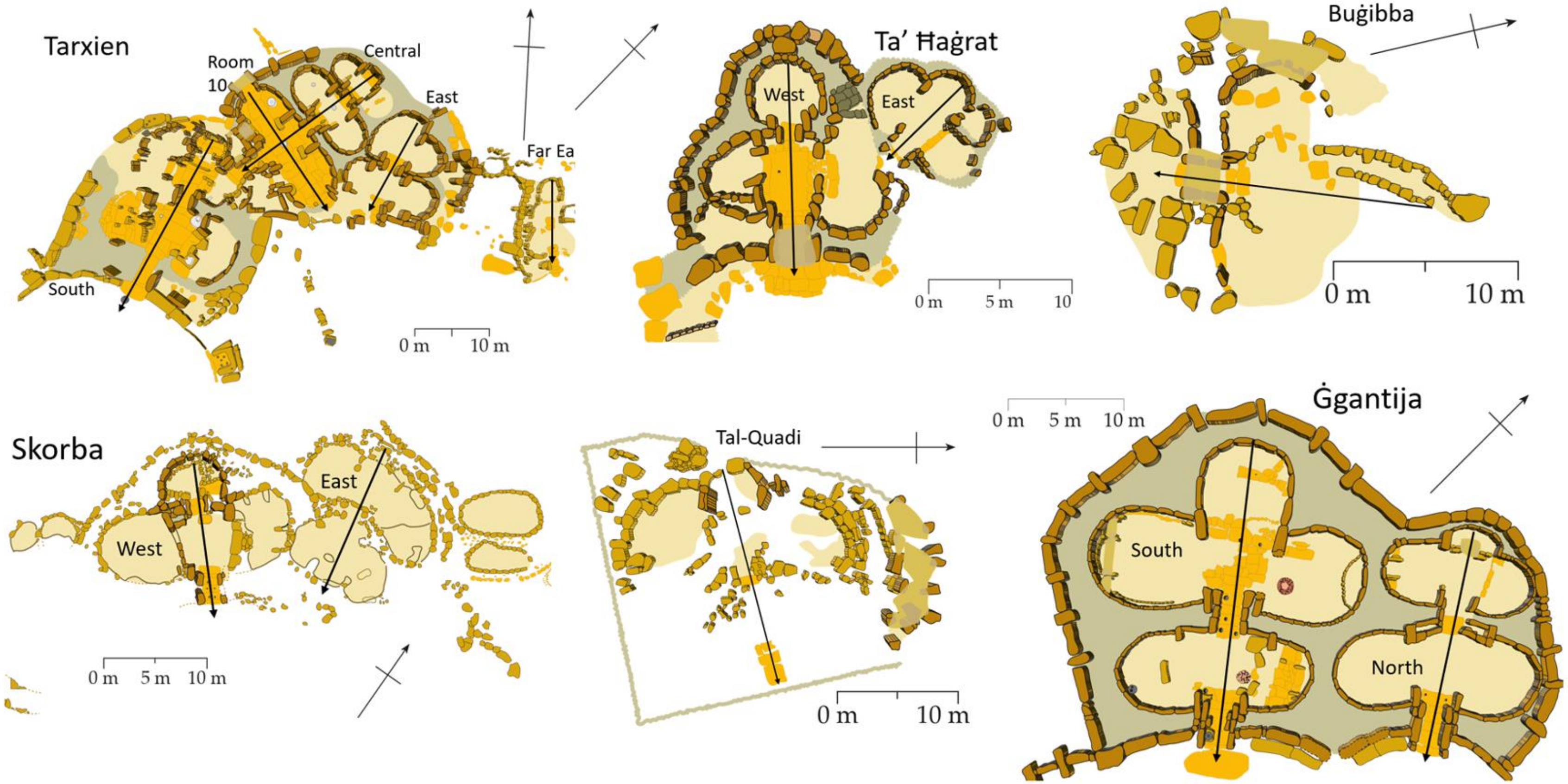


Figure 4.14. Temple plans, after Cilia (2004), showing central axis of entrance frame.
Top row from left to right, Tarxien, Ta' Ħaġrat, Buġibba.
Bottom row from left to right, Skorba, Tal-Qadi, Ġgantija.

Figure 4.15. Temple plans, showing central axis of entrance frame.
Kunċizzjoni to the left and Xemxija to the right.

Temple phases and statistics

After a wider analysis of distribution of temples, their phases and orientations, this final part of the discussion of Ġgantija vs. Tarxien Phase will analyse the most important findings from the significance test, that is why patterning of orientation occurs predominantly in the Ġgantija and not in Tarxien or Uncertain Phase (ref. Figure 4.6 page 252).

The significance test for the Ġgantija Phase (ref. Figure 4.6 page 252) has a global p-value of 0.01953 implying the temple entrance frame distribution was highly significant and not randomly chosen by the Ġgantija Phase temple builders. Table 4.8 page 251 illustrates the sites falling in each of the two significant areas in that period, listed under Region of ST 3 and Region of ST 4. Avior with a declination at 3,250 BCE of -49.0 fall in Region of ST 3 and Gacrux with a declination -30.6 in Region ST 4. Out of the ten sites represented in either one of these ranges, 60% are aligned to Gacrux rising and 40% to Avior setting. Again, we see another example of a Ġgantija Phase predominant interest towards the rising positions of the stars in the eastern hemispheric sector of the sky. The two other phases, Tarxien and Uncertain Phase, have both a non-significant global p-value and have consequently a temple entrance frame distribution randomly selected by their builders (ref. Figure 4.6 page 252). The whole reasoning behind temple distribution, orientations, and phases has been widely analysed. A simple and straightforward possible answer to the result concerned here, could be that the Maltese Ġgantija Phase society had a cosmology more oriented towards stars with an emphasis on eastern rising positions of celestial targets than the Tarxien Phase. A plausible hypothesis is that the Tarxien Phase temple builder society became more interested or concerned about solar events in the sky.

4.5.6 Stellar seasonality and cultural implications

According to Malville (2008: 25) the passage of the earth orbiting around the Sun gives us a calendric timing, seasonality, as well as heat in the summer and cold in the winter in the nothern hemisphere. Ventura (2004: 323-324) discloses that at 3,000 BCE Gacrux had its heliacal rising on September 24th (day 267 of the year) and 'that this could have been of special interest to the temple people as it rose so close to the autumn equinox'. This is in accordance with this study; however, Ventura does not indicate the time period when Gacrux is setting. In order to better compare the seasonality between Gacrux and Avior, the following Table 4.14 and Figure 4.16, indicates that Gacrux and Avior at 3,250 BCE start with their heliacal rising around the time of the autumn equinox and they both set just before the spring equinox.

	GACRUX	AVIOR
Rise (R)	September 18 to December 25	September 14 to October 12
Rising and Setting (RS)	December 24 to March 17	October 13 to March 27
Setting (S)	March 18 to June 25	March 28 to April 27
Arising and Laying Hidden (Yellow Area)	April 28 to September 13	April 28 to September 13
Achronycal Setting (AS)	June 25	April 27
Heliacal Rising (HR)	September 18	September 14

Table 4.14. Comparison Seasonality of Gacrux and Avior 3,250 BCE.
This table dates the time of the year the stars were visible or not visible in the sky.

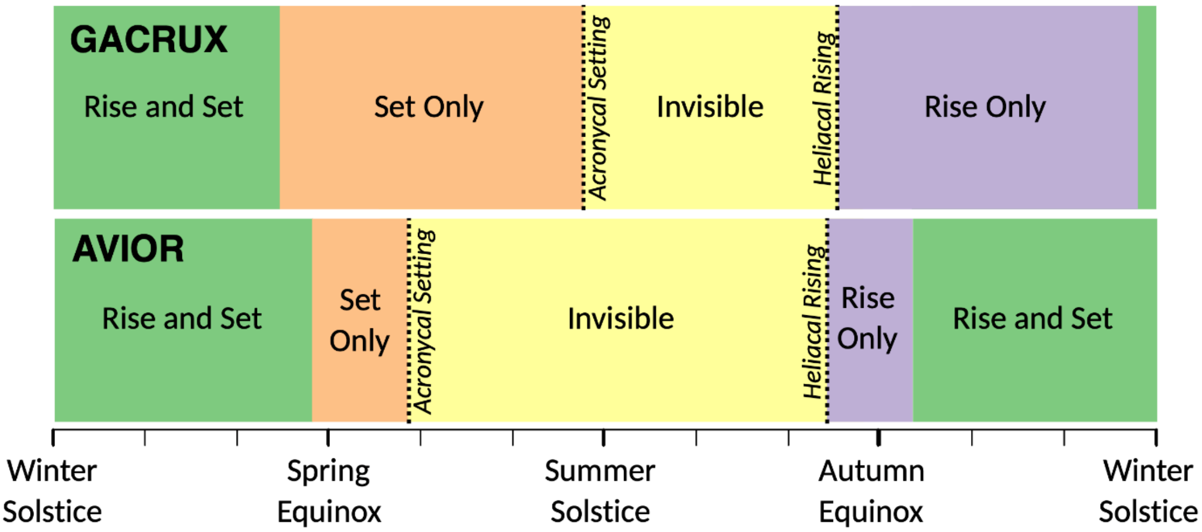


Figure 4.16. Graphical Comparison of Seasonality of Gacrux and Avior 3,250 BCE.
This Figure illustrates the seasonal visibility of Gacrux and Avior from Malta during the Temple Period. Both stars have a similar seasonality, and both rise around the time of the autumn equinox and finish their rise and set periods close to spring equinox. This cycle and especially the heliacal rising (the first time a star become visible again after a period of inconspicuousness) could be an important time indicator for the start of the rainy and winter season. When Gacrux and Avior would be only visible when setting, they could have been used as a marker that the warmer and summerly season were approaching. Despite the fact that the Sun could be used for similar purposes, for the Temple Period society it may have been that it was the observation of these special stars that was most important.

Gacrux can further be seen setting for the following three months whereas Avior being lower in the sky cannot be seen setting after the spring equinox. An alluring circumstance is that the alignments of Avior and Gacrux patterning (ref. Table 4.11) enable their visibility only during the winter season, give and take a couple of weeks on each side of the equinox depending on the years in question. This brings forth some thought-provoking hypotheses.

One hypothesis may be that the winter could have been more of a concern and importance to the Temple Period society than the summer, as the winter season was essential for harvesting agricultural products as winter was (and still is) the rainy green season in Malta, while summer is the dry and hot period (Gambin *et al.* 2016, Grima 2016b). According to Micallef (2019: 159):

> Autumn on the Maltese Islands is characterised by warm and moist air occluding with closer depressions. These atmospheric conditions generate short but intense thunderstorms with heavy precipitation, which lead to soil loss.

This underlines the importance for life sustainability based on rain and suitable atmospheric conditions for cultivation and harvesting during the winter months. A sub-consequence of this could generate the importance of religious rituals or secular festivals during the winter time as a part of their worldview and cosmology (Grima 2016).

In the light of these possibilities, another engaging argument could be that the origin of determining the time span from autumn to spring equinox may have actually originated with Avior and Gacrux as the main celestial targets. To accentuate this possibility, one element to bear in mind is that the alignments of Region ST 1 and Region ST 2 (Table 4.7 page 250) have a considerable high statistical significance and indicates that these patterns are not made by chance (ref. Section 4.4.4 page 252). For clarification and correctness, it is not Avior or Gacrux that have the high statistical significance, but Region ST 1 and 2. However as Avior and Gacrux do fall very clearly inside their respective patterns, it is difficult to exclude that they would not have been the celestial targets for the temple builders.

If relevant to the Maltese prehistoric society or not, the first known Mesopotamian calendars were lunar (Kelly and Milone 2005: 97). The oldest predynastic Egyptian calendars were also lunar for the need of agricultural purposes to keep track of the seasons (Ruggels 2005: 9). However, lunar calendar got out of sync with the actual seasons due to the fact that there are 13 lunar cycles in a solar year and therefore solar calendars came into effect (Aveni 2008b: 46, Kelly and Milone 2005: 99-100, 219). According to Rochberg (2004: 6-7) the non-divinatory astronomical sources in Old Babylon primarily concerned themselves with a schematic calendar associated with the appearance of fixed stars. The heliacal rising of the fixed stars in the constellation Crux (where Gacrux belongs) were used as to mark the start of the rainy season in Babylon (White 2007: 169). Coincidently, what happened in Babylon corresponds to the same patterning of the start of the rainy season in Temple Period Malta with the heliacal rising of Gacrux and Avior. Based on the significant statistical findings in this study of a possible star gazing interest of the Maltese prehistoric society, it cannot be excluded that the rising and setting of Gacrux and Avior could have been a marker to keep track of seasons for agricultural, sailing, or life sustainability purposes in a challenging habitat, connected to a cosmological perspective of the world they lived in.

4.5.7 Other potential temple alignments

Regardless of which period the temples were built, Fodera Serio *et al.* (1992: 116-117) maintain that the distribution of the temples were 'highly non-random' as a clear majority of the temple orientations stays within 78.5° of the south-east/south-west bearing, which represent less than a quadrant of a circle. A chi-square test by Agius and Ventura (1980: 9) showed that the probability of this distribution of azimuths occurred by chance is less than 1 in a 1000. Due to the geographical latitude of Malta, it is an astronomical fact, today as it was during the Temple Period, that the winter solstice Sun rises in the south-east and sets in the south-west. It could mean that the Ġgantija people were more cosmologically oriented towards the period of the winter solstice sunrise and the Tarxien one more towards the period of the winter solstice sunset. This is, of course, highly hypothetical.

Even with such a clear statistical indication the issue remains an open question, nevertheless the question of intentionality by the temple builders prevails.

Equinox and solstice alignments

The equinoctial and solstitial sunrise alignments of the Maltese Prehistoric Temples are probably the part of archaeoastronomy that have mostly engaged both amateurs and scholars, as referenced in the literature review. To be more specific, the summer, winter, and equinox sunrise alignments of Mnajdra South is the single prehistoric Maltese temple that has received most attention which started with an astronomical research by Agius and Ventura (1980, 1981), followed up with a more popular publication of Paul Micallef (1990), arguing that Mnajdra was a 'Calendar in Stone' which was also the title of his publication. Since then, a series of work has been published specifically on Mnajdra (Agius *et al.* 2021, Foderà Serio *et al.* 1992, Lomsdalen 2014a, Micallef 2000, Thomson Foster 1999, Ventura and Agius 2017, Ventura *et al.* 1993). Other publications have described more generally the concept of the Maltese temples' alignments to the sunrise or sunset at specific times of the year, mostly at the equinox and the solstices (Albrecht 2007, Cox 2001, Cox and Lomsdalen 2010, Mayrhofer 1995, Micallef 2001, Ventura 2004, Ventura and Agius 2017). Mario Vassallo (2000, 2003, 2007) from Mġarr in Malta has done considerable research on the builder's reasoning behind and especially on how and why the temples received an off-set or cross-jamb illumination of the rising Sun at winter solstice and concludes that; 'The main factor for orientating our monuments towards the south-east was the winter solstice sunrise'. Vassallo (2007) further argues that 'a total of 21 out of 24 sites (or 88%) show an alignment with the winter sunrise'.

There is no statistical testing on these illumination events. However based on the empirical evidences, a relevant question to ask at this stage would be; 'Why did not the builders orient their temples directly towards the rising of the Sun at winter solstice if this may have been an important element in their cosmology?'. To this there are many possible unverifiable suggestions. One of these may be that the builders considered the cross-jamb or off-set solstice sunrise illumination more important than a direct illumination of the temple's central corridor. The areas with an off-set or cross-jam Sun illumination has often an altar like installation being illuminated. A principle of dichotomy of which area should be illuminated and which areas to be kept in dark seem to prevail and could be a part of their cosmology (Albrecht 2007, Lomsdalen 2014a: 138-142, 2014b, Vassallo 2000, Ventura 2004: 317-321).

If the builders had aligned the temples along the axis of symmetry with the winter solstice sunrise which had a declination of -24.0° in 3,000 BCE (ref. Agius and Ventura (1980: 13), both Avior and Gacrux would fall outside this area in the sky. The only star that would fit with such an alignment would be the star Sargas with a declination of -23°59’54.7’’ and listed among the 40th brightest stars in the night sky with a magnitude of +1.87 (Stellarium 2019). Sargas is yellowish in colour and one of the seven stars that form the tail of Scorpius (Allen 1963: 369, Cornelius 1997: 104). At least from a modern mind set, comparing the visual impact of a star rising at around 1:30 am and the winter Sun rising on the horizon in the morning, the latter would largely prevail when it comes to visual illumination and effects. If a prehistoric person had a similar mindset, we do not know of course, so the issue has to be left as an open question. Nevertheless, based on a single star candidate compared with the high number of temples with an off-set orientation of winter sunrise, one cannot exclude that builders purposely oriented some of their temples to this skyscape event. Seen from a lager skyscape perspective, it is relevant not to limit oneself only to these two celestial objects, Avior and Gacrux, when it comes to the Temple Period’s cosmology and skyscape observations.

Another reason why the equinox or solstice alignments are not further examined in this chapter, is because none of these events fall inside Region St 1 and 2 of the statistical tests (see Section 4.4.4 page 252). The results of this research as listed in the Result section, are based on a strict and rigid approach of temple entrance window frames as explained in the Methodology section. This technique was chosen in order to obtain results that are qualitatively significant through statistical testing. As no other study so far has used this approach of ‘entrance frame’ for measuring Maltese temple alignments, it is essential to compare with similar work and develop and construct new theories, and also test existing theories against the one retrieved in this study. Besides works of Ventura and collaborators, few researchers of Maltese temple alignments, if any, have been using a statistical approach to conclude on results. Another aspect is that this study searches for celestial object visible from a specific point seen from inside the temple, while other studies mainly refer to off-set or cross-jamb illumination of sunrise or sunsets illuminations to specific areas inside the temple based on outside solar rays.

Perhaps the early temple builders were more interested in stars and not really concerned with the Sun for seasonal chronology. The Sun may have become more emphasised when the Mnajdra South Temple was completed in Tarxien Phase (Evans 1971: 103, Lomsdalen 2014a: 145-154, Pace 2004a: 129-131). As Mnajdra South stands today it is well documented that the inside illumination of the sunrise appears through the main entrance during a calendric year (Albrecht 2007, Lomsdalen 2013a, Micallef 2000, Micallef 1990, Thomson Foster 1999, Vassallo 2003). According to Evans (1971: 96) and Pace (2004a: 129) the Mnajdra South façade express itself in an antique design with its apses well retained.

Ventura *et al*. (1993) investigate that Mnajdra South Temple may have been oriented by the builders in the direction of the Equinox sunrise, which is midway between the winter and summer solstice sunrise. However, they argue that it is not likely due to the difficulty in mathematical calculations in prehistory. Therefore, they propose that Pleiades was a more likely candidate for the orientation of Mnajdra South as it had its heliacal and seasonal rising at the same declination as the Sun would have had during the Temple Period. In a larger skyscape context these two separate events of Pleiades, Avior, and Gacrux may have had a complementary significance by framing the beginning and the ending of the winter season. As stated, the last part of Mnajdra South was finished in the Tarxien Phase, but the back apse is dated to Ġgantija Phase (Evans 1971: 101-103). The first decision taken by the temple builders would be the orientation of the axis of which the entrance would be constructed (Torpiano 2004: 360). Regarding Mnajdra South Temple, Agius and Ventura (1981: 13, Table 1) measured the central axis alignments from the back apse to the main entrance which is aligned to the rising of Pleiades. As suggested by Ventura *et al.* (1993: 176) and later by an updated study of Ventura and Agius (2017: 92), Mnajdra South could have been aligned towards the rising of Pleiades and not the rising Sun at the equinox, which could imply that Pleiades could have been the initial celestial marker for the early construction period in the Ġgantija Phase, and the rising Sun at the equinox could belong to a subsequent Tarxien Phase development of celestial dominance.

In order to better understand if the cosmology of the temple builders was incorporated into a possible astronomical phenomena, Ventura (2016) proposes potential symbolic correlation in the following Temple Period's archaeological artefacts:

Sun and Moon symbolism

- The Ħal Saflieni hypogea red ochre ceiling painting representing solar disks and the tree of life.
- The so-called 'solar wheel' retrieved at Ħaġar Qim could support the representation of sun symbolism as promoted by Vassallo's (2011a, 2011b) that the temple was built as a sun marker of time throughout a solar year.
- At the Tarxien site the carved illustration of a bull and sow with 13 appendages under the belly, suggested to represent the Moon's thirteen lunar cycles in a solar year.

Star symbolism

- The Tal-Qadi stone named after the site where it was found, could have been a part of larger piece. It could represent the sky divided into sections containing six and seven pointed stars with an empty section with a D-shaped figure, possibly illustrating an ecliptic Sun, or a crescent Moon.
- As noted in 4.5.4 page 268, the Tarxien Temple horizontal slab could represent the Southern Cross.
- The standing stone with the cup-marks in the Mnajdra East Temple named *tally stone*, proposed to be a tally of the helicacal rising of southern stars seen from Malta with also some drilled holes representing the Pleiades (Agius *et al.* 2021, Ventura 2004).

A further incentive for alignments to stars, previously mentioned as a calendric time device and navigations, could be connected to a belief system that they could represent supernatural entities, ancestors who should be ritualised, or a form of an astrological conviction that celestial bodies could influence happenings in life (Ventura 2017: 178). According to England (2004: 413) the motivation of the builders for temple alignments to celestial bodies was to view and pursue a cosmic unification of the sky and the Earth. What England here proposes is that the builders seemingly had a holistic worldview.

If the motivation was to align temples to any of these proposed hypotheses, will remain an open question. However, based on the fact that these temple alignments are substantiated in a clearly defined and narrow viewscape of Gacrux and Avior, it cannot be completely neglected that stars and star groups could have been a significant ingredient in their cosmology.

4.6 Conclusion

Based on the paradigm of this research topic, the aim of this study was to research if the Maltese Prehistoric Temples had any alignments of celestial bodies using the approach of *entrance frame* orientation. This approach was based on a very strict and clearly specified methodology. It should test which part of the sky would be visible from a predetermined observation point at the very back of a temple sturcture through a temple's entrance frame. A main objective has been that any result from this research had to be statistically validated and whenever pssible tested against existing theories and findings. Furthermore, it has developed and constructed new theories based on relevant publications and works by other reserachers, including this author, in the fields of archaeology, skyscape archaeology, archaeoastronomy and cultural astronomy.

The core innovative approach of this research topic is on how to identify celestial objectives in the sky by inferring original methodologies of Hoskin's (2001a) 'axis of symmetry', Silva's (2014a) 'window of visibility', and Silva's (2019a, 2020) approaches in using method of maximum likelihood and significant test in revealing statistical patterning. In addition, theories and results of previous research of Maltese temple orientation towards celestial objects has also been analysed and tested in relation to the findings of this study.

There are three important results and new findings from this study, which are the following:

First Finding

The first finding is that based on two different statistical tests there are two distinct patterns of orientation emerging (ref. Figure 4.4 page 246 and Figure 4.5 page 249).

Second Finding

The second finding is that these two patterns are stronger for the Ġgantija Phase than for the Tarxien and Uncertain Phase. Out of a total of 14 sites, ten (71.4%) belong to Ġgantija, while three (21.4%) to Tarxien, and one (7.1%) to Uncertain Phase (ref. Table 4.5 page 247 and Table 4.7 page 250).

In addition, only the Ġgantija Phase has a pattern that is statistically significant, as Tarxien and Uncertain Phase are not statistically significant (ref. Table 4.6 page 248).

Third Finding

Third finding is that when all other possibilities are considered, the most likely orientational targets are Avior and Gacrux (ref. Table 4.7 page 250 and Table 4.8 page 251).

There are statistically significant patterns of temple orientation in the Ġgantija Phase, while in the Tarxien Phase there are none. This brings forth an argument that the temple builders in the Ġgantija Phase could have a more star-oriented cosmology which was not adopted or followed up by Tarxien Phase society. This could imply a change in cosmology from star to more Sun priorities, as previously discussed. This change may also be related to life sustainability due to changes in climate and atmospheric conditions in a general hash habitat.

The present author is not aware of any research outside Malta that is based on the method of 'entrance frame', and even more so, combined with the method of maximum likelihood and significance testing as done in this study. Silva (2014a, 2019a) who launched the concept of the ‘Window of Visibility’ and statistical testing alignments using method of maximum likelihood, differs from the methodology used in this study. The window of visibility as employed by Silva is not restricted to one specific point inside a monumental structure, but can be taken cross-jamb, off-set, or from any position inside a megalithic monument and consequently can include a large group of celestial alignments. Silva’s approach stands in contrast to works of Hoskin (2001a) and Ventura *et al*. (1993) who mainly used the temple’s ‘axis of symmetry’ as a base for their alignment calculations, and consequently limiting their results of potential celestial observations. By adopting elementary measuring techniques of prehistoric megalithic monuments from both Hoskin and Silva, especially Silva’s used method of maximum likelihood, this study has been able to research an area of the sky and obtain results that otherwise would not have been possible.

Archaeoastronomy and skyscape archaeology can be useful and indicative when it comes to statstical qualitfied patternings between celestial bodies and material culture. Based on the reserach question at hand; ‘Were Temples built to allow their entrances to frame specific skyscape features?’, this study has provided new theories and new statistical evidences that may justify a ‘*yes*’ answer through the obtained results and thoroughly discussing and analysing them. Based on the null hypothesis of the significant test of this study, that the builders did not have any preference in orientating their temples, the statistical test concludes that the orientation of temples’ entrance frames were not randomly selected, nor occurred by chance alone. This entails that there were some factors that influenced the builders’ choice in orienting their temples. As other elements in this respect as, birds flying pattern, wind and weather, aspects of terrain, orientation towards ancestry origin, solar or lunar influences, do not seem to have influenced the entrance frame orientations, we are then left with a statistically proven alternative, namely the two stars Avior and Gacrux. The fact that these two stars also have similar seasonal rising and setting timeframe, may however be an influential factor of this stellar entrance frame alignment for calendric and time keeping purposes.

Nevertheless, one question still remains open and cannot be fully answered; Did the builders *intentionally* orient their temple entrances to frame the two stars Avior and

Gacrux? Based on the archaeological record there are still more areas within skyscape archaeology, archaeoastronomy and, cultural astronomy to be explored quantitively and qualitatively for the Maltese Temple Period. Future work may continue to bring more answers to why the builders oriented their temples the way they did with a possible predetermined viewscape of celestial bodies as a part of their cosmology.

5 General Discussion and Conclusion

5.1 Introduction

This final chapter will draw together the main findings of the three respective core result chapters (Chapter 2, 3, and 4), which until now have been presented independently. The purpose of this final chapter is to consider these results together, and to explore their wider implications when considered in conformity. This shall be done through the concept of cosmology interrelated with viewscape. It will follow a three-step pathway from the wider to the narrower viewscape. It shall start with temple intervisibility in the landscape, then proceed to the vista of the apparent horizon from a temple location, considers what celestial targets can be observed through a temple entranced frame, and finally, merge all these findings to discuss the implications for the Neolithic worldview as well as for the cosmology of the Neolithic temple society in Malta.

Though the chapters are individual in their research objectives, there is nevertheless a pathway of research thread connecting each one of them. The first one, the GIS chapter (Chapter 2) of temple visibility and intervisibility in the landscape, has a link to the second one, the horizon chapter (Chapter 3). This consists of temple positioning in the landscape with an open vs restricted vista of the apparent horizon. There is also a further link, in that temples are located on southern slopes with an open view to the south. Therefore, these two chapters share a common concern about visibility and viewscape in a cultural landscape setting. The horizon chapter has a second research area related to astronomy and skyscape, in common with Chapter 4. Chapter 4 investigates which celestial targets can be observed through the entrance frame from a central position at the back of a temple. Without the horizon chapter, there would not have been a channelled pathway through this thesis. The GIS-based landscape analysis in the first chapter, and the astronomical study in the last chapter, are bridged and connected by the Horizon chapter (Chapter3), which besides its findings, has this essential purpose. That is also the pathway and sequence that will be followed in the discussions and conclusions of this final chapter.

5.2 Main findings

This section shall list the three main findings from the three research chapters, staring with the GIS, then the horizon, and lastly temple window frame.

5.2.1 Topography and visibility (Chapter 2)

When it comes to temple locations' relationship to the topographic variables of elevation, slope and aspect, the present research found:

i) there is no preference for low or high elevations;
ii) there is a preference for slopes between 4° and 14°;
iii) there is a larger proportion of sites on slopes that are facing south.

These results show that temples are not largely located on flat land or on the top of the highest points in the landscape. Personal observations of temple positions have shown that none of the temples are positioned at the very top of a hill or a slope formation. This seems not to have been a priority from the builder's side. On the other hand, to locate temples on south-facing slopes could have been a priority, or it could just have been a natural consequence of the archipelago's topographical formation. Further potential reasoning behind southern slope locations will be discussed below.

Concerning temple visibility and intervisibility in the landscape, this study has revealed two primary empirical findings:

i) temples are preferentially located at points that are visible from many other temples;
ii) temples are preferentially located in the inherently most visible portions of the archipelago.

Overall, based on an estimate of temple height of 6 m, and also by taking distance and human acuity into consideration, 70% of all temples have an intervisibility with at least one other temple on the archipelago.

Though visibility and intervisibility do seem to have been an eminent part in temple locations, other elements may also have had an influencing factor. These could be proximity to fresh water sources and sustainable agricultural land (Grima and Mallia 2011, Grima *et al.* 2020, Grima and Vassallo 2008, Ruffell *et al.* 2018). As suggested by Grima (2008: 38), temple locations with easy access to the sea seem to have had a preference, but to locate temples close to the seashore did not seem to have been a priority. Temples were not used for dwelling, though there are archaeological evidences that some temples are built on pre-existing settlement sites (McLaughlin *et al.* 2020b, Trump 1966a). This could have been based on a motivation to preserve and to maintain ancestral liaisons, where a shrine was also found on the Skorba dwelling site (Trump 1966a: 11).

The topography of the Maltese landscape could be another reason for temple locations. With most of the temples located on southern facing slopes, they would naturally become more conspicuous in the landscape as their view and visibility would not be hampered by ridges or valleys. In this case, temple visibility would dominate regardless of whether locations were chosen for their visibility or not. Temple visibility is certainly an intrinsic property of monumental architectural constructions in the environment (Kostof 2010: 3). In this case, these eye-catching megalithic monuments would undoubtedly dominate any viewscape in the relatively open prehistoric Maltese landscape.

In this study there are also indications relating to regional preferences. The analysis revealed groups of temples with intervisibility between them, with scant-to-no visibility between groups. For example, several temples in Gozo were built on a single plain, which would afford intervisibility between them. However, the ridges and valleys in the northern part of Malta would make intervisibility more challenging. Therefore, this is less likely to have happened accidentally. On the other hand, if visibility was the only driving force behind temple location, the builders could have maximised and optimised it to an even higher level than what they did. Regional and local socio-political and ideological factors could also have played a role (Cazzella and Recchia 2015: 106, Renfrew 2007: 12). Nevertheless, these findings show that temple viewscape most likely was an ingredient in their builders' culture. The builders could easily have constructed the temples in less conspicuous locations more hidden from public view, which they obviously did not do.

Besides the findings of temple visibility and intervisibility, this study has also contributed to knowledge in archaeology by applying principles of human acuity. As viewshed analyses are prone to edge effect errors (Wheatley and Gillings 2002: 209), and this became an inspiration. Temple intervisibility calculations applying human acuity are based on a mathematical formula that does take into account how much of the target object *is* visible, or *not* visible from a vantage point. However, these analyses are prone to edge effect errors, where the visible portion of an object in reality is too small to be recognisable for what it is from the distance in question. This study (ref. 2.3.3 page 31 and 2.5.7 page 130) therefore, went one step further by calculating the visible proportion of the temples from a given vantage point. This demonstrated that in several cases where the human acuity formula suggested that a temple would be visible, where actually it would physically not be possible to see the temple from that given vantage point. This study shows that if detailed studies of potential edge effect errors in viewshed analysis are not applied, subjective findings are likely to appear. Furthermore, this author is not aware of a previous visibility study which brought together viewshed analysis, human acuity, and the question of visible proportion of an archaeological target object. This is the essence of what this part of the study has tried to offer as a new knowledge to humanity when it comes to GIS analysis in archaeology.

5.2.2 Apparent horizon (Chapter 3)

This chapter was divided into two main investigation areas, each of which have yielded interesting empirical findings. Both areas were concerned about to what extent the temple builders were influenced by the apparent horizon when deciding upon a given location.

The first area of investigation was to establish if an open vs a restricted vista of the horizon was an influential factor for a temple location. The first area's finding was that temples were preferentially located in places with an open vista towards the southern hemisphere and with a restricted vista to the north. This result shows that temple locations were not chosen by chance.

The second area investigated if the builders had an interest in matching the rising and setting positions of Sun and Moon on specific horizon features upon selecting a temple location. The second area's finding was that the builders had no preference for locating a temple in places where the Sun and Moon rise or set occurred on particular landscape features of the apparent horizon. The builders could have had other priorities for temple locations in the landscape, such as the ones suggested above. Though there is a negative result to this specific research question, it is nevertheless an important finding. It disproves a hypothesis which in itself is an important contribution to knowledge. However, this does not mean that the Temple Period society had no interest in the Sun and Moon or other celestial objects, for which there are clear indications that they had (Cox 2009, Lomsdalen 2014a, Vassallo 2000, Ventura 2004, 2017). The topic of astronomical phenomena is discussed further below.

5.2.3 Temple entrance frames (Chapter 4)

Chapter 4 focussed on the views through temple entrance frames. This chapter yielded three essential findings:

i) there were two distinct patterns of orientation;
ii) the two patterns were stronger for Ġgantija Phase Temples than for Tarxien Phase;
iii) the most likely celestial targets were the stars Avior and Gacrux, respectively.

The study shows that the alignment to these two stars through the relatively narrow viewscape entrance frame (from about 6° to 12°) was not randomly chosen by the builders and did carry a level of constructional intentionality. Regarding the fact that these patterns are stronger in the Ġgantija Phase and not Tarxien Phase, this could indicate a change in cosmological priorities and perspectives of the Temple Period society (ref. 4.5.5 page 277).

Furthermore, it has been concluded that temples were located in southernly slopes with open vistas to the south. This could be relevant to the interpretation of these findings, since it was found that the rising and setting of the two stars mentioned above happened in the southern celestial hemisphere. The overall result indicates that the builders had a preference to locate temples on southern slopes, and in addition had a preference to orient the temple entrances so that they captured the rising or setting of Avior and Gacrux. These findings further confirm that viewscape to the southern quadrant of the sky was likely to be more important to the temple builders than the northern one.

These findings bridge the gap from the broader to the narrower pathway of the research questions of this thesis by establishing a linkage between viewscapes and a possible cosmological implication. This shall be analysed and disused further down but firstly, possible limitation of this study shall be explored.

5.3 Limitation of study

Each of the three research chapters has listed the limitations of the study related to that specific research area of the chapter. This part shall only consider any perceived limitations regarding viewscape and cosmology.

As already noted, Malville's (2010) warning sign is the challenge we have today, that is to see the cosmos through the eyes of a person living in prehistory. In other words, not let our modern mindset influence any analysis or discussion of empirical findings. This challenge does not only apply to astronomy, but likewise to archaeology, or any research field concerning prehistory, the time period before the introduction of a written language. The challenge to this study, and any prehistoric research programs for that matter, is the difficulty to say or state anything with a high degree of certainty. In science, mistakes and blunders cannot be avoided, and as Taylor (1997: 3) proposes, even carefully taken measurements cannot be completely free of uncertainties. A null hypothesis can be rejected, but it does not declare why it was rejected, and that is where human interpretations come in. Relating Taylor's statement to a Maltese Temple Period study of viewscape and cosmology, where any views, meanings, discussion, and conclusion from the findings of this thesis, could be contradicted by new relevant research in the future. The limitation with such a study as this one, is that any interpretation, argument or even suggestions are theoretical and subjective even if they are solidly based on statistical and empirical data. This goes for both the archaeological and the skyscape part of this study, even if the author's propositions are sustained by scholarly literature and references.

The core limitation to this study is that the main research question is both theoretical and subjective in its essence. To identify how a prehistoric person perceived or believed what he or she visualised is close to impossible. But if the visual target is clearly defined, and related analyses are based on statistical and empirical data, the probabilities that the observable target reflects the person's visual perception could be strengthened. It would at least leave the person with a certain opinion of the target. Without any direct communication with the observer, we can never be ascertained what the person, in prehistoric or historic time periods, actually experienced by looking at a given target. On the other hand, relating to relevant archaeological, anthropological, or astronomical studies from other parts of the world could bring a certain sustainability into the discussion, as the following section shall emphasise.

Studying viewscape can be considered a subjective topic, and when that is done in regard to a belief system, we get a double dose of uncertainty. To minimize this uncertainty, this study has tried to have a cognitive open mind and evaluated any subjective and theoretical scenarios from various points of view and base it on a diversified referencing and discussion. Nevertheless, founded on sustainable arguments, the future can accept or reject these arguments and statements based on conceiving research programs.

5.4 Implications for cosmology

Having discussed the core findings of this research project, one can now explore the cosmological implications of the identified viewscapes. This is necessarily speculative, but it will be grounded in the archaeological evidence, both those resulting from this thesis and those of previous scholars. The core findings highlight five key questions that any interpretation needs to address, namely: why is it that the prehistoric Maltese built temples on the locations and with the orientations that show the patterns that have been identified here? To explore these questions, the literature was searched for specific case studies with similar findings where interpretations for the patterns found were suggested. Following this, an assessment of whether the same interpretations may have applied to the Maltese temples is done based on the available evidences.

5.4.1 Why do people build monuments on more visible places in the landscape?

Kantner and Hobgood (2016: 1303) referring to the tower kivas of the Ancient Puebloan societies in Chaco Canyon, US Southwest, summarised a number of possibilities from the literature to explain their positioning in highly visible places. The first interpretation is that the kivas could act as a regional communication system by being used as signalling stations using hand-held flares for rapid communication (Kantner and Hobgood 2016: 1305). A second hypothesis is that kivas may have been defensive towers. Thirdly, it has also been suggested that tower kivas may have represented new belief system centred on the heavens, therefore explaining why they built in high locations (Kantner and Hobgood 2016: 1303). A fourth possibility is that kivas were ceremonial centres, and that their high visibility made them ideal venues for awe-inspiring spectacles meant to be seen from a broad region (Kantner and Hobgood 2016: 1305). Finally, they also mention the possibility that kivas may have been meant *to be seen*, rather than *to see* from them – a distinction also highlighted by Gillings and Wheately (2020: 325) and Van Dyke *et al*. (2016: 207). Kantner and Hobgood (2016: 1305) propose that the kivas may have been 'symbols of power and authority, meant to influence local socio-political dynamics within the communities where they were constructed.' The conclusion of their GIS-based viewshed analysis reveals that the defensive and visibility over long distances options are unlikely to be the case, instead the tower kivas was a religious architecture, acting much like church and mosque spires (Kantner and Hobgood 2016: 1313-1315). Kantner and Hobgood (2016: 1315) conclude that the kivas:

> Helped to define the great house as the *social* and *political* centre of the communities in which they were built, even while no doubt possessing their own *symbolism* related to the *religious* architecture of which they were a part.

According to this author, this statement implies that the tower kivas were monuments that brought together the social, political, symbolic, and religious dimensions representing the Ancient Puebloan cosmology.

Relating to Maltese temples, regarding the first possibility (communication) there are no indications that the temples were used for a similar purpose, but smoke or open fires could have been a means to communicate between sites, although this can only be speculated. The second possibility (defence) is unlikely for three key reasons:

i) the temples were not always placed on locations offering natural protection or defensive capabilities (Grima 2008: 37-38);
ii) there is no evidence of warfare and violence of any kind during the Temple Period (Evans 1977: 24, Trump 2002: 239);
iii) the structures are regarded as religious rather than domestic or military structures (Trump 1972: 24-25).

Regarding the third possibility (belief system centred on the heavens), Maltese temples were not always built on high places, though built on the inherently most visible places in the landscape. Nevertheless, as the present findings indicate, the temples do connect to the skyscape in other ways, adding further weight to this hypothesis, as discussed below. The fourth possibility (ceremonial) could also be relevant to Malta as these unique and impressive megalithic structures, seem to not only be purposely built *to be seen* in their regional settings but they would also be eye-catching as they would stand out in the surrounding landscape (Sagona 2015: 47, Tilley 2004: 89-91). Lastly, the idea that temple location may relate to power and authority is not new. Renfrew (1973: 170-172) suggested that the Maltese temples were territorial markers dividing the islands into separate chiefdoms, which is a theory that may now be considered outdated (Cazzella and Recchia 2015: 106, Renfrew 2007: 12). Nevertheless, the possibility that these prehistoric structures, were a symbol of both religious and political connotations not unlike medieval churches, mosques and the tower kivas (Kantner and Hobgood 2016), the symbolic effect of viewscape, cosmology and temples cannot be so easily discarded.

Other studies have highlighted other possibilities. According to Susmann (2020: 1-3), the ancient Greeks built sanctuaries in prominent, that is noticeable, locations which were believed to be the venue where the gods wished to establish contact with people. The Maltese Temples too have been described as sacred sanctuaries devoted to a deity (Zammit 1929a: 46, 55). There are many examples of Temple Period statues and statuettes assumed to represent deities (Krupp 1997: 129-130, Malone and Stoddart 2011: 765, Monsarrat 2004: 303-305, Renfrew 1986: 129, Vella Gregory and Cilia 2005: 19). Based on the above, it is not inconceivable that Maltese temples, like the Greek sanctuaries, were positioned where the gods wanted to intervene with humans.

Another possibility is suggested by Drageset's (2017: 175-178) study of the Iron Age Eide barrow in Norway, which was erected by powerful local leaders where the intention was *not to be seen*, but *to see* and exercise control of trading and traffic routes in the area. Within prehistoric Malta, we do not know what the trading routes were, but it is possible that temples were located within sight of them (Grima and Mallia 2011: 228), further adding to the political dimensions discussed above.

5.4.2 Why did people build monuments on places with intervisibility to other similar monuments?

There are studies of intervisibility between monumental sites, however, most do not go into the interpretative possibilities of why intervisibility was intentionally sought by the builders of those monuments (Chapman 2006, Lopez-Romero Gonzalez de la Aljea 2008, Vukomanovica *et al.* 2018). Some authors have interpreted intervisibility between similar sites as evidence of communication through signalling (Čučković 2014, Grau 2003, Ruestes Bitrià 2008, Van Dyke *et al.* 2016). The viability of this for Temple Period Malta has already been discussed above.

Applying cumulative viewshed methodology, Wheatley (1995: 174-176) suggested that the Neolithic Long Barrows in southern England must represent some sort of socio-political entities, and that the monuments were ritual foci in addition to imposing features in the landscape. As most barrows are intervisible with each other, it is suggested that new monuments were created in locations where an existing one could be seen, thereby the constructional legitimacy of the extant barrow progresses to the new one, reproducing a structure of social authority embedded in territorial markers (Wheatley 1995: 179-180).

For Temple Period Malta, Wheatley's hypothesis could bring in some new points on why some temples had intervisibility and others not, as follows:

i) building a new temple with intervisibility to an existing temple could add or transfer religious, cosmological, social, or political legitimacy to the newer temple;
ii) temples with reciprocal viewscapes could have their legitimacy further strengthened;
iii) temples without intervisibility may be indicative of socio-political or cosmological differences, as could have been a case in territorial regions in Malta, where in this respect temple chronology should be considered (ref. Chapter 2).

5.4.3 Why do people build monuments on places with opens views to the south?

This question has not been addressed by many scholars. One of the few studies on the subject is that of Cummings *et al*. (2002) who noted that the Welsh chambered cairns were built on locations with a restricted horizon on one side and an open one on the other (see Chapter 3). This asymmetry is reflected also in the structure of the cairns and the placement of the bodies inside (Cummings *et al.* 2002: 66-67). Cummings *et al*. (2002: 67) suggest that 'it is the transitory and in-between nature of these places that was emphasized upon construction’. The cairns would have taken advantage of this quality and transformed the dead person from the symmetric being they were when alive, to an asymmetric one that mirrored the wider world (Cummings *et al.* 2002: 67). Cumming *et al.* (2002: 68) conclude that the decision to build cairns in these asymmetric locations , and the usage of the cairns ‘…all helped to reinforce ideas about the world,’ where the ‘…human body could be both understood and reworked.’ In other worlds, the cairns and the activity that took place in them emphasised how the builders viewed the world, their cosmology.

When considering the possible application of these ideas to the Maltese temples, a number of aspects need to be considered. Firstly, the temples were not burial sites, but were used by the living (Malone and Stoddart 2011: 762), therefore the funerary transformation suggested by Cummings *et al*. (2002) is not directly applicable. Nevertheless, Maltese temples could have been the place of ritualized processions and other ceremonies which embodied an understanding of a holistic worldview of life, death, and ancestors (Malone and Stoddart 2009: 365, 374). In addition to the asymmetric horizons, temple structures also showed a form of asymmetry in their plan through the existence of low visibility and hidden areas, potentially involving secret deity cults, in contrast to other high visibility and accessibility areas used for more open liturgical actions (Anderson and Stoddart 2007: 43). This has been interpreted as emphasising different levels of access, the hidden areas only for a selected few, whereas the high visibility areas open to commoners (Malone 2007: 24, Trump 2002: 89). However, Cummings *et al*.’s (2002) work suggests that such asymmetries may not relate so much to differential access but both sides complement each other to represent an asymmetric cosmology, as well as work together to help in whatever ritual transformations were enacted in the temples themselves. Relating to this study, more research on the hypothesis of comparing the internal layout of the temples with external landscape asymmetries, would be needed and could be a research area for future studies.

Nevertheless, one possible explanation for this cosmological landscape enactment could be that temples were intentionally built on terrain with southern aspect which would often (though not necessarily always) offer more open views towards the south. This is exactly what Grima (2004: 340-41) found in his statistical study. There are several potential reasons for an interest in this. Archaeological evidence indicates that some temples were built on pre-existing settlement sites (McLaughlin *et al.* 2020b, Trump 1966a). Much like contemporary Maltese *girna*, the majority of which are built with a southern facing entrance (Fsadni 1999), the Maltese temples may have been built on southern facing slopes to maximise sunlight entering the monuments (Turnbull 2002: 132) or protect from harsh winter northern winds (Agius and Ventura 1981: 13, Foderà Serio *et al.* 1992: 117). A third hypothesis is to minimise workload when building forecourt terraces level with the temples by taking advantage of the southern facing slopes (Grima 2004: 340-341). Another potential reason is that, if the temple builders wanted to align the temples with something to the south (see discussion below), then having an open, uninterrupted view would have helped at the very least, if it was not a requirement on its own. For example, Hoskin (2001a: 29, 43) maintains that the taula sanctuaries of Menorca, with a construction peak around 1,000 BCE, were built with an orientation to the south in order to have an uninterrupted view of the Cross-Centaurus star group which at that time was low in the sky, and close to the horizon.

5.4.4 Why do people build monuments that align with stars?

There are many claims of alignments to Sun and Moon in the archaeoastronomical literature, but alignments to stars are rarer (Ruggles 2015c). A study of Silva (2015a) of the Neolithic dolmens in central Portugal showed them to align to the rising of the star Aldebaran. Silva (2015a: 131-135) provided a number of possible interpretations for this alignment, which he split into two groups. One group focuses on what this celestial alignment may have meant for the people who built the dolmens. The seasonality of Aldebaran's rising coincided with the seasonal movements of these pastoral communities in the landscape, making the alignment to the star's heliacal rising a good calendrical marker for what must have been the most important social event for those communities (see also (Dicks 1970: 36, Ventura 2004: 323)). Other hypotheses of Silva (2015a: 134-135) are that the heliacal rising marked the right time for either initiation rites that were performed inside the dolmens (see also (Aveni 2008b: 231-236, Brady 2015, 2018: 132, Harding 2013: 217)), or it could be the right time for funerary rites to bury the dead inside

(Silva 2015a: 133). The second group of interpretations focuses on what the star may have meant for the dead buried inside the chambers of these dolmens. Silva suggested that the star may have either:

i) marked the heavenly abode the dead ancestors returned to;
ii) escorted the dead into the afterlife (see also Magli (2009: 350));
iii) taken care of the dead buried inside while the living was away for half of the year;
iv) was a beacon showing the dead where the living went in summer, which was the mountain above which the star rose (Silva 2015a: 133-134).

Silva's (2015a) reasoning behind the dolmens' stellar alignment can be applied to the Maltese temple alignments towards Gacrux and Avior. The Maltese temples were places for the living (Malone and Stoddart 2011: 762), therefore the group of Silva's interpretations that relate to the dead are unlikely to be relevant. However, it has been suggested that the temples may have been part of a ritualised procession wherein the bodies of the dead were carried from the temples to the hypogea where they were buried (Malone and Stoddart 2011: 768, Malone *et al.* 2009: 376). The stellar alignments of the temples may have timed or played a cosmological role in these rituals. However, further study of this connection with the hypogea is necessary to fully explore this possiblity.

Focusing now on Silva's (2015a: 134-135) interpretations for the living. As to the seasonality of the stars acting as calendrical markers for the agropastoral cycles of the living there is no evidence to allow an independent reconstruction of the seasonality of the prehistoric Maltese. On the other hand, Ruffell *et al.* (2018: 186) suggest that the seasonal climate in Malta was typical for a south Mediterranean location with heavy rainfalls from October to February and a dry season from May to August with maximum temperatures from May to September.

Silva's (2015a: 135) other hypothesis is that the heliacal rising marked the right time for rites performed inside the megalithic structures. In particular, Silva focuses on initiation rites where the initiate would spend the night at the dolmen and observe the rising star just before sunrise. Similarly, in the Maltese temples aligned to Gacrux or Avior the same phenomena could have been experienced by initiates standing along the main axis and facing the entrance to observe the star (as originally suggested, in slightly different form, by Foderà Serio *et al*. (1992: 107). Therefore, the temples may have played a role in the cosmological initiation of the younger generations into adulthood. If this occurred in Malta, then it would have had to happen around either the September equinox (for those temples aligned to the rising of Gacrux or Avior) or around the March equinox (for those aligned to their setting).

It is possible that these stars did not only provide the timing of events, but they were actually active participants in ritual performances. This was suggested by Boutsikas and Ruggles (2011) who investigated the Artemis Orthia rites carried out at her sanctuary in Sparta. There are independent evidences that ritualised performances involving sacrifices may have been conducted at the temples, namely:

i) 'tethering' holes (Pace 2004b: 112), also named 'rope-hole' (Evans 1971: 81, 96), found in temple forecourts which may have been used to tie up animals before being sacrificed;

ii) at the Tarxien Temple a low-relief illustration of animals lined up in a row, could represent the animals most used for sacrifice, since quantities of their bones were found in various parts of the temple (Evans 1971: 120).

A similarity with the sacrificial rituals at Artemis Orthia could be present in Malta, where it is possible that rituals to worship, appease, or maintain favour with a star deity, represented in this case by Gacrux and Avior, may have been performed. It has been suggested that a specialised priesthood or ceremonial entity, that is an organizational body for both building and ritualised temple practice, was operating in the Maltese temples (Cazzella and Recchia 2015: 106, Evans 1971: 222, Renfrew 2007: 12). In similar fashion, Liritzis and Castro (2013) and Castro *et al*. (2015: 393) examined five Apollo temples in the Aegean and their orientations to celestial bodies, confirming through their study that '…there was a relationship between oracular temples where the heliacal rising and visual path of the constellations of the Lyra and Cygnus'. The orientations of the temples are argued to have been a deciding factor with regards to the oracular nature of these temples, while others without this celestial orientation were not considered oracular.

As already noticed, some Maltese temples had both stellar orientations and may have been the site of oracular practices. This is based on:

i) several temples having so-called oracle holes and rooms of a secretive quality, suggested to be used for communication, passing objects devoted to praying which could be in the context of religion, cult, or healing where exotic artefacts and cult objects were stored
(Barrowclough 2007: 50-51, Malone 2007, Zammit 1929b: 32-33);

ii) all oracular holes of the known six sites are on the right-hand side of the temple entrance (Lomsdalen 2014a: 24, 2014b: 31) and based on religious orientation of sun worshippers, right is strong (sunrise) and left is weak (sunset) (Hertz 1973, Malone 2007: 32), which could imply that oracular temple cult was an act of giving strength to the living;

iii) a form of oracular practice could have taken place at the same time that other rituals were performed, influenced by celestial events in the sky.

Another possibility is suggested by the study of Malville *et al*. (2008: 141-142) from the site of Nabta Playa in the Eastern Sahara, 100 km west of Abu Simbel. This was a cosmological ceremonial centre around 5,000 BCE, where young cows were scarified as part of ritualised ceremonies and there are cemeteries indicating that there was also an interest to preserve the remains of the dead (Malville *et al.* 2008: 131-133, 140). A solid testimony for sky involvement could be the persistent orientations of megaliths, human and cattle entombments towards the brightest stars in the fifth and fourth millennium BCE night sky, namely Arcturus, Sirius, α Centauri, and Alnilam in the belt of Orion (Malville *et al.* 2008: 137-138). Malville *et al*. (2008: 142) suggest that 'survival in the desert may have required an ability to navigate by the stars, as the nomads moved across the sea of sand without trails or major landmarks'. As discussed in Chapter 4, the stars Gacrux and Avior have historically played a role in navigation and may have also done so during the Maltese Temple Period.

Finally, Hoskin's (2001a: 43) possibility that the already-mentioned stellar alignments of the Menorcan taula sanctuaries helped identify these as places for healing must be mentioned. According to him the stars of Centaurus in the southern hemisphere represented, in Greek mythology, Chiron which was their god of medicine. However, the scholar did not explore what specific role the alignments may have played in this.

That the Maltese temples were a site for religious rituals and ceremonies connected to celestial events is already widely proposed in this thesis, but that some of them were also used, at least partially, as sanctuaries for healing, could be argued based on the following:

i) several clay figures with diseased body parts were found, suggesting the site was devoted to a healing deity (Zammit 1929a: 55);
ii) pieces of shells were inserted into figurines before firing, hinting at magical practices that may have had a healing purpose
(Vella Gregory and Cilia 2005: 106);
iii) there are also what appear to be representations of foetuses, associated with weeks of gestation, and midwife's form of body function
(Vella Gregory and Cilia 2005: 106);
iv) a shrine containing human and animal parts was found before building the temple at Skorba (Trump 1966a: 10-11).

5.4.5 Implications for previous research on Temple Period cosmology

Stoddart (2022: 8) recently stated that 'There is strong evidence that the cosmology of prehistoric Maltese religion can be reconstructed from the placement of the club houses [temples] in the landscape'. The present thesis has provided further support for Stoddart's statement. This section shall briefly discuss the implications of this thesis' results for the understanding of Maltese prehistoric cosmology, and how it has confirmed or put into question earlier interpretations by previous authors.

The results obtained from the present research have lent new support to the interpretation put forward by Grima (2001: 56) when he proposed, by looking at temples' inner spatial distribution and iconography, that the Maltese temples may have made references to land and sea, '… the two most inevitable components of an islander's cosmology…'. Although the present thesis did not fully consider the relationship between the temples and the sea (ref. 2.5.8), it has added further weight to Grima's argument that there was a significant relationship between the temples and their landscape setting. The present research has demonstrated that Maltese temples were preferentially built in very specific locations with unique features to the wider landscape. Temples were built in the inherently most visible part of the landscape, likely to ensure their visibility across wide areas (Chapter 2) and commanding an open view (Chapter 3). Grima (2001: 56, 2005: 246-253, 2007: 40), informed by Turnbull (2002), has argued for a performative aspect to the iconographic representations of elements of land and sea inside the temples. The present work highlights how such ritual performances may have involved engaging with a view of the landscape itself and/or included elements that were meant to be seen by people in the wider landscape. In addition, this thesis brings in a third element to Grima's islander's cosmology, namely the sky and cosmos, which makes for a more holistic and 3-dimentional view of the world they lived in (Chapter 4).

In another seminal paper, Robb (2001: 190) argued that the movements inside the temples were a travel in space and time for exploring new knowledge, '…and returning as changed individuals…'. Robb (2001: 192) highlights the role of the geographical positioning of temples in the cultural landscape and how, through rituals, the islanders constructed a new cosmological value system. The results obtained here support this interpretation. The present research has demonstrated the careful choice of location for building the temples, and how location appear to have been chosen to enhance visibility of whatever ritual performances were conducted there (ref. 2.5.8). In addition, the temples may have played a role for cosmological initiation rites involving sky watching from within the temples. In particular, the results obtained here have shown compelling evidence that the Temple builders may have given particular attention to observing when Gacrux and Avior were rising on the horizon (see 5.4.4).

This thesis has argued that the special location of the Maltese temples, as well as the networks of intervisibility between them, by imposing a structure or order unto the landscape, could act as a form of domestication of the landscape itself. This finding is consistent with Tilley's (2004: 144) general proposal that the temples '…created the landscape through its domestication and incorporation into a social and cosmological world'.

With respect to Tilley's more specific suggestions, the results of the present research lend support to some, while rejecting others. For example, Tilley (2004: 92) suggests that temples are located on upper and lower hill slopes. However, on the basis of statistical testing, no preference for temples being built on high or low locations was found (ref. 2.4.1). Another point raised by Tilley (2004: 92) is that temples were built in locations with a view to either the sea or fertile inland. This is supported by the present results which, as already mentioned, feature a statistically significant preference for locations with an open view. On the other hand, regarding temple visibility, Tilley (2004: 92) maintains that 'They are not sited for maximum visibility'. The findings of the thesis have led to a different conclusion. Statistical analysis concluded that temples were located in the most inherently visible portions of the archipelago's landscape (ref. 2.4.2). In fact, as stated in 2.5.8 the present work shows that visibility and intervisibility were a '…unifying element for the viewscape of the cosmology they all shared…' and, therefore, an important element of the Maltese temple cosmology, an aspect not considered by Tilley.

Skeates (2010: 97) suggests that it is debatable whether the Maltese landscape was structured '…according to cosmological belief and ritual monuments…'. It appears that there is now less reason for such reticence, in view of the clear evidence obtained in the present research that the temples as ritual monuments were not randomly located in the cultural landscape, and that intervisibility between temples most likely was an important ingredient in the role they played in the islanders' cosmology.

The suggestion by Malone (2007: 26-27) that celestial bodies like Sun, Moon, and constellations like the Southern Cross, could in some cases have been '… significant stimuli for temple orientations…' is strongly supported by the present research. The results of two completely different but complementary statistical analyses (see 4.4 Results) clearly indicate that the Maltese temples were not orientated at random but, instead, display statistically significant alignment to Gacrux, which is a star in the Southern Cross, and Avior, a star in the so-called False Cross (ref. 4.5.4). Therefore, these stars are likely to have been important stimuli for temple orientations, at least early on in the Ġgantija phase. In addition, Malone and Stoddard (2009: 376, 2011: 769) consider a holistic cosmological perspective that places the dead under the ground, the living on the ground, and the ancestors on the sky. This hypothesis may be extended further by this thesis, as it may be suggested that Gacrux and Avior may have symbolically represented the islanders' ancestors, or their heavenly abode.

The results obtained here for significant stellar alignments arguably vindicate, confirm and build upon a long tradition in the history of Maltese prehistoric research. Vance (1842: 231-233) was the first to propose an astronomical connection with the temples, while Zammit (1929b: 13) was the first scholar to connect the Maltese temples with the Southern Cross. Ugolini (1934: 128, 138) advocated a potential link between temple orientations and celestial bodies. With respect to more recent research, this thesis' findings support Ventura (2004), Ventura et al. (1993), Agius and Ventura (1981) and Cox (2001) and their findings with respect to the possibility of stellar alignments to constellations such as the Southern Cross, as well as stars like Avior. The present research, however, has gone further, by explicitly exploring cosmology in a broader sense that looks not only at the skyscape, but also at the landscape and viewscape.

During the final revision of this thesis, a new paper was published bringing in a cosmological connection between Crux (the Southern Cross) and the Maltese temples (Barratt 2022). Barratt (2022: 15) suggests a line from inside the temples to Crux was an axis mundi, '…leading from the centre of the world (the temple) to the skies (Crux), via the human world (landscape)…'. The present research concurs with and supports the possibility of a holistic relationship between the temples, some stars and the landscape. Another intersection with Barratt's (2022: 16) work, is the view, already mentioned above, that rites of passage performed at the temples may have included star watching as part of the ritualised cosmological transformation process. A key difference between the present thesis and Barratt's research, however, is that Barratt considers the whole of the constellation Crux, while the results obtained here indicate a more specific interest in one star of the Southern Cross, Gacrux, as well as a second star from the False Cross, Avior, as already mentioned (ref. 4.5.4).

As a final reflection on this topic, the results of the present research have lent new support to Darvill's (2008a: 111) definition of cosmology: 'The world view and belief system of a community based upon their understanding of order in the universe'. This thesis has demonstrated through landscape archaeology, horizon astronomy and skyscape archaeology that the Maltese Temple Period's communities did have an understanding of an order in the universe they lived in. Future research will undoubtedly continue to enrich our understanding of the complex and nuanced cosmology of this extraordinary culture.

5.4.6 Conclusion: Bringing it all together

Above a total of twenty seven possible interpretations were considered, of which nineteen were retained based on archaeological, anthropological, and astronomical considerations (see Table 5.1).

RETAINED	LACK OF EVIDENCE	DISCARDED
Most visible places: • **Belief system focused on heavens** • **Ceremonies to be seen in the distance** • **Power and authority** • **Place of gods establish contact**	*Most visible places:* • Communication	*Most visible places:* • Defense
Intervisibility: • **Transfer of political/cosmological legitimacy**	*Intervisibility:* • Communication • Control over trading routes	
Open views on one side: • **Ritual transformations** • **Holistic cosmology**		*Open views on one side:* • Funerary transformation
Open views to the south: • **Maximise sunlight and solar energies** • **Protection from winter wind** • **Minimise workload for building** • **Uninterrupted view for alignments**		
Stellar Alignments: • **Rituals timed by the stars** • **Calendrical markers** • **Initiation rites** • **Stars as ritual participants** • **Star deity** • **Oracular** • **Navigation** • **Healing**		*Stellar Alignments:* • Heavenly abode of the ancestors • Escort to afterlife • Taking care of the dead • Beacon for the dead

Table 5.1. Possible concluding interpretations.
The table lists by columns which elements connect to implications of cosmology were retained, which ones have a lack of evidence and the one discarded.

Of the elements retained in Table 5.1, it is clear that interpretations that focus on the temples as potential places for ritual ceremonies are present in all five areas, therefore making them strong candidates for a holistic interpretation. Though speculative, based on the findings of this thesis, it can be suggested that ceremonies with the following qualities may have been performed at the Maltese temples. Firstly, at least some ceremonies were meant to be seen from afar, including from other temple sites, possibly creating a cosmological or religious transfer of legitimacy between temples. Secondly, some ceremonies, of a more private nature, would involve ritual transformations such as those found in initiation, oracular, or healing rites. These are more likely to have happened inside the temples, possibly in some of the less accessible rooms. Thirdly, such ceremonies would have involved a holistic cosmology that related and connected the external world with the inner space of the temple, while still involving a focus on the heavenly sphere. Finally, the viewscape of the stars Gacrux and Avior would have played a role in these ceremonies, either by providing the right time in the year for them to occur, or by more actively participanting in them, for example if these stars, or the constellations they represent, were considered to be deities. This ceremonial focus does not deny the others, such as navigation, power and authority, communication, etc. These could also have played a complementary role at these sites. However, the ceremonial explanation of temples and their positioning in the landscape sufficiently explains all observed findings to this research relating to;

Viewscapes and Cosmology in the Prehistoric Temples of Malta.

5.5 Further research

Though this study is fairly complex in itself, there are still areas for further research. When it comes to each separate research chapter, some areas for future studies have already been mentioned. Concerning this final chapter regarding the integration of viewscape and cosmology, the following research areas could be such a case.

Regarding GIS, there are specifically two areas that could be suitable for further research. One is to analyse the visual relationship between two Maltese sacred monumental structures, being temples and hypogea. The other areas could be investigating to what extent there is a temple affiliation between landscape and seascape based on viewscape and cosmology. This could imply that temples were visible from the sea, and temples were an integrated part of the archipelago's seascape.

By combining GIS and astronomy, one study could be new research emerging from the first and the third research question of this thesis. That study could consider the temple intervisibility it has already identified, and further examine each site's azimuths and declinations to reveal if temples were placed in locations where celestial events would rise and set over other temples.

In horizon astronomy and archaeoastronomy a further study to what is done in this thesis could be to investigate the cycle of the Moon, monthly, yearly and its 18.6-year cycle. As illustrated in this thesis, astronomical phenomena in the southern hemisphere seemed to be of high concern to Temple Period's society. A relevant study could be to examine if celestial events in the northern hemisphere may also have been of cosmological significance. Another area which this study has touched upon is sky events related to timing of the year and calendric revelation. A new study could further develop this part, and in association with cosmological implications related to feasts and ritualized ceremonies and events.

Relating to a holistic worldview concept, research could be to what terms the stars were considered deities and if the Sun and Moon could have been god or goddesses' representation of the Temple Period cosmology as they have been in many ancient cultures and societies.

Many scholarly questions have been raised regarding the rise and fall of the Maltese Temple Period. A relevant research area could be to further investigate on the assumption that the start and the end was influenced by the islanders' cosmology, or; if cosmology was the essential ingredient and core motivation for the rise and fall of the Maltese Temple Period?

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7 Appendices

This section presents 6 Appendices of data collection used for further analysis as referenced in the relevant chapters. The intention of this section is to allow for data collection verification.

7.1 Resumé fieldwork

Short version of names and solar descriptions:
Summer solstice sunrise (SSSR), Summer solstice sunset (SSSS), Equinox sunrise (EQSR), Equinox sunset (EQSSS), Winter solstice sunrise (WSSSR), Winter solstice sunset (WSSS), Tore Lomsdalen (TL). If a site visit was just by my myself or with my assistant, no name is mentioned.

A total of 196 registered site visits during the research program.

2015

June
Kordin III, FRAGSUS Excavation (about two weeks participation)
SSSR observation

September
22 SEP: Xrobb l-Għaġin, EQSR
22 SEP: Tas-Silġ, EQSS
23 SEP: Tas-Silġ, EQSS
24 SEP: Xrobb l-Għaġin, EQSR
25 SEP: Tas-Silġ, EQSR
26 SEP: Xrobb l-Għaġin, EQSR
27 SEP: Mnajdra – Moon observation

December

18 DEC: Xagħra Circle, WSSR

19 DEC: Xagħra Circle, WSSR

20 DEC: Xrobb l-Għaġin, WSSR

21 DEC: Xrobb l-Għaġin, WSSR

22 DEC: Xrobb l-Għaġin, WSSR

23 DEC: Kordin III, WSSR

26 DEC: Ta' Marżiena, WSSR

2015: Total 15 field visits

2016

January

21 JAN: F. Silva, TL – observing Mount Etna from Mdina

23 JAN: F. Silva, TL, Xrobb l-Għaġin, site visit, Total Station

24 JAN: F. Silva, M. Vassallo, R. Grima, TL – Ħaġar Qim and Mnajdra – site visits

February

20 FEB: Xrobb l-Għaġin, Total station

March

19 MAR: Borġ in-Nadur, EQSR & EQSS

20 MAR: Borġ in-Nadur, WQSR & EQSS

April

15 APR: Tas-Silġ, A. Bonanno, TL, site visit

16 APR: Tas-Silġ, Total Station

June

10 JUN: F. Ventura, TL, Mnajdra, cup mark stone

13 JUN: Ħal Saflieni, site visit Joe Farrugia, Katya Strout, Marie Helena Zammit, TL

14 JUN: Ħal Saflieni, A. Bonanno, TL, site visit, plus TL alignment measuring

16 JUN: Ħal Saflieni, R. Grima with students, TL site visit emphasis on faults, plus TL alignment measuring

17 JUN: Ħal Saflieni, F. Ventura, TL – alignment measuring

18 JUN: Ħal Saflieni, Alignment measuring

20 JUN: Ħal Saflieni, Alignment measuring

October

22 OCT: Ta' Ħaġrat, horizon observation

November

10 NOV: Ta' Ħaġrat, horizon observation

12 NOV: Xrobb l-Għaġin, horizon and waterfront

12 NOV: Xrobb l-Għaġin, horizon

14 NOV: Santa Verna, D. Cilia, TL, horizon observations

22 NOV: Tas-Silġ, F. Ventura, TL, site vist

24 NOV: Ta' Ħaġrat, Horizon observation

26 NOV: Tas-Silġ, Horizon observation

26 7NOV: Tas-Silġ, Horizon observation

December

09 DEC: R. Grima, TL – Tal-Qadi, Buġibba (Dolmen Hotel closed), Xemxija Temple – site visits

15 DEC: N. Vella, TL – Borġ in-Nadur, site visit, TL GPS readings Għar Dalam

19 DEC: Borġ in-Nadur, WSSR

20 DEC: Ta' Ħaġrat, WSSR and WSSS

20 DEC: Ta' Ħaġrat, WSSS

21 DEC: Borġ in-Nadur, WSSR

22 DEC: Tal-Qadi, WSS

23 DEC: Borġ in-Nadur, WSSR

24 DEC: Ta' Ħaġrat, WSSR and WSSS

25 DEC: Skorba, WSSR and WSSS

27 DEC: Xemxija Temple WSSR, Xemxija tombs WSSS

Total 2016: 41 site visits

2017

January

18 JAN: R. Grima, TL – Kunċizzjoni, site visit

19 JAN: Megaliths seaside down from Kunċizzjoni and Kunċizzjoni site

20 JAN: Ta' Ħaġrat, Skorba, Ġnejna Bay area for observation towards Kunċizzjoni

JAN total: 5 site visits

February

05 FEB: R. Grima, M. Vassallo, and TL Ras il-Pellegrin and Lippija

08 FEB: Żebbuġ Gozo for observations Sicily, St. Agatha's Tower, Selmun Palace

10 FEB: Met Mario Vassallo in Mġarr, discussed landscape, gave me all the published work

11 FEB: 4-5 hours research around the Ras il-Pellegrin site, cliff and landscape, horizon

14 FEB: Lippija. Panorama 360° and measurements of local horizon

16 FEB: Baħrija cliff, observation and measuring

26 FEB: GPS measurements Mnajdra South entrance, postholes SSSR, WSSR and 'Bowel stone'

FEB total: 9 site visits

MARCH

08 MAR: F. Ventura, TL Mnajdra, observation and measures 'Bowl stone' and SSSR point

17 MAR: Borġ in-Nadur, EQSR

18 MAR: Mnajdra South, EQSR, observations of rising point of Sun at the apparent horizon

Midday observations and panorama shots of apparent horizon of Ħaġar Qim and Mnajdra, Mnajdra South, EQSSW observations

19 MAR: 3 different sites visited

Ras il-Pellegrin: EQSR

Noon: Xrobb l-Għaġin: Observation apparent horizon and panorama photos

Kunċizzjoni: EQSS

20 MAR: Mnajdra: EQSR. F. Ventura and TL, observations sun rising on horizon and on MNS inner Altar

22 MAR: Lippija: EQSS

23 MAR: Ras il-Pellegrin: EQSR and EQSS

26 MAR: Kunċizzjoni and the two Megaliths: F. Silva TL, observations and alignments

29 MAR: Mnajdra: F. Silva and TL Bowel stone and standing stone

30 MAR: Tas-Silġ and Borġ in-Nadur: F. Silva and TL general observation. Tas-Silġ, Total Station

31 MAR: Ras il-Pellegrin and Lippija, Ta' Ħaġrat, Skorba: M. Vassallo, F. Silva,
TL general Observations

March total: 21 site visits

April

28 APR: Buġibba: General observations and horizon

30 APR: Buġibba: Controlling measurements done previous day

APR total: 2 site visits

MAY

09 MAY: Ħal Ġinwi: Two visits morning and afternoon

11 MAY: D. Cilia and TL. Gozo. Borġ il-Għarib South, Borġ il-Ġħarib North, L-Imrejsbiet, Xagħra Circle, Ġgantija, Triq ix-Xabbata, Borġ L-Imramma (Ta'Ċenċ)

12 MAY: Ħal Ġinwi, Ta'Raddiena, Ħal-Resqun (Gudja)

14 MAY: L-Iklin

17 MAY: Ta'Ħammut

31 May: Sailing tour around Malta. Intention to see all posible temple sites from the seaside. With a special permit from the authorities could go closer to Filfla Island and with

a dingy, even closer just meters away. General photosession of visble temple sites from the sea.

Total May: 14 site visits

Total site visits to this date: 107

<u>JUNE</u>

Summer soltice was on 21JUN at 04:24 GMT

17 JUN: Kunċizzjoni. SSSS

18 JUN: Kunċizzjoni. SSSS

19 JUN: Lippija. SSSS

20 JUN: Ħal Ġinwi. SSSR

20 JUN: Mnajdra, Standing Stone. SSSS

21 JUN: Xrobb l-Għaġin. SSSS, Gully

22 JUN: Xagħra Circle

23 JUN: Xagħra Circle, SSSR

North Cave, Xagħra

Ġgantija

Għar ta' Għejżu Cave, Xagħra

Xemxija

Pergola Cave (searched for it, but was not found)

Santa Verna, SSSS

24 JUN: Borġ L-Imramma, SSSR

Xlendi Cave

Kerċem Catacomb

Xemxija: M. Parker-Pearson, R. Grima, TL

25 JUN: Buġibba: SSSS

26 JUN: Ras ir-Raħeb, SSSR

Kunċizzjoni

Tal-Qadi, SSSS

27 JUN: Ħal Ġinwi, A. Bonanno and TL

20 JUN: Ta' Ħaġrat, Total Station

June: 25 site visits

SEPTEMBER

13 SEP: Tal-Ġiebja, searching for megaliths (not found) and GPS readings

It-Tumbata, GPS readings. Ħaġar Qim and Mnajdra South, verifying GPS readings and

intervisibility between two temples

28 SEP: Żebbuġ tombs inspection at San Blas Caritas, with person from Caritas R. Grima and TL

30 SEP: San Pawl Milqi, GPS reading of tombs. Tal-Qadi, verification of GPS readings

September: 7 site visits

NOVEMBER

01 NOV: Mġarr Hypogeum, Zafflieni, GPS readings

Santa Lucia Hypogeum, GPS readings

21 NOV: Lippija, Total Station readings of prominent features in the horizon – not concluded, raining

22 NOV: Lippija, same as yesterday, good atmospheric conditions

26 NOV: Lippija, readings, GPS, altitude, and azimuth

November: 5 visits

DECEMBER

03 DEC: Kunċizzjoni, Total Station readings of prominent features in the landscape

17 DEC: Xrobb l-Għaġin, Gully site, WSSR

Ras il-Pellegrin, WSSS

18 DEC: Lippija, WSSS

19 DEC: Ħaġar Qim, WSSR and measurements

23 DEC: Xrobb l-Għaġin, Gully site, WSSR

Lippija, WSSS

24 DEC: Ħaġar Qim, WSSR
Ras il-Pellegrin, WSSS

25 DEC: Skorba, Total Station
Ta’ Ħaġrat, Total Station
Xemxija Tomb 4, WSSS

December: 12 visits

Total site visits up to this date: 156, whereof 59 visits for sunrise and sunsets.

2018

FEBRUARY

16 FEB: Mġarr area, Id-Dwejra. TS-all_Malta_ED50, looking for possible temple sites

MAY

13 MAY: Ras il-Pellegrin, Total Station reading

JUNE

24 JUN: Mnajdra, SSSR and Entrance Window alignments of South Temple and Middle Temple

SEPTEMBER

25 SEP: EQSR Mnajdra, photographic session of sunrise

30 SEP: Ġgantija South and North, Total Station readings

OCTOBER

01 OCT: Ġgantija South and North, Total Station readings

04 OCT: Tarxien, entrance frame measurements, FS and TL

November

28 NOV: Landscape observations with Ħaġar Qim on apparent horizon, RG and TL

30 NOV: GPS registration with iPhone of observable places of Ħaġar Qim for QGIS

December

12 DEC: Kordin III, Total Station measurements

13 DEC: Ta' Ħaġrat, Total Station measurements

Skorba, measurements entrance

Ħal Saflieni, measurements entrance frame from level 1 to level 2

17 DEC: Mnajdra, Sunrise observation and Total Station measurements

18 DEC: Mnajdra, Total Station measurements of the three temples' entrance frame

19 DEC: Ħaġar Qim, Sunrise observation, Total Station measurements of the east and west entrance frame

21 DEC: Ta' Ħaġrat, sunrise observations

Ġgantija, sunset and landscape observations

22 DEC: Ġgantija, sunrise and landscape observations

24 DEC: Tarxien, Total Station measurements

2018 total site visits in 2018 were 20 and through all years up to this date are 176, of which 64 were for sunrise or sunset observations.

2019

January

30 JAN: Tas-Silġ, Total Station, measurements of the western entrance

March

04 MAR: Ħaġar Qim, Total Station, measurements of entrances Rooms 13, 12, 11, and the North Temple

07 MAR: Ħaġar Qim, measurements of entrance Room 19 by compass and clinometer

April

09 APR: Kordin III, East Total Station measurements of entrance

24 APR: Buġibba, with FV checking alignment measurements

Tal-Qadi, with FV checking alignment measurements

Xemxija Temple, taking back apse entrance window frame measurements

27 APR: Skorba East with MV, measurements with Total Station.

27 APR: Xemxija, retaking measurements from 24 APR 2019, plus outer apse entrance

May

05 MAY: Kunċizzjoni, Temple window entrance measurements with compass

10 MAY: Buġibba, Temples' window entrance measurements with Total Station

June

03 JUN: Tal-Qadi, with RG, Total Station readings of the East entrance

06 JUN: Borġ in-Nadur, Total Station readings of the West Temple

07 JUN: Tarxien, entrance window frame measure of Tarxien Far East

08 JUN: Borġ in-Nadur, Total Station readings of the East Temple

10 JUN: Tarxien, entrance window frame measurements with the Total Station of the Far East Temple

23 JUN: Ħaġar Qim, observation of SSSR

24 JUN: Mnajdra South, observation of SSSR and measure orientation of Room 3

17 site visits in 2019 with a total of 193 site visits to this date.

2020

September

07 SEP: Ħaġar Qim. Site inspection and GPS readings of a hypothetical relocation of Ħaġar Qim applying GIS

25 DEC: Xemxija and Kunċizzjoni, verification of GPS and alignment data

Three site visits in 2020.

A total of 196 registered site visits during the research program.

7.2 Attributions of temple structures to different phases

This table is commented on in section 4.3.4 page 227.

Temple Name	Phase	References archaeological record
Mnajdra South	Ġgantija	Evans (1971: 101-103), Pace (2004a: 128-131), Trump (2002a: 148-151)
Mnajdra Central	Tarxien	Evans (1971: 101-103), Pace (2004a: 128-131), Trump (2002a: 148-151)
Mnajdra East	Ġgantija	Evans (1971: 101-103), Pace (2004a: 128-131), Trump (2002a: 148-151)
Ħaġar Qim East	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim West	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim Room 10	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim Room 11	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim Room 12	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim Room 13	Ġgantija	Evans (1971: 88-90)
Ħaġar Qim North	Tarxien	Evans (1971: 88-90)
Borġ in-Nadur West	Tarxien	Evans (1971: 7-14), Pace (2004a: 105), Trump (2002a: 140-141)
Borġ in-Nadur East	Tarxien	Evans (1971: 7-14), Pace (2004a: 105), Trump (2002a: 140-141)
Tas-Silġ East	Tarxien	Pace (2004a: 101), Trump (2002a: 138-139)
Tas-Silġ West	Tarxien	Pace (2004a: 101), Trump (2002a: 138-139)
Xrobb l-Għaġin	Ġgantija	Evans (1971: 26-27), Pace (2004a: 103),
Tarxien South	Tarxien	Evans (1971: 135-137), Pace (2004a: 64), Trump (2002a: 120-127).
Tarxien Central	Tarxien	Evans (1971: 135-137), Pace (2004a: 64), Trump (2002a: 120-127)
Tarxien Room 10	Tarxien	Evans (1971: 135-137), Pace (2004a: 64), Trump (2002a: 120-127)
Tarxien East	Uncertain	Evans (1971: 135-137)
Tarxien Far East	Ġgantija	Evans (1971: 135-137), Pace (2004a: 64), Trump (2002a: 120-127)
Kordin III West	Ġgantija	Evans (1971: 77-78), Trump (1966: 47)
Kordin III East	Ġgantija	Evans (1971: 77-78), Trump (1966: 47)
Ta' Ħaġrat West	Ġgantija	Evans (1971: 34), Trump (1966: 47)
Ta' Ħaġrat East	Ġgantija	Evans (1971: 34), Trump (1966: 47)
Skorba West	Ġgantija	Trump (1966: 47)
Skorba East	Tarxien	Trump (1966: 47)
Konċizzjoni	Tarxien	Pace (2004a: 157), Trump (2002a: 166)
Buġibba	Tarxien	Evans (1971: 111)
Tal-Qadi	Tarxien	Evans (1971: 42)
Xemxija Temple	Uncertain	Trump (2002a: 162-165)
Ġgantija South	Ġgantija	Evans (1971: 180)
Ġgantija North	Ġgantija	Evans (1971: 180)

7.3 Temple coordinates

The following temple coordinates are based on this study's field surveys, except in 5 cases where temples are destroyed, and coordinates are referenced by Grima and Cilia (ref. sections 2.3.1 page 26 and 2.3.9 page 53).

Sites	**Details**	**Location**	**Y**	**X**
Hagar Qim	Centre	Qrendi	35.82770	14.44205
Mnajdra	South entr.	Qrendi	35.82663	14.43628
It-Tumbata (Destroyed)	Grima 2005	Luqa	35.85816	14.48324
Id-Debdieba (Destroyed)	Grima 2005	Luqa	35.85296	14.46712
Hal Resqun	Site, Gudja	Luqa	35.85315	14.49607
Tarxien	Oracle Sanct.	Tarxien	35.86926	14.51225
Kordin I (Destroyed)	Cilia 2004	Tarxien	35.88125	14.50482
Kordin II (Destroyed)	Cilia 2004	Tarxien	35.88144	14.50637
Kordin III	Entrance	Tarxien	35.87712	14.50876
Borg in-Nadur	Centre site	Marsaxlokk	35.83114	14.52892
Tas-Silg	West entr.	Marsaxlokk	35.84583	14.55231
Xrobb I-Ghagin	Back apse	Marsaxlokk	35.84385	14.56853
Hal Ginwi	Site	Marsaxlokk	35.84700	14.54681
Tar-Raddiena	Site	Iklin	35.90463	14.46301
L-Iklin	Site	Iklin	35.91056	14.45424
Ta' Hagrat	Entrance	Mgarr	35.91853	14.36858
Skorba	Back apse	Mgarr	35.92089	14.37767
Ras il-Pellegrin	Site	Mgarr	35.91689	14.33747
Tal-Lippija	Site	Mgarr	35.92375	14.34525
Kuncizzjoni	Entrance	Mgarr	35.90083	14.34000
Ras ir-Raheb	2 megaltihs	Mgarr	35.90639	14.32872
Tal-Qadi	Entr. stairs	St. Paul Bay	35.93663	14.42050
Ta' Hammut	Site, PA	St. Paul Bay	35.94201	14.44412
Bugibba	Back apse	St. Paul Bay	35.95480	14.41808
Xemxija	Back apse	St. Paul Bay	35.94909	14.37938
Ghajn Zejtuna (Destroyed)	Grima 2005	St. Paul Bay	35.96825	14.36841
Ggantija	Entr. South	Gozo	36.04717	14.26905
Santa Verna	Site	Gozo	36.04575	14.25861
Borg Gharib South	Site	Gozo	36.03025	14.28601
Borg Gharib North	Site	Gozo	36.03012	14.28449
L-Imrejsbiet	Site	Gozo	36.02969	14.28435
Xewkija	Site	Gozo	36.03153	14.26128
Triq ix-Xabbata	Site	Gozo	36.02361	14.24296
Ta' Marziena	Back apse	Gozo	36.03336	14.23990
Borg L-Imramma	Site	Gozo	36.01971	14.25807

7.4 Temple entrance orientations

This table shows the data compilation applied to establish the orientations of temple entrances as explained in section 4.3.6 page 231. The measurements of azimuth (Az.Mid) and declination (Dec.Mid) are from the middle of the entrance, and the azimuth of the half-width (Az.Half-width) of the temple entrances, were the computing dataset for static inferential analyses (ref. Results 4.4).

		Azimuth				**Altitude**		**Horizon**	**Declination**		
Temple Name	**Latitude**	**Az.Left**	**Az.Mid**	**Az.Right**	**Az.Half-width**	**Alt.Top**	**Alt.Bottom**	**Alt.Middle**	**Dec.Min**	**Dec.Mid**	**Dec.Max**
Mnajdra South	35.82664	90.9	94.0	99.1	4.1	7.0	-7.0	4.0	-5.0	-0.9	1.6
Mnajdra Central	35.82684	135.2	136.9	140.5	2.6	0.1	-6.6	-3.0	-40.9	-38.5	-34.4
Mnajdra East	35.82683	197.9	205.7	211.8	6.9		-6.0	-1.7	-52.1	-48.4	-44.9
Hagar Qim East	35.82774	123.9	128.7	134.4	5.3	3.9	-6.6	0.0	-34.6	-30.4	-26.9
Hagar Qim West	35.82774	301.6	307.6	314.6	6.5	9.2	-8.2	2.0	26.4	31.0	36.1
Hagar Qim Room 10	35.82763	294.2	298.2	301.2	3.5	10.0	-1.0	2.0	20.7	23.8	26.1
Hagar Qim Room 11	35.82786	349.7	357.5	5.3	7.8			0.3	53.2	54.1	54.5
Hagar Qim Room 12	35.82786	249.7	254.5	259.6	5.0			0.3	-16.2	-12.3	-8.2
Hagar Qim Room 13	35.8276	201.6	207.9	215.0	6.7	7.0	-5.0	0.4	-49.3	-46.1	-42.0
Hagar Qim North	35.82819	183.4	187.3	189.9	3.2			0.1	-53.9	-53.4	-52.9
Borg in-Nadur West	35.83121	112.1	119.4	126.5	7.2		-5.0	0.1	-28.7	-23.4	-17.6
Borg in-Nadur East	35.83115	94.8	101.2	107.3	6.2	1.8	-6.8	0.9	-13.4	-8.5	-3.4
Tas-Silg East	35.84589	99.9	105.0	109.7	4.9		-6.0	1.0	-15.3	-11.5	-7.4
Tas-Silg West	35.84583	277.5	285.4	293.0	7.8		-6.0	1.0	6.7	13.0	19.1
Xrobb l-Ghagin	35.84381	124.0	128.6	132.0	4.0		-10.0	0.0	-32.9	-30.4	-27.0
Tarxien South	35.86926	196.5	199.7	202.7	3.1	0.7	-4.8	0.5	-50.5	-49.3	-47.9
Tarxien Central	35.86935	226.2	230.2	233.2	3.5	4.0	-7.0	0.6	-33.7	-30.8	-28.6
Tarxien Room 10	35.86931	139.7	141.7	142.7	1.5	4.0	-3.0	0.0	-40.1	-39.5	-38.2
Tarxien East	35.86929	193.9	199.7	206.4	6.3	6.5	-10.6	0.4	-51.5	-49.4	-46.2
Tarxien Far East	35.86919	165.6	169.7	172.5	3.5		-6.6	0.4	-53.1	-52.5	-51.3
Kordin III West	35.87718	146.6	148.9	151.3	2.3		-2.0	1.2	-41.8	-42.9	-44.0
Kordin III East	35.87714	194.7	199.2	204.0	4.6		-3.0	0.8	-50.9	-49.2	-47.1
Ta' Hagrat West	35.9185	127.1	131.1	135.2	4.0	5.0	-6.0	4.0	-32.1	-29.4	-26.5
Ta' Hagrat East	35.91867	168.5	175.6	182.7	7.1		-3.0	5.0	-50.0	-48.9	-48.7
Skorba West	35.92087	128.6	133.6	138.1	4.8	4.5	-8.0	4.0	-34.1	-31.1	-27.6
Skorba East	35.92081	165.6	169.9	173.6	4.0		-7.0	3.2	-50.4	-49.7	-48.6
Koncizzjoni	35.90085	265.2	268.2	270.7	2.8		-3.0	1.5	-3.0	-0.6	1.2
Bugibba	35.95858	182.6	186.5	190.0	3.7	2.0	-3.0	1.5	-52.5	-52.1	-51.4
Tal-Qadi	35.93666	64.5	72.1	74.8	5.1		-3.0	4.5	14.9	17.1	23.2
Xemxija	35.94908	134.2	139.2	146.2	6.0		-2.0	3.0	-40.7	-35.5	-32.9
Ggantija South	36.04727	127.6	129.9	131.4	1.9	2.0	-5.0	1.0	-32.0	-30.5	-28.9
Ggantija North	36.04741	128.9	132.6	135.4	3.2	3.0	-5.0	1.0	-34.4	-32.5	-29.8

7.5 Visible portions when temple heights are set to 6 m

The following table shows the part of the target that is theoretically visible when temple heights are set to 6 m, for the 151 cases of visibility (visible = TRUE) that were detected. The FID (Field Identification Number) of the visible (TRUE) in this table are extracted from the FID in the table Appendix 7.6, and further explained in sections 2.3.3 and 2.3.7. The table is sorted according to visible portions (Target Size) from lowest to highest values in metres.

FID	Source	Target	Visible	Target Size	Distance
838	Xewkija	Ras il-Pellegrin	TRUE	0.062	14453.84
361	L-Iklin	Hagar Qim	TRUE	0.21	9256.71
773	Borg Gharib South	Bugibba	TRUE	0.496	14550.14
894	Borg L-Imramma	Ras il-Pellegrin	TRUE	0.558	13470.63
656	Bugibba	Xemxija	TRUE	0.57	3542.91
759	Santa Verna	Ras il-Pellegrin	TRUE	0.887	15966.19
130	Tarxien	Id-Debdieba	TRUE	0.947	4453.38
819	L-Imrejsbiet	Ras il-Pellegrin	TRUE	1.062	13401.21
779	Borg Gharib South	Ras il-Pellegrin	TRUE	1.087	13405.77
799	Borg Gharib North	Ras il-Pellegrin	TRUE	1.093	13439.87
740	Ggantija	Ras il-Pellegrin	TRUE	1.155	15712.71
487	Tal-Lippija	Kuncizzjoni	TRUE	1.17	2586.83
184	Kordin II	Kordin III	TRUE	1.281	523.93
882	Borg L-Imramma	Santa Verna	TRUE	1.321	2885.85
833	Xewkija	Bugibba	TRUE	1.386	16497.02
185	Kordin II	Tarxien	TRUE	1.422	1451.35
120	Hal Resqun	Hagar Qim	TRUE	1.722	5632.42
813	L-Imrejsbiet	Bugibba	TRUE	1.742	14638.04
319	Tar-Raddiena	Hal Resqun	TRUE	1.896	6444.8
793	Borg Gharib North	Bugibba	TRUE	2.069	14655.7
832	Xewkija	Borg L-Imramma	TRUE	2.092	1339.04
145	Tarxien	Hagar Qim	TRUE	2.233	7834.55
347	L-Iklin	Hal Resqun	TRUE	2.367	7404.03
828	Xewkija	Borg Gharib North	TRUE	2.453	2096.9
70	It-Tumbata	Hagar Qim	TRUE	2.559	5023.93
72	It-Tumbata	Tas-Silg	TRUE	2.618	6385.37
45	Mnajdra	Hagar Qim	TRUE	2.728	537.45
311	Hal Ginwi	Tas-Silg	TRUE	2.955	513.08
318	Tar-Raddiena	It-Tumbata	TRUE	3.219	5468.02
255	Tas-Silg	It-Tumbata	TRUE	3.229	6385.37
79	Id-Debdieba	Tar-Raddiena	TRUE	3.307	5745.07
344	L-Iklin	Tar-Raddiena	TRUE	3.374	1029.42

389	Ta' Hagrat	Ras il-Pellegrin	TRUE	3.502	2809.85
387	Ta' Hagrat	Kuncizzjoni	TRUE	3.624	3239
631	Bugibba	Santa Verna	TRUE	3.863	17560.39
864	Ta' Marziena	Santa Verna	TRUE	3.864	2173.16
209	Kordin III	Kordin II	TRUE	3.909	523.93
317	Tar-Raddiena	Id-Debdieba	TRUE	3.926	5745.07
467	Tal-Lippija	Santa Verna	TRUE	3.957	15622.85
158	Kordin I	Kordin II	TRUE	4.114	141.42
183	Kordin II	Kordin I	TRUE	4.176	141.42
455	Ras il-Pellegrin	Kuncizzjoni	TRUE	4.193	1792.94
753	Santa Verna	Borg L-Imramma	TRUE	4.249	2885.85
762	Santa Verna	Tal-Lippija	TRUE	4.32	15622.85
457	Ras il-Pellegrin	Ta' Hagrat	TRUE	4.37	2809.85
885	Borg L-Imramma	L-Imrejsbiet	TRUE	4.474	2617.73
734	Ggantija	Borg L-Imramma	TRUE	4.582	3200.23
553	Ras ir-Raheb	Kuncizzjoni	TRUE	4.782	1191.99
323	Tar-Raddiena	Tarxien	TRUE	4.856	5927.81
110	Hal Resqun	Tarxien	TRUE	4.865	2308.53
812	L-Imrejsbiet	Borg L-Imramma	TRUE	4.939	2617.73
772	Borg Gharib South	Borg L-Imramma	TRUE	4.98	2779.1
826	Xewkija	Santa Verna	TRUE	5.011	1596.65
768	Borg Gharib South	L-Imrejsbiet	TRUE	5.057	161.55
792	Borg Gharib North	Borg L-Imramma	TRUE	5.105	2645.81
805	L-Imrejsbiet	Borg Gharib South	TRUE	5.147	161.55
60	It-Tumbata	Tarxien	TRUE	5.148	2892.55
351	L-Iklin	Tarxien	TRUE	5.196	6956.74
767	Borg Gharib South	Borg Gharib North	TRUE	5.22	140.8
845	Triq ix-Xabbata	Santa Verna	TRUE	5.27	2829.96
865	Ta' Marziena	Ggantija	TRUE	5.345	3041.33
785	Borg Gharib North	Borg Gharib South	TRUE	5.348	140.8
132	Tarxien	Hal Resqun	TRUE	5.483	2308.53
55	It-Tumbata	Id-Debdieba	TRUE	5.504	1562.67
822	L-Imrejsbiet	Tal-Lippija	TRUE	5.548	12969.89
156	Kordin I	It-Tumbata	TRUE	5.564	3219.27
731	Ggantija	Xewkija	TRUE	5.591	1871.93
881	Borg L-Imramma	Borg Gharib South	TRUE	5.6	2779.1
181	Kordin II	It-Tumbata	TRUE	5.603	3322.04
533	Ras ir-Raheb	Santa Verna	TRUE	5.619	16697.73
206	Kordin III	It-Tumbata	TRUE	5.622	3118.87
750	Santa Verna	Xewkija	TRUE	5.645	1596.65
131	Tarxien	It-Tumbata	TRUE	5.759	2892.55
868	Ta' Marziena	Xewkija	TRUE	5.804	1937.53
346	L-Iklin	It-Tumbata	TRUE	5.855	6372.82
782	Borg Gharib South	Tal-Lippija	TRUE	5.868	12962.93
802	Borg Gharib North	Tal-Lippija	TRUE	5.9	13006.66
80	Id-Debdieba	It-Tumbata	TRUE	5.938	1562.67
849	Triq ix-Xabbata	Xewkija	TRUE	5.953	1867.42

500	Kuncizzjoni	Santa Verna	TRUE	5.955	17669.64
537	Ras ir-Raheb	Xewkija	TRUE	5.965	15150.14
159	Kordin I	Kordin III	TRUE	5.967	578.01
57	It-Tumbata	Kordin I	TRUE	5.968	3219.27
153	Kordin I	L-Iklin	TRUE	5.994	5606.08
540	Ras ir-Raheb	Borg L-Imramma	TRUE	5.998	14091.72
53	It-Tumbata	L-Iklin	TRUE	6	6372.82
58	It-Tumbata	Kordin II	TRUE	6	3322.04
59	It-Tumbata	Kordin III	TRUE	6	3118.87
78	Id-Debdieba	L-Iklin	TRUE	6	6494.07
128	Tarxien	L-Iklin	TRUE	6	6956.74
129	Tarxien	Tar-Raddiena	TRUE	6	5927.81
154	Kordin I	Tar-Raddiena	TRUE	6	4579.94
178	Kordin II	L-Iklin	TRUE	6	5708.86
179	Kordin II	Tar-Raddiena	TRUE	6	4684.45
203	Kordin III	L-Iklin	TRUE	6	6161.19
204	Kordin III	Tar-Raddiena	TRUE	6	5133
208	Kordin III	Kordin I	TRUE	6	578.01
246	Borg in-Nadur	Tas-Silg	TRUE	6	2668.11
252	Tas-Silg	L-Iklin	TRUE	6	11397.58
268	Tas-Silg	Borg in-Nadur	TRUE	6	2668.11
320	Tar-Raddiena	Kordin I	TRUE	6	4579.94
321	Tar-Raddiena	Kordin II	TRUE	6	4684.45
322	Tar-Raddiena	Kordin III	TRUE	6	5133
345	L-Iklin	Id-Debdieba	TRUE	6	6494.07
348	L-Iklin	Kordin I	TRUE	6	5606.08
349	L-Iklin	Kordin II	TRUE	6	5708.86
350	L-Iklin	Kordin III	TRUE	6	6161.19
363	L-Iklin	Tas-Silg	TRUE	6	11397.58
466	Tal-Lippija	Borg Gharib South	TRUE	6	12962.93
469	Tal-Lippija	Borg Gharib North	TRUE	6	13006.66
470	Tal-Lippija	L-Imrejsbiet	TRUE	6	12969.89
474	Tal-Lippija	Borg L-Imramma	TRUE	6	13232.39
499	Kuncizzjoni	Borg Gharib South	TRUE	6	15158.41
501	Kuncizzjoni	Ggantija	TRUE	6	17444.6
502	Kuncizzjoni	Borg Gharib North	TRUE	6	15188.8
503	Kuncizzjoni	L-Imrejsbiet	TRUE	6	15149.46
504	Kuncizzjoni	Xewkija	TRUE	6	16139.61
507	Kuncizzjoni	Borg L-Imramma	TRUE	6	15116.7
520	Kuncizzjoni	Ras ir-Raheb	TRUE	6	1191.99
532	Ras ir-Raheb	Borg Gharib South	TRUE	6	14266.66
534	Ras ir-Raheb	Ggantija	TRUE	6	16511.9
535	Ras ir-Raheb	Borg Gharib North	TRUE	6	14289.67
536	Ras ir-Raheb	L-Imrejsbiet	TRUE	6	14249.11
732	Ggantija	Triq ix-Xabbata	TRUE	6	3514.39
733	Ggantija	Ta' Marziena	TRUE	6	3041.33
738	Ggantija	Kuncizzjoni	TRUE	6	17444.6

739	Ggantija	Ras ir-Raheb	TRUE	6	16511.9
751	Santa Verna	Triq ix-Xabbata	TRUE	6	2829.96
757	Santa Verna	Kuncizzjoni	TRUE	6	17669.64
758	Santa Verna	Ras ir-Raheb	TRUE	6	16697.73
777	Borg Gharib South	Kuncizzjoni	TRUE	6	15158.41
778	Borg Gharib South	Ras ir-Raheb	TRUE	6	14266.66
788	Borg Gharib North	L-Imrejsbiet	TRUE	6	46.1
797	Borg Gharib North	Kuncizzjoni	TRUE	6	15188.8
798	Borg Gharib North	Ras ir-Raheb	TRUE	6	14289.67
808	L-Imrejsbiet	Borg Gharib North	TRUE	6	46.1
817	L-Imrejsbiet	Kuncizzjoni	TRUE	6	15149.46
818	L-Imrejsbiet	Ras ir-Raheb	TRUE	6	14249.11
827	Xewkija	Ggantija	TRUE	6	1871.93
830	Xewkija	Triq ix-Xabbata	TRUE	6	1867.42
831	Xewkija	Ta' Marziena	TRUE	6	1937.53
836	Xewkija	Kuncizzjoni	TRUE	6	16139.61
837	Xewkija	Ras ir-Raheb	TRUE	6	15150.14
846	Triq ix-Xabbata	Ggantija	TRUE	6	3514.39
850	Triq ix-Xabbata	Ta' Marziena	TRUE	6	1118.09
869	Ta' Marziena	Triq ix-Xabbata	TRUE	6	1118.09
883	Borg L-Imramma	Ggantija	TRUE	6	3200.23
884	Borg L-Imramma	Borg Gharib North	TRUE	6	2645.81
892	Borg L-Imramma	Kuncizzjoni	TRUE	6	15116.7
893	Borg L-Imramma	Ras ir-Raheb	TRUE	6	14091.72
897	Borg L-Imramma	Tal-Lippija	TRUE	6	13232.39

7.6 Visible relationship between temples with 6 m height

This table shows all theoretically visible (TRUE) or non-visible (FALSE) parts of 900 temple relations set at a 6 m temple height. This analysis was the initial data compilaton for any of the further and more detailed examinations regarding temple intervisibility and applying the concept of human acuity (see sections 2.3.3 and 2.3.7).

FID	Source	Target	Visible	TargetSize	Distance
0	Hagar Qim	Bugibba	FALSE	-273.097	14263.22
1	Hagar Qim	Tal-Qadi	FALSE	-236.673	12239.47
2	Hagar Qim	Ta' Hammut	FALSE	-202.438	12682.67
3	Hagar Qim	L-Iklin	FALSE	-74.18	9256.71
4	Hagar Qim	Tar-Raddiena	FALSE	-78.185	8742.95
5	Hagar Qim	Id-Debdieba	FALSE	-18.198	3603.12
6	Hagar Qim	It-Tumbata	FALSE	-13.134	5023.93
7	Hagar Qim	Hal Resqun	FALSE	-15.895	5632.42
8	Hagar Qim	Kordin I	FALSE	-42.677	8210.85
9	Hagar Qim	Kordin II	FALSE	-36.118	8322.89
10	Hagar Qim	Kordin III	FALSE	-36.021	8142.79
11	Hagar Qim	Tarxien	FALSE	-13.843	7834.55
12	Hagar Qim	Kuncizzjoni	FALSE	-320.836	12277.87
13	Hagar Qim	Ras ir-Raheb	FALSE	-481.859	13453.05
14	Hagar Qim	Ras il-Pellegrin	FALSE	-379.094	13674.32
15	Hagar Qim	Ta' Hagrat	FALSE	-301.978	12064.16
16	Hagar Qim	Skorba	FALSE	-252.073	11857.46
17	Hagar Qim	Tal-Lippija	FALSE	-366.147	13782.59
18	Hagar Qim	Xemxija	FALSE	-309.493	14605.84
19	Hagar Qim	Ghajn Zejtuna	FALSE	-418.318	16948.89
20	Hagar Qim	Mnajdra	FALSE	-9.899	537.45
21	Hagar Qim	Borg in-Nadur	FALSE	-118.025	7852.36
22	Hagar Qim	Tas-Silg	FALSE	-71.034	10155.93
23	Hagar Qim	Xrobb l-Ghagin	FALSE	-102.444	11560.93
24	Hagar Qim	Hal Ginwi	FALSE	-88.307	9698.97
25	Mnajdra	Bugibba	FALSE	-1984.823	14310.28
26	Mnajdra	Tal-Qadi	FALSE	-1706.461	12284.4
27	Mnajdra	Ta' Hammut	FALSE	-1745.384	12819.06
28	Mnajdra	L-Iklin	FALSE	-1193.987	9449.64
29	Mnajdra	Tar-Raddiena	FALSE	-1174.364	8984.76
30	Mnajdra	Id-Debdieba	FALSE	-474.051	4038.2
31	Mnajdra	It-Tumbata	FALSE	-639.756	5497.57
32	Mnajdra	Hal Resqun	FALSE	-658.446	6147.38
33	Mnajdra	Kordin I	FALSE	-1074.948	8663.21
34	Mnajdra	Kordin II	FALSE	-1072.872	8778.11
35	Mnajdra	Kordin III	FALSE	-1047.139	8613.93

36	Mnajdra	Tarxien	FALSE	-959.717	8330.63
37	Mnajdra	Kuncizzjoni	FALSE	-1556.604	11970.41
38	Mnajdra	Ras ir-Raheb	FALSE	-1798.125	13138
39	Mnajdra	Ras il-Pellegrin	FALSE	-1852.711	13405.79
40	Mnajdra	Ta' Hagrat	FALSE	-1768.113	11885.09
41	Mnajdra	Skorba	FALSE	-1715.594	11714.77
42	Mnajdra	Tal-Lippija	FALSE	-1971.285	13550.02
43	Mnajdra	Xemxija	FALSE	-2154.362	14521.39
44	Mnajdra	Ghajn Zejtuna	FALSE	-2570.416	16860.19
45	Mnajdra	Hagar Qim	TRUE	2.728	537.45
46	Mnajdra	Borg in-Nadur	FALSE	-771.657	8382.36
47	Mnajdra	Tas-Silg	FALSE	-984.172	10693.26
48	Mnajdra	Xrobb l-Ghagin	FALSE	-1114.381	12097.29
49	Mnajdra	Hal Ginwi	FALSE	-965.939	10236.41
50	It-Tumbata	Bugibba	FALSE	-148.235	12224.36
51	It-Tumbata	Tal-Qadi	FALSE	-112.411	10381.35
52	It-Tumbata	Ta' Hammut	FALSE	-131.054	9946.76
53	It-Tumbata	L-Iklin	TRUE	6	6372.82
54	It-Tumbata	Tar-Raddiena	FALSE	-7.398	5468.02
55	It-Tumbata	Id-Debdieba	TRUE	5.504	1562.67
56	It-Tumbata	Hal Resqun	FALSE	-1.305	1285.79
57	It-Tumbata	Kordin I	TRUE	5.968	3219.27
58	It-Tumbata	Kordin II	TRUE	6	3322.04
59	It-Tumbata	Kordin III	TRUE	6	3118.87
60	It-Tumbata	Tarxien	TRUE	5.148	2892.55
61	It-Tumbata	Kuncizzjoni	FALSE	-119.114	13767.57
62	It-Tumbata	Ras ir-Raheb	FALSE	-254.074	14938.76
63	It-Tumbata	Ras il-Pellegrin	FALSE	-159.488	14677.58
64	It-Tumbata	Ta' Hagrat	FALSE	-150.025	12325.83
65	It-Tumbata	Skorba	FALSE	-56.874	11794.29
66	It-Tumbata	Tal-Lippija	FALSE	-190.669	14423.27
67	It-Tumbata	Xemxija	FALSE	-55.84	13765.74
68	It-Tumbata	Ghajn Zejtuna	FALSE	-127.931	16013.65
69	It-Tumbata	Mnajdra	FALSE	-59.125	5497.57
70	It-Tumbata	Hagar Qim	TRUE	2.559	5023.93
71	It-Tumbata	Borg in-Nadur	FALSE	-55.879	5100.25
72	It-Tumbata	Tas-Silg	TRUE	2.618	6385.37
73	It-Tumbata	Xrobb l-Ghagin	FALSE	-19.221	7864.71
74	It-Tumbata	Hal Ginwi	FALSE	-20.222	5872.86
75	Id-Debdieba	Bugibba	FALSE	-126.164	12132.42
76	Id-Debdieba	Tal-Qadi	FALSE	-86.302	10190.54
77	Id-Debdieba	Ta' Hammut	FALSE	-114.163	10094.18
78	Id-Debdieba	L-Iklin	TRUE	6	6494.07
79	Id-Debdieba	Tar-Raddiena	TRUE	3.307	5745.07
80	Id-Debdieba	It-Tumbata	TRUE	5.938	1562.67
81	Id-Debdieba	Hal Resqun	FALSE	-9.297	2610
82	Id-Debdieba	Kordin I	FALSE	-15.321	4629.34

83	Id-Debdieba	Kordin II	FALSE	-7.683	4746.91
84	Id-Debdieba	Kordin III	FALSE	-25.715	4613.95
85	Id-Debdieba	Tarxien	FALSE	-2.068	4453.38
86	Id-Debdieba	Kuncizzjoni	FALSE	-154.014	12646.44
87	Id-Debdieba	Ras ir-Raheb	FALSE	-286.201	13831.54
88	Id-Debdieba	Ras il-Pellegrin	FALSE	-194.81	13682.88
89	Id-Debdieba	Ta' Hagrat	FALSE	-152.253	11492.03
90	Id-Debdieba	Skorba	FALSE	-94.173	11042.52
91	Id-Debdieba	Tal-Lippija	FALSE	-206.025	13518.08
92	Id-Debdieba	Xemxija	FALSE	-70.757	13281.76
93	Id-Debdieba	Ghajn Zejtuna	FALSE	-159.292	15585.98
94	Id-Debdieba	Mnajdra	FALSE	-57.54	4038.2
95	Id-Debdieba	Hagar Qim	FALSE	-11.995	3603.12
96	Id-Debdieba	Borg in-Nadur	FALSE	-111.004	6080.44
97	Id-Debdieba	Tas-Silg	FALSE	-47.858	7729.69
98	Id-Debdieba	Xrobb I-Ghagin	FALSE	-83.674	9210.62
99	Id-Debdieba	Hal Ginwi	FALSE	-68.233	7223.51
100	Hal Resqun	Bugibba	FALSE	-488.937	13292.1
101	Hal Resqun	Tal-Qadi	FALSE	-429.954	11500.23
102	Hal Resqun	Ta' Hammut	FALSE	-316.514	10915.59
103	Hal Resqun	L-Iklin	FALSE	-178.949	7404.03
104	Hal Resqun	Tar-Raddiena	FALSE	-171.932	6444.8
105	Hal Resqun	Id-Debdieba	FALSE	-25.77	2610
106	Hal Resqun	It-Tumbata	FALSE	-21.407	1285.79
107	Hal Resqun	Kordin I	FALSE	-32.692	3218.59
108	Hal Resqun	Kordin II	FALSE	-27.26	3275.78
109	Hal Resqun	Kordin III	FALSE	-17.997	2897.35
110	Hal Resqun	Tarxien	TRUE	4.865	2308.53
111	Hal Resqun	Kuncizzjoni	FALSE	-352.091	15047.71
112	Hal Resqun	Ras ir-Raheb	FALSE	-502.333	16220.51
113	Hal Resqun	Ras il-Pellegrin	FALSE	-434.593	15963.3
114	Hal Resqun	Ta' Hagrat	FALSE	-413.32	13602.52
115	Hal Resqun	Skorba	FALSE	-395.359	13061.02
116	Hal Resqun	Tal-Lippija	FALSE	-510.812	15705.3
117	Hal Resqun	Xemxija	FALSE	-471.849	14970.41
118	Hal Resqun	Ghajn Zejtuna	FALSE	-579.424	17196.66
119	Hal Resqun	Mnajdra	FALSE	-49.256	6147.38
120	Hal Resqun	Hagar Qim	TRUE	1.722	5632.42
121	Hal Resqun	Borg in-Nadur	FALSE	-71.85	3841.75
122	Hal Resqun	Tas-Silg	FALSE	-32.281	5143.23
123	Hal Resqun	Xrobb I-Ghagin	FALSE	-62.155	6625.35
124	Hal Resqun	Hal Ginwi	FALSE	-50.913	4633.18
125	Tarxien	Bugibba	FALSE	-174.609	12737.12
126	Tarxien	Tal-Qadi	FALSE	-137.915	11151.93
127	Tarxien	Ta' Hammut	FALSE	-132.685	10144.01
128	Tarxien	L-Iklin	TRUE	6	6956.74
129	Tarxien	Tar-Raddiena	TRUE	6	5927.81

130	Tarxien	Id-Debdieba	TRUE	0.947	4453.38
131	Tarxien	It-Tumbata	TRUE	5.759	2892.55
132	Tarxien	Hal Resqun	TRUE	5.483	2308.53
133	Tarxien	Kordin I	FALSE	-31.269	1489.24
134	Tarxien	Kordin II	FALSE	-19.337	1451.35
135	Tarxien	Kordin III	FALSE	-18.344	928.29
136	Tarxien	Kuncizzjoni	FALSE	-91.288	15935.8
137	Tarxien	Ras ir-Raheb	FALSE	-234.33	17069.86
138	Tarxien	Ras il-Pellegrin	FALSE	-138.358	16632.44
139	Tarxien	Ta' Hagrat	FALSE	-96.716	14071.45
140	Tarxien	Skorba	FALSE	-15.584	13425.13
141	Tarxien	Tal-Lippija	FALSE	-168.922	16238.52
142	Tarxien	Xemxija	FALSE	-105.043	14903.01
143	Tarxien	Ghajn Zejtuna	FALSE	-211.798	17000.3
144	Tarxien	Mnajdra	FALSE	-70.229	8330.63
145	Tarxien	Hagar Qim	TRUE	2.233	7834.55
146	Tarxien	Borg in-Nadur	FALSE	-129.226	4487.81
147	Tarxien	Tas-Silg	FALSE	-151.084	4453.57
148	Tarxien	Xrobb l-Ghagin	FALSE	-235.169	5811.24
149	Tarxien	Hal Ginwi	FALSE	-152.463	3977.75
150	Kordin I	Bugibba	FALSE	-209.813	11306.91
151	Kordin I	Tal-Qadi	FALSE	-169.824	9779.31
152	Kordin I	Ta' Hammut	FALSE	-151.922	8684.84
153	Kordin I	L-Iklin	TRUE	5.994	5606.08
154	Kordin I	Tar-Raddiena	TRUE	6	4579.94
155	Kordin I	Id-Debdieba	FALSE	-7.923	4629.34
156	Kordin I	It-Tumbata	TRUE	5.564	3219.27
157	Kordin I	Hal Resqun	FALSE	-14.057	3218.59
158	Kordin I	Kordin II	TRUE	4.114	141.42
159	Kordin I	Kordin III	TRUE	5.967	578.01
160	Kordin I	Tarxien	FALSE	-0.939	1489.24
161	Kordin I	Kuncizzjoni	FALSE	-119.873	15035.82
162	Kordin I	Ras ir-Raheb	FALSE	-255.508	16139.94
163	Kordin I	Ras il-Pellegrin	FALSE	-172.051	15611.79
164	Kordin I	Ta' Hagrat	FALSE	-68.188	12975.27
165	Kordin I	Skorba	FALSE	-14.136	12287.97
166	Kordin I	Tal-Lippija	FALSE	-137.867	15155.22
167	Kordin I	Xemxija	FALSE	-172.528	13591.68
168	Kordin I	Ghajn Zejtuna	FALSE	-281.214	15641.72
169	Kordin I	Mnajdra	FALSE	-86.621	8663.21
170	Kordin I	Hagar Qim	FALSE	-30.744	8210.85
171	Kordin I	Borg in-Nadur	FALSE	-97.127	5968.75
172	Kordin I	Tas-Silg	FALSE	-139.663	5813.15
173	Kordin I	Xrobb l-Ghagin	FALSE	-365.71	7089.68
174	Kordin I	Hal Ginwi	FALSE	-153.608	5363.5
175	Kordin II	Bugibba	FALSE	-199.028	11389.38
176	Kordin II	Tal-Qadi	FALSE	-174.795	9875.65

177	Kordin II	Ta' Hammut	FALSE	-147.36	8757.79
178	Kordin II	L-Iklin	TRUE	6	5708.86
179	Kordin II	Tar-Raddiena	TRUE	6	4684.45
180	Kordin II	Id-Debdieba	FALSE	-2.058	4746.91
181	Kordin II	It-Tumbata	TRUE	5.603	3322.04
182	Kordin II	Hal Resqun	FALSE	-11.431	3275.78
183	Kordin II	Kordin I	TRUE	4.176	141.42
184	Kordin II	Kordin III	TRUE	1.281	523.93
185	Kordin II	Tarxien	TRUE	1.422	1451.35
186	Kordin II	Kuncizzjoni	FALSE	-112.327	15171.28
187	Kordin II	Ras ir-Raheb	FALSE	-251.886	16274.17
188	Kordin II	Ras il-Pellegrin	FALSE	-167.45	15741.94
189	Kordin II	Ta' Hagrat	FALSE	-63.12	13101.39
190	Kordin II	Skorba	FALSE	-11.182	12411.35
191	Kordin II	Tal-Lippija	FALSE	-125.809	15281.81
192	Kordin II	Xemxija	FALSE	-156.295	13696.98
193	Kordin II	Ghajn Zejtuna	FALSE	-266.692	15739.31
194	Kordin II	Mnajdra	FALSE	-63.743	8778.11
195	Kordin II	Hagar Qim	FALSE	-7.884	8322.89
196	Kordin II	Borg in-Nadur	FALSE	-90.497	5938.7
197	Kordin II	Tas-Silg	FALSE	-256.778	5725.08
198	Kordin II	Xrobb I-Ghagin	FALSE	-474.235	6989
199	Kordin II	Hal Ginwi	FALSE	-206.162	5280.54
200	Kordin III	Bugibba	FALSE	-193.593	11881.66
201	Kordin III	Tal-Qadi	FALSE	-156.663	10342.23
202	Kordin III	Ta' Hammut	FALSE	-145.515	9262.67
203	Kordin III	L-Iklin	TRUE	6	6161.19
204	Kordin III	Tar-Raddiena	TRUE	6	5133
205	Kordin III	Id-Debdieba	FALSE	-11.948	4613.95
206	Kordin III	It-Tumbata	TRUE	5.622	3118.87
207	Kordin III	Hal Resqun	FALSE	-9.92	2897.35
208	Kordin III	Kordin I	TRUE	6	578.01
209	Kordin III	Kordin II	TRUE	3.909	523.93
210	Kordin III	Tarxien	FALSE	-3.907	928.29
211	Kordin III	Kuncizzjoni	FALSE	-117.729	15456.22
212	Kordin III	Ras ir-Raheb	FALSE	-245.096	16571.12
213	Kordin III	Ras il-Pellegrin	FALSE	-169.131	16072.8
214	Kordin III	Ta' Hagrat	FALSE	-89.5	13459.3
215	Kordin III	Skorba	FALSE	-12.571	12784.62
216	Kordin III	Tal-Lippija	FALSE	-137.287	15636.28
217	Kordin III	Xemxija	FALSE	-160.128	14140.12
218	Kordin III	Ghajn Zejtuna	FALSE	-250.453	16202.42
219	Kordin III	Mnajdra	FALSE	-60.35	8613.93
220	Kordin III	Hagar Qim	FALSE	-12.121	8142.79
221	Kordin III	Borg in-Nadur	FALSE	-165.513	5416.1
222	Kordin III	Tas-Silg	FALSE	-43.802	5244.74
223	Kordin III	Xrobb I-Ghagin	FALSE	-82.091	6538.01

224	Kordin III	Hal Ginwi	FALSE	-56.772	4790.87
225	Borg in-Nadur	Bugibba	FALSE	-654.098	16976.98
226	Borg in-Nadur	Tal-Qadi	FALSE	-718.881	15253.14
227	Borg in-Nadur	Ta' Hammut	FALSE	-487.394	14484.74
228	Borg in-Nadur	L-Iklin	FALSE	-344.241	11093.11
229	Borg in-Nadur	Tar-Raddiena	FALSE	-333.991	10092.73
230	Borg in-Nadur	Id-Debdieba	FALSE	-171.864	6080.44
231	Borg in-Nadur	It-Tumbata	FALSE	-156.35	5100.25
232	Borg in-Nadur	Hal Resqun	FALSE	-140.99	3841.75
233	Borg in-Nadur	Kordin I	FALSE	-146.304	5968.75
234	Borg in-Nadur	Kordin II	FALSE	-133.8	5938.7
235	Borg in-Nadur	Kordin III	FALSE	-123.557	5416.1
236	Borg in-Nadur	Tarxien	FALSE	-80.723	4487.81
237	Borg in-Nadur	Kuncizzjoni	FALSE	-538.43	18725.62
238	Borg in-Nadur	Ras ir-Raheb	FALSE	-723.967	19909.49
239	Borg in-Nadur	Ras il-Pellegrin	FALSE	-818.879	19724.42
240	Borg in-Nadur	Ta' Hagrat	FALSE	-585.39	17420.88
241	Borg in-Nadur	Skorba	FALSE	-660.766	16894.52
242	Borg in-Nadur	Tal-Lippija	FALSE	-791.537	19505.06
243	Borg in-Nadur	Xemxija	FALSE	-827.95	18795.8
244	Borg in-Nadur	Mnajdra	FALSE	-471.635	8382.36
245	Borg in-Nadur	Hagar Qim	FALSE	-410.022	7852.36
246	Borg in-Nadur	Tas-Silg	TRUE	6	2668.11
247	Borg in-Nadur	Xrobb I-Ghagin	FALSE	-56.468	3846.85
248	Borg in-Nadur	Hal Ginwi	FALSE	-10.947	2391.79
249	Tas-Silg	Bugibba	FALSE	-159.821	17112.13
250	Tas-Silg	Tal-Qadi	FALSE	-130.106	15585.37
251	Tas-Silg	Ta' Hammut	FALSE	-126.839	14460.48
252	Tas-Silg	L-Iklin	TRUE	6	11397.58
253	Tas-Silg	Tar-Raddiena	FALSE	-5.458	10368.21
254	Tas-Silg	Id-Debdieba	FALSE	-15.443	7729.69
255	Tas-Silg	It-Tumbata	TRUE	3.229	6385.37
256	Tas-Silg	Hal Resqun	FALSE	-3.882	5143.23
257	Tas-Silg	Kordin I	FALSE	-26.625	5813.15
258	Tas-Silg	Kordin II	FALSE	-16.319	5725.08
259	Tas-Silg	Kordin III	FALSE	-15.895	5244.74
260	Tas-Silg	Tarxien	FALSE	-5.806	4453.57
261	Tas-Silg	Kuncizzjoni	FALSE	-104.143	20112.71
262	Tas-Silg	Ta' Hagrat	FALSE	-117.666	18441.14
263	Tas-Silg	Skorba	FALSE	-73.886	17823.84
264	Tas-Silg	Tal-Lippija	FALSE	-184.642	20591.55
265	Tas-Silg	Xemxija	FALSE	-96.001	19356.22
266	Tas-Silg	Mnajdra	FALSE	-54.645	10693.26
267	Tas-Silg	Hagar Qim	FALSE	-3.124	10155.93
268	Tas-Silg	Borg in-Nadur	TRUE	6	2668.11
269	Tas-Silg	Xrobb I-Ghagin	FALSE	-18.352	1482.18
270	Tas-Silg	Hal Ginwi	FALSE	-3.065	513.08

271	Xrobb l-Ghagin	Bugibba	FALSE	-1574.435	18324.73
272	Xrobb l-Ghagin	Tal-Qadi	FALSE	-1897.307	16862.76
273	Xrobb l-Ghagin	Ta' Hammut	FALSE	-1315.935	15638.48
274	Xrobb l-Ghagin	L-Iklin	FALSE	-1396.821	12695.7
275	Xrobb l-Ghagin	Tar-Raddiena	FALSE	-1305.419	11668.94
276	Xrobb l-Ghagin	Id-Debdieba	FALSE	-929.163	9210.62
277	Xrobb l-Ghagin	It-Tumbata	FALSE	-826.201	7864.71
278	Xrobb l-Ghagin	Hal Resqun	FALSE	-649.503	6625.35
279	Xrobb l-Ghagin	Kordin I	FALSE	-819.584	7089.68
280	Xrobb l-Ghagin	Kordin II	FALSE	-780.024	6989
281	Xrobb l-Ghagin	Kordin III	FALSE	-721.157	6538.01
282	Xrobb l-Ghagin	Tarxien	FALSE	-726.684	5811.24
283	Xrobb l-Ghagin	Ta' Hagrat	FALSE	-2753.905	19859.62
284	Xrobb l-Ghagin	Skorba	FALSE	-2624.305	19227.99
285	Xrobb l-Ghagin	Mnajdra	FALSE	-1209.138	12097.29
286	Xrobb l-Ghagin	Hagar Qim	FALSE	-1105.961	11560.93
287	Xrobb l-Ghagin	Borg in-Nadur	FALSE	-520.747	3846.85
288	Xrobb l-Ghagin	Tas-Silg	FALSE	-127.204	1482.18
289	Xrobb l-Ghagin	Hal Ginwi	FALSE	-202.024	1992.79
290	Hal Ginwi	Bugibba	FALSE	-876.489	16669.68
291	Hal Ginwi	Tal-Qadi	FALSE	-844.698	15123.13
292	Hal Ginwi	Ta' Hammut	FALSE	-713.586	14030.91
293	Hal Ginwi	L-Iklin	FALSE	-501.908	10931.17
294	Hal Ginwi	Tar-Raddiena	FALSE	-500.423	9901.81
295	Hal Ginwi	Id-Debdieba	FALSE	-206.508	7223.51
296	Hal Ginwi	It-Tumbata	FALSE	-197.34	5872.86
297	Hal Ginwi	Hal Resqun	FALSE	-145.708	4633.18
298	Hal Ginwi	Kordin I	FALSE	-272.152	5363.5
299	Hal Ginwi	Kordin II	FALSE	-249.996	5280.54
300	Hal Ginwi	Kordin III	FALSE	-232.107	4790.87
301	Hal Ginwi	Tarxien	FALSE	-168.297	3977.75
302	Hal Ginwi	Kuncizzjoni	FALSE	-775.501	19600.23
303	Hal Ginwi	Ras il-Pellegrin	FALSE	-885.486	20421.15
304	Hal Ginwi	Ta' Hagrat	FALSE	-817.873	17937.74
305	Hal Ginwi	Skorba	FALSE	-775.981	17324.09
306	Hal Ginwi	Tal-Lippija	FALSE	-940.405	20086.3
307	Hal Ginwi	Xemxija	FALSE	-963.435	18879.25
308	Hal Ginwi	Mnajdra	FALSE	-199.067	10236.41
309	Hal Ginwi	Hagar Qim	FALSE	-139.269	9698.97
310	Hal Ginwi	Borg in-Nadur	FALSE	-12.258	2391.79
311	Hal Ginwi	Tas-Silg	TRUE	2.955	513.08
312	Hal Ginwi	Xrobb l-Ghagin	FALSE	-88.151	1992.79
313	Tar-Raddiena	Bugibba	FALSE	-599.783	6884.25
314	Tar-Raddiena	Tal-Qadi	FALSE	-443.535	5224.86
315	Tar-Raddiena	Ta' Hammut	FALSE	-318.126	4481.79
316	Tar-Raddiena	L-Iklin	FALSE	-27.034	1029.42
317	Tar-Raddiena	Id-Debdieba	TRUE	3.926	5745.07

318	Tar-Raddiena	It-Tumbata	TRUE	3.219	5468.02
319	Tar-Raddiena	Hal Resqun	TRUE	1.896	6444.8
320	Tar-Raddiena	Kordin I	TRUE	6	4579.94
321	Tar-Raddiena	Kordin II	TRUE	6	4684.45
322	Tar-Raddiena	Kordin III	TRUE	6	5133
323	Tar-Raddiena	Tarxien	TRUE	4.856	5927.81
324	Tar-Raddiena	Kuncizzjoni	FALSE	-314.689	11110.67
325	Tar-Raddiena	Ras ir-Raheb	FALSE	-484.834	12123.01
326	Tar-Raddiena	Ras il-Pellegrin	FALSE	-416.749	11409.34
327	Tar-Raddiena	Ta' Hagrat	FALSE	-335.263	8662.18
328	Tar-Raddiena	Skorba	FALSE	-327.377	7908.23
329	Tar-Raddiena	Tal-Lippija	FALSE	-453.266	10837.55
330	Tar-Raddiena	Xemxija	FALSE	-714.786	9012.54
331	Tar-Raddiena	Ghajn Zejtuna	FALSE	-955.371	11074.57
332	Tar-Raddiena	Mnajdra	FALSE	-54.517	8984.76
333	Tar-Raddiena	Hagar Qim	FALSE	-2.151	8742.95
334	Tar-Raddiena	Borg in-Nadur	FALSE	-60.934	10092.73
335	Tar-Raddiena	Tas-Silg	FALSE	-0.981	10368.21
336	Tar-Raddiena	Xrobb I-Ghagin	FALSE	-24.276	11668.94
337	Tar-Raddiena	Hal Ginwi	FALSE	-27.595	9901.81
338	L-Iklin	Borg Gharib South	FALSE	-345.765	20156.81
339	L-Iklin	Borg Gharib North	FALSE	-340.165	20251.86
340	L-Iklin	L-Imrejsbiet	FALSE	-342.731	20229.73
341	L-Iklin	Bugibba	FALSE	-253.95	5892.44
342	L-Iklin	Tal-Qadi	FALSE	-154.941	4197.47
343	L-Iklin	Ta' Hammut	FALSE	-269.434	3606.54
344	L-Iklin	Tar-Raddiena	TRUE	3.374	1029.42
345	L-Iklin	Id-Debdieba	TRUE	6	6494.07
346	L-Iklin	It-Tumbata	TRUE	5.855	6372.82
347	L-Iklin	Hal Resqun	TRUE	2.367	7404.03
348	L-Iklin	Kordin I	TRUE	6	5606.08
349	L-Iklin	Kordin II	TRUE	6	5708.86
350	L-Iklin	Kordin III	TRUE	6	6161.19
351	L-Iklin	Tarxien	TRUE	5.196	6956.74
352	L-Iklin	Kuncizzjoni	FALSE	-121.708	10364.82
353	L-Iklin	Ras ir-Raheb	FALSE	-224.257	11336.71
354	L-Iklin	Ras il-Pellegrin	FALSE	-183.543	10557.75
355	L-Iklin	Ta' Hagrat	FALSE	-182.427	7780.78
356	L-Iklin	Skorba	FALSE	-128.358	7001.02
357	L-Iklin	Tal-Lippija	FALSE	-228.772	9942.65
358	L-Iklin	Xemxija	FALSE	-155.152	7990.3
359	L-Iklin	Ghajn Zejtuna	FALSE	-254.94	10045.15
360	L-Iklin	Mnajdra	FALSE	-49.463	9449.64
361	L-Iklin	Hagar Qim	TRUE	0.21	9256.71
362	L-Iklin	Borg in-Nadur	FALSE	-40.797	11093.11
363	L-Iklin	Tas-Silg	TRUE	6	11397.58
364	L-Iklin	Xrobb I-Ghagin	FALSE	-15.713	12695.7

365	L-Iklin	Hal Ginwi	FALSE	-22.01	10931.17
366	Ta' Hagrat	Borg Gharib South	FALSE	-808.816	14455.93
367	Ta' Hagrat	Santa Verna	FALSE	-960.614	17245.48
368	Ta' Hagrat	Ggantija	FALSE	-917.023	16853.07
369	Ta' Hagrat	Borg Gharib North	FALSE	-811.931	14514.82
370	Ta' Hagrat	L-Imrejsbiet	FALSE	-813.071	14481.48
371	Ta' Hagrat	Xewkija	FALSE	-893.103	15831.37
372	Ta' Hagrat	Triq ix-Xabbata	FALSE	-866.235	16249.55
373	Ta' Hagrat	Ta' Marziena	FALSE	-944.173	17228.83
374	Ta' Hagrat	Borg L-Imramma	FALSE	-807.721	15009.67
375	Ta' Hagrat	Bugibba	FALSE	-400.155	6010
376	Ta' Hagrat	Tal-Qadi	FALSE	-361.135	5100.04
377	Ta' Hagrat	Ta' Hammut	FALSE	-499.687	7300.44
378	Ta' Hagrat	L-Iklin	FALSE	-206.191	7780.78
379	Ta' Hagrat	Tar-Raddiena	FALSE	-255.776	8662.18
380	Ta' Hagrat	Id-Debdieba	FALSE	-673.699	11492.03
381	Ta' Hagrat	It-Tumbata	FALSE	-617.817	12325.83
382	Ta' Hagrat	Hal Resqun	FALSE	-666.454	13602.52
383	Ta' Hagrat	Kordin I	FALSE	-242.34	12975.27
384	Ta' Hagrat	Kordin II	FALSE	-233.392	13101.39
385	Ta' Hagrat	Kordin III	FALSE	-319.86	13459.3
386	Ta' Hagrat	Tarxien	FALSE	-410.395	14071.45
387	Ta' Hagrat	Kuncizzjoni	TRUE	3.624	3239
388	Ta' Hagrat	Ras ir-Raheb	FALSE	-36.189	3839.07
389	Ta' Hagrat	Ras il-Pellegrin	TRUE	3.502	2809.85
390	Ta' Hagrat	Skorba	FALSE	-14.054	863.51
391	Ta' Hagrat	Tal-Lippija	FALSE	-63.534	2182.66
392	Ta' Hagrat	Xemxija	FALSE	-257.883	3529.62
393	Ta' Hagrat	Ghajn Zejtuna	FALSE	-291.437	5515.04
394	Ta' Hagrat	Mnajdra	FALSE	-699.528	11885.09
395	Ta' Hagrat	Hagar Qim	FALSE	-767.726	12064.16
396	Ta' Hagrat	Borg in-Nadur	FALSE	-965.628	17420.88
397	Ta' Hagrat	Tas-Silg	FALSE	-635.365	18441.14
398	Ta' Hagrat	Xrobb l-Ghagin	FALSE	-631.011	19859.62
399	Ta' Hagrat	Hal Ginwi	FALSE	-661.827	17937.74
400	Skorba	Borg Gharib South	FALSE	-264.663	14680.21
401	Skorba	Santa Verna	FALSE	-209.967	17524.7
402	Skorba	Ggantija	FALSE	-256.431	17090.89
403	Skorba	Borg Gharib North	FALSE	-252.743	14746.29
404	Skorba	L-Imrejsbiet	FALSE	-254.027	14714.82
405	Skorba	Xewkija	FALSE	-235.876	16148.29
406	Skorba	Triq ix-Xabbata	FALSE	-363.48	16653.97
407	Skorba	Ta' Marziena	FALSE	-386.01	17607.71
408	Skorba	Borg L-Imramma	FALSE	-310.653	15381.34
409	Skorba	Bugibba	FALSE	-94.003	5236.39
410	Skorba	Tal-Qadi	FALSE	-136.165	4241.61
411	Skorba	Ta' Hammut	FALSE	-153.17	6438.65

412	Skorba	L-Iklin	FALSE	-7.656	7001.02
413	Skorba	Tar-Raddiena	FALSE	-32.635	7908.23
414	Skorba	Id-Debdieba	FALSE	-387.144	11042.52
415	Skorba	It-Tumbata	FALSE	-241.972	11794.29
416	Skorba	Hal Resqun	FALSE	-256.707	13061.02
417	Skorba	Kordin I	FALSE	-59.788	12287.97
418	Skorba	Kordin II	FALSE	-49.942	12411.35
419	Skorba	Kordin III	FALSE	-60.078	12784.62
420	Skorba	Tarxien	FALSE	-84.687	13425.13
421	Skorba	Kuncizzjoni	FALSE	-2.788	4062.29
422	Skorba	Ras ir-Raheb	FALSE	-162.099	4701.65
423	Skorba	Ras il-Pellegrin	FALSE	-172.685	3654.22
424	Skorba	Ta' Hagrat	FALSE	-46.894	863.51
425	Skorba	Tal-Lippija	FALSE	-217.342	2944.69
426	Skorba	Xemxija	FALSE	-79.799	3134.89
427	Skorba	Ghajn Zejtuna	FALSE	-131.4	5321.24
428	Skorba	Mnajdra	FALSE	-666.287	11714.77
429	Skorba	Hagar Qim	FALSE	-595.853	11857.46
430	Skorba	Borg in-Nadur	FALSE	-397.964	16894.52
431	Skorba	Tas-Silg	FALSE	-103.494	17823.84
432	Skorba	Xrobb I-Ghagin	FALSE	-134.987	19227.99
433	Skorba	Hal Ginwi	FALSE	-131.215	17324.09
434	Ras il-Pellegrin	Borg Gharib South	FALSE	-572.323	13405.77
435	Ras il-Pellegrin	Santa Verna	FALSE	-750.755	15966.19
436	Ras il-Pellegrin	Ggantija	FALSE	-654.579	15712.71
437	Ras il-Pellegrin	Borg Gharib North	FALSE	-575.724	13439.87
438	Ras il-Pellegrin	L-Imrejsbiet	FALSE	-579.287	13401.21
439	Ras il-Pellegrin	Xewkija	FALSE	-842.355	14453.84
440	Ras il-Pellegrin	Triq ix-Xabbata	FALSE	-673.93	14586.27
441	Ras il-Pellegrin	Ta' Marziena	FALSE	-736.67	15632.89
442	Ras il-Pellegrin	Borg L-Imramma	FALSE	-614.682	13470.63
443	Ras il-Pellegrin	Bugibba	FALSE	-128.589	8397.78
444	Ras il-Pellegrin	Tal-Qadi	FALSE	-113.829	7805.51
445	Ras il-Pellegrin	Ta' Hammut	FALSE	-112.654	10019.11
446	Ras il-Pellegrin	L-Iklin	FALSE	-6.525	10557.75
447	Ras il-Pellegrin	Tar-Raddiena	FALSE	-74.597	11409.34
448	Ras il-Pellegrin	Id-Debdieba	FALSE	-513.022	13682.88
449	Ras il-Pellegrin	It-Tumbata	FALSE	-537.453	14677.58
450	Ras il-Pellegrin	Hal Resqun	FALSE	-592.964	15963.3
451	Ras il-Pellegrin	Kordin I	FALSE	-415.772	15611.79
452	Ras il-Pellegrin	Kordin II	FALSE	-393.9	15741.94
453	Ras il-Pellegrin	Kordin III	FALSE	-441.419	16072.8
454	Ras il-Pellegrin	Tarxien	FALSE	-447.315	16632.44
455	Ras il-Pellegrin	Kuncizzjoni	TRUE	4.193	1792.94
456	Ras il-Pellegrin	Ras ir-Raheb	FALSE	-28.057	1405
457	Ras il-Pellegrin	Ta' Hagrat	TRUE	4.37	2809.85
458	Ras il-Pellegrin	Skorba	FALSE	-3.619	3654.22

459	Ras il-Pellegrin	Tal-Lippija	FALSE	-41.102	1036.64
460	Ras il-Pellegrin	Xemxija	FALSE	-42.649	5203.9
461	Ras il-Pellegrin	Ghajn Zejtuna	FALSE	-216.817	6343.74
462	Ras il-Pellegrin	Mnajdra	FALSE	-462.821	13405.79
463	Ras il-Pellegrin	Hagar Qim	FALSE	-437.392	13674.32
464	Ras il-Pellegrin	Borg in-Nadur	FALSE	-745.74	19724.42
465	Ras il-Pellegrin	Hal Ginwi	FALSE	-539.995	20421.15
466	Tal-Lippija	Borg Gharib South	TRUE	6	12962.93
467	Tal-Lippija	Santa Verna	TRUE	3.957	15622.85
468	Tal-Lippija	Ggantija	FALSE	-6.493	15312.84
469	Tal-Lippija	Borg Gharib North	TRUE	6	13006.66
470	Tal-Lippija	L-Imrejsbiet	TRUE	6	12969.89
471	Tal-Lippija	Xewkija	FALSE	-27.096	14147.27
472	Tal-Lippija	Triq ix-Xabbata	FALSE	-25.314	14409.69
473	Tal-Lippija	Ta' Marziena	FALSE	-45.86	15427.21
474	Tal-Lippija	Borg L-Imramma	TRUE	6	13232.39
475	Tal-Lippija	Bugibba	FALSE	-461.321	7415.4
476	Tal-Lippija	Tal-Qadi	FALSE	-559.482	6939.61
477	Tal-Lippija	Ta' Hammut	FALSE	-707.581	9149.6
478	Tal-Lippija	L-Iklin	FALSE	-785.886	9942.65
479	Tal-Lippija	Tar-Raddiena	FALSE	-917.533	10837.55
480	Tal-Lippija	Id-Debdieba	FALSE	-1337.463	13518.08
481	Tal-Lippija	It-Tumbata	FALSE	-1412.065	14423.27
482	Tal-Lippija	Hal Resqun	FALSE	-1546.587	15705.3
483	Tal-Lippija	Kordin I	FALSE	-1384.069	15155.22
484	Tal-Lippija	Kordin II	FALSE	-1380.309	15281.81
485	Tal-Lippija	Kordin III	FALSE	-1433.442	15636.28
486	Tal-Lippija	Tarxien	FALSE	-1500.035	16238.52
487	Tal-Lippija	Kuncizzjoni	TRUE	1.17	2586.83
488	Tal-Lippija	Ras ir-Raheb	FALSE	-128.266	2435.62
489	Tal-Lippija	Ras il-Pellegrin	FALSE	-1.697	1036.64
490	Tal-Lippija	Ta' Hagrat	FALSE	-167.242	2182.66
491	Tal-Lippija	Skorba	FALSE	-196.448	2944.69
492	Tal-Lippija	Xemxija	FALSE	-152.622	4170.62
493	Tal-Lippija	Ghajn Zejtuna	FALSE	-222.397	5357.31
494	Tal-Lippija	Mnajdra	FALSE	-1393.914	13550.02
495	Tal-Lippija	Hagar Qim	FALSE	-1374.139	13782.59
496	Tal-Lippija	Borg in-Nadur	FALSE	-1993.217	19505.06
497	Tal-Lippija	Tas-Silg	FALSE	-1959.155	20591.55
498	Tal-Lippija	Hal Ginwi	FALSE	-1938.169	20086.3
499	Kuncizzjoni	Borg Gharib South	TRUE	6	15158.41
500	Kuncizzjoni	Santa Verna	TRUE	5.955	17669.64
501	Kuncizzjoni	Ggantija	TRUE	6	17444.6
502	Kuncizzjoni	Borg Gharib North	TRUE	6	15188.8
503	Kuncizzjoni	L-Imrejsbiet	TRUE	6	15149.46
504	Kuncizzjoni	Xewkija	TRUE	6	16139.61
505	Kuncizzjoni	Triq ix-Xabbata	FALSE	-19.995	16185.33

506	Kuncizzjoni	Ta' Marziena	FALSE	-36.283	17250.26
507	Kuncizzjoni	Borg L-Imramma	TRUE	6	15116.7
508	Kuncizzjoni	Bugibba	FALSE	-72.763	9241.75
509	Kuncizzjoni	Tal-Qadi	FALSE	-215.639	8279.48
510	Kuncizzjoni	Ta' Hammut	FALSE	-266.777	10448.48
511	Kuncizzjoni	L-Iklin	FALSE	-527.562	10364.82
512	Kuncizzjoni	Tar-Raddiena	FALSE	-626.25	11110.67
513	Kuncizzjoni	Id-Debdieba	FALSE	-649.221	12646.44
514	Kuncizzjoni	It-Tumbata	FALSE	-650.033	13767.57
515	Kuncizzjoni	Hal Resqun	FALSE	-716.834	15047.71
516	Kuncizzjoni	Kordin I	FALSE	-844.51	15035.82
517	Kuncizzjoni	Kordin II	FALSE	-847.499	15171.28
518	Kuncizzjoni	Kordin III	FALSE	-818.571	15456.22
519	Kuncizzjoni	Tarxien	FALSE	-813.301	15935.8
520	Kuncizzjoni	Ras ir-Raheb	TRUE	6	1191.99
521	Kuncizzjoni	Ras il-Pellegrin	FALSE	-3.626	1792.94
522	Kuncizzjoni	Ta' Hagrat	FALSE	-25.126	3239
523	Kuncizzjoni	Skorba	FALSE	-36.545	4062.29
524	Kuncizzjoni	Tal-Lippija	FALSE	-103.084	2586.83
525	Kuncizzjoni	Xemxija	FALSE	-101.823	6426.27
526	Kuncizzjoni	Ghajn Zejtuna	FALSE	-213.496	7903.4
527	Kuncizzjoni	Mnajdra	FALSE	-801.502	11970.41
528	Kuncizzjoni	Hagar Qim	FALSE	-770.006	12277.87
529	Kuncizzjoni	Borg in-Nadur	FALSE	-993.705	18725.62
530	Kuncizzjoni	Tas-Silg	FALSE	-972.257	20112.71
531	Kuncizzjoni	Hal Ginwi	FALSE	-968.865	19600.23
532	Ras ir-Raheb	Borg Gharib South	TRUE	6	14266.66
533	Ras ir-Raheb	Santa Verna	TRUE	5.619	16697.73
534	Ras ir-Raheb	Ggantija	TRUE	6	16511.9
535	Ras ir-Raheb	Borg Gharib North	TRUE	6	14289.67
536	Ras ir-Raheb	L-Imrejsbiet	TRUE	6	14249.11
537	Ras ir-Raheb	Xewkija	TRUE	5.965	15150.14
538	Ras ir-Raheb	Triq ix-Xabbata	FALSE	-24.095	15123.7
539	Ras ir-Raheb	Ta' Marziena	FALSE	-49.22	16199.65
540	Ras ir-Raheb	Borg L-Imramma	TRUE	5.998	14091.72
541	Ras ir-Raheb	Bugibba	FALSE	-233.119	9683.92
542	Ras ir-Raheb	Tal-Qadi	FALSE	-260.151	8936.61
543	Ras ir-Raheb	Ta' Hammut	FALSE	-321.413	11139.43
544	Ras ir-Raheb	L-Iklin	FALSE	-360.122	11336.71
545	Ras ir-Raheb	Tar-Raddiena	FALSE	-505.597	12123.01
546	Ras ir-Raheb	Id-Debdieba	FALSE	-1278.984	13831.54
547	Ras ir-Raheb	It-Tumbata	FALSE	-1368.623	14938.76
548	Ras ir-Raheb	Hal Resqun	FALSE	-1508.073	16220.51
549	Ras ir-Raheb	Kordin I	FALSE	-1150.903	16139.94
550	Ras ir-Raheb	Kordin II	FALSE	-1138.188	16274.17
551	Ras ir-Raheb	Kordin III	FALSE	-1246.939	16571.12
552	Ras ir-Raheb	Tarxien	FALSE	-1304.022	17069.86

553	Ras ir-Raheb	Kuncizzjoni	TRUE	4.782	1191.99
554	Ras ir-Raheb	Ras il-Pellegrin	FALSE	-0.445	1405
555	Ras ir-Raheb	Ta' Hagrat	FALSE	-57.848	3839.07
556	Ras ir-Raheb	Skorba	FALSE	-56.415	4701.65
557	Ras ir-Raheb	Tal-Lippija	FALSE	-90.335	2435.62
558	Ras ir-Raheb	Xemxija	FALSE	-216.196	6583.54
559	Ras ir-Raheb	Ghajn Zejtuna	FALSE	-486.126	7736.79
560	Ras ir-Raheb	Mnajdra	FALSE	-1452.885	13138
561	Ras ir-Raheb	Hagar Qim	FALSE	-1250.935	13453.05
562	Ras ir-Raheb	Borg in-Nadur	FALSE	-1924.653	19909.49
563	Tal-Qadi	Borg Gharib South	FALSE	-199.867	15963.69
564	Tal-Qadi	Santa Verna	FALSE	-206.314	18961.15
565	Tal-Qadi	Ggantija	FALSE	-200.041	18348.5
566	Tal-Qadi	Borg Gharib North	FALSE	-197.258	16059.9
567	Tal-Qadi	L-Imrejsbiet	FALSE	-201.479	16038.27
568	Tal-Qadi	Xewkija	FALSE	-257.54	17800.16
569	Tal-Qadi	Triq ix-Xabbata	FALSE	-229.926	18688.06
570	Tal-Qadi	Ta' Marziena	FALSE	-291.126	19500.51
571	Tal-Qadi	Borg L-Imramma	FALSE	-209.97	17305.82
572	Tal-Qadi	Bugibba	FALSE	-15.922	2025.91
573	Tal-Qadi	Ta' Hammut	FALSE	-150.673	2213.7
574	Tal-Qadi	L-Iklin	FALSE	-65.652	4197.47
575	Tal-Qadi	Tar-Raddiena	FALSE	-161.079	5224.86
576	Tal-Qadi	Id-Debdieba	FALSE	-273.981	10190.54
577	Tal-Qadi	It-Tumbata	FALSE	-282.344	10381.35
578	Tal-Qadi	Hal Resqun	FALSE	-348.207	11500.23
579	Tal-Qadi	Kordin I	FALSE	-454.189	9779.31
580	Tal-Qadi	Kordin II	FALSE	-451.817	9875.65
581	Tal-Qadi	Kordin III	FALSE	-452.005	10342.23
582	Tal-Qadi	Tarxien	FALSE	-418.803	11151.93
583	Tal-Qadi	Kuncizzjoni	FALSE	-358.595	8279.48
584	Tal-Qadi	Ras ir-Raheb	FALSE	-583.207	8936.61
585	Tal-Qadi	Ras il-Pellegrin	FALSE	-290.088	7805.51
586	Tal-Qadi	Ta' Hagrat	FALSE	-264.922	5100.04
587	Tal-Qadi	Skorba	FALSE	-173.693	4241.61
588	Tal-Qadi	Tal-Lippija	FALSE	-186.275	6939.61
589	Tal-Qadi	Xemxija	FALSE	-119.185	3957.78
590	Tal-Qadi	Ghajn Zejtuna	FALSE	-121.839	5865.03
591	Tal-Qadi	Mnajdra	FALSE	-319.997	12284.4
592	Tal-Qadi	Hagar Qim	FALSE	-302.532	12239.47
593	Tal-Qadi	Borg in-Nadur	FALSE	-589.436	15253.14
594	Tal-Qadi	Tas-Silg	FALSE	-678.277	15585.37
595	Tal-Qadi	Xrobb l-Ghagin	FALSE	-822.079	16862.76
596	Tal-Qadi	Hal Ginwi	FALSE	-649.121	15123.13
597	Ta' Hammut	Borg Gharib South	FALSE	-1747.394	17290.76
598	Ta' Hammut	Santa Verna	FALSE	-2008.419	20301
599	Ta' Hammut	Ggantija	FALSE	-1953.052	19623

600	Ta' Hammut	Borg Gharib North	FALSE	-1772.41	17397.33
601	Ta' Hammut	L-Imrejsbiet	FALSE	-1782.18	17380.1
602	Ta' Hammut	Xewkija	FALSE	-2118.306	19243.64
603	Ta' Hammut	Triq ix-Xabbata	FALSE	-2772.346	20268.07
604	Ta' Hammut	Borg L-Imramma	FALSE	-2489.318	18861.9
605	Ta' Hammut	Bugibba	FALSE	-319.782	2746.62
606	Ta' Hammut	Tal-Qadi	FALSE	-189.82	2213.7
607	Ta' Hammut	L-Iklin	FALSE	-96.507	3606.54
608	Ta' Hammut	Tar-Raddiena	FALSE	-265.872	4481.79
609	Ta' Hammut	Id-Debdieba	FALSE	-486.307	10094.18
610	Ta' Hammut	It-Tumbata	FALSE	-620.899	9946.76
611	Ta' Hammut	Hal Resqun	FALSE	-747.95	10915.59
612	Ta' Hammut	Kordin I	FALSE	-419.069	8684.84
613	Ta' Hammut	Kordin II	FALSE	-396.833	8757.79
614	Ta' Hammut	Kordin III	FALSE	-440.99	9262.67
615	Ta' Hammut	Tarxien	FALSE	-544.784	10144.01
616	Ta' Hammut	Kuncizzjoni	FALSE	-287.418	10448.48
617	Ta' Hammut	Ras ir-Raheb	FALSE	-586.58	11139.43
618	Ta' Hammut	Ras il-Pellegrin	FALSE	-741.509	10019.11
619	Ta' Hammut	Ta' Hagrat	FALSE	-330.663	7300.44
620	Ta' Hammut	Skorba	FALSE	-255.196	6438.65
621	Ta' Hammut	Tal-Lippija	FALSE	-801.163	9149.6
622	Ta' Hammut	Xemxija	FALSE	-604.641	5892.34
623	Ta' Hammut	Ghajn Zejtuna	FALSE	-1063.33	7426.08
624	Ta' Hammut	Mnajdra	FALSE	-525.295	12819.06
625	Ta' Hammut	Hagar Qim	FALSE	-530.877	12682.67
626	Ta' Hammut	Borg in-Nadur	FALSE	-1038.431	14484.74
627	Ta' Hammut	Tas-Silg	FALSE	-618.526	14460.48
628	Ta' Hammut	Xrobb l-Ghagin	FALSE	-698.846	15638.48
629	Ta' Hammut	Hal Ginwi	FALSE	-623.918	14030.91
630	Bugibba	Borg Gharib South	FALSE	-19.638	14550.14
631	Bugibba	Santa Verna	TRUE	3.863	17560.39
632	Bugibba	Ggantija	FALSE	-37.369	16890.88
633	Bugibba	Borg Gharib North	FALSE	-10.045	14655.7
634	Bugibba	L-Imrejsbiet	FALSE	-12.147	14638.04
635	Bugibba	Xewkija	FALSE	-11.313	16497.02
636	Bugibba	Triq ix-Xabbata	FALSE	-276.276	17531.13
637	Bugibba	Ta' Marziena	FALSE	-149.258	18272.4
638	Bugibba	Borg L-Imramma	FALSE	-181.185	16122.36
639	Bugibba	Tal-Qadi	FALSE	-66.212	2025.91
640	Bugibba	Ta' Hammut	FALSE	-66.436	2746.62
641	Bugibba	L-Iklin	FALSE	-98.812	5892.44
642	Bugibba	Tar-Raddiena	FALSE	-164.417	6884.25
643	Bugibba	Id-Debdieba	FALSE	-378.814	12132.42
644	Bugibba	It-Tumbata	FALSE	-365.595	12224.36
645	Bugibba	Hal Resqun	FALSE	-394.15	13292.1
646	Bugibba	Kordin I	FALSE	-309.048	11306.91

647	Bugibba	Kordin II	FALSE	-307.024	11389.38
648	Bugibba	Kordin III	FALSE	-317.258	11881.66
649	Bugibba	Tarxien	FALSE	-325.031	12737.12
650	Bugibba	Kuncizzjoni	FALSE	-215.166	9241.75
651	Bugibba	Ras ir-Raheb	FALSE	-350.506	9683.92
652	Bugibba	Ras il-Pellegrin	FALSE	-211.897	8397.78
653	Bugibba	Ta' Hagrat	FALSE	-142.442	6010
654	Bugibba	Skorba	FALSE	-99.202	5236.39
655	Bugibba	Tal-Lippija	FALSE	-173.282	7415.4
656	Bugibba	Xemxija	TRUE	0.57	3542.91
657	Bugibba	Ghajn Zejtuna	FALSE	-120.273	4721.37
658	Bugibba	Mnajdra	FALSE	-475.793	14310.28
659	Bugibba	Hagar Qim	FALSE	-426.497	14263.22
660	Bugibba	Borg in-Nadur	FALSE	-543.532	16976.98
661	Bugibba	Tas-Silg	FALSE	-484.122	17112.13
662	Bugibba	Xrobb l-Ghagin	FALSE	-573.452	18324.73
663	Bugibba	Hal Ginwi	FALSE	-481.47	16669.68
664	Xemxija	Borg Gharib South	FALSE	-620.945	12324.35
665	Xemxija	Santa Verna	FALSE	-729.195	15280.58
666	Xemxija	Ggantija	FALSE	-713.781	14738.04
667	Xemxija	Borg Gharib North	FALSE	-622.728	12408.75
668	Xemxija	L-Imrejsbiet	FALSE	-627.275	12382.85
669	Xemxija	Xewkija	FALSE	-681.27	14034.19
670	Xemxija	Triq ix-Xabbata	FALSE	-785.775	14816.89
671	Xemxija	Ta' Marziena	FALSE	-822.044	15669.06
672	Xemxija	Borg L-Imramma	FALSE	-678.8	13455.53
673	Xemxija	Bugibba	FALSE	-55.404	3542.91
674	Xemxija	Tal-Qadi	FALSE	-137.013	3957.78
675	Xemxija	Ta' Hammut	FALSE	-30.666	5892.34
676	Xemxija	L-Iklin	FALSE	-119.079	7990.3
677	Xemxija	Tar-Raddiena	FALSE	-195.702	9012.54
678	Xemxija	Id-Debdieba	FALSE	-465.166	13281.76
679	Xemxija	It-Tumbata	FALSE	-550.808	13765.74
680	Xemxija	Hal Resqun	FALSE	-484.87	14970.41
681	Xemxija	Kordin I	FALSE	-330.678	13591.68
682	Xemxija	Kordin II	FALSE	-323.446	13696.98
683	Xemxija	Kordin III	FALSE	-331.85	14140.12
684	Xemxija	Tarxien	FALSE	-323.578	14903.01
685	Xemxija	Kuncizzjoni	FALSE	-62.835	6426.27
686	Xemxija	Ras ir-Raheb	FALSE	-125.735	6583.54
687	Xemxija	Ras il-Pellegrin	FALSE	-26.897	5203.9
688	Xemxija	Ta' Hagrat	FALSE	-104.751	3529.62
689	Xemxija	Skorba	FALSE	-39.946	3134.89
690	Xemxija	Tal-Lippija	FALSE	-40.006	4170.62
691	Xemxija	Ghajn Zejtuna	FALSE	-154.821	2344.63
692	Xemxija	Mnajdra	FALSE	-457.136	14521.39
693	Xemxija	Hagar Qim	FALSE	-389.321	14605.84

694	Xemxija	Borg in-Nadur	FALSE	-566.978	18795.8
695	Xemxija	Tas-Silg	FALSE	-435.462	19356.22
696	Xemxija	Hal Ginwi	FALSE	-426.984	18879.25
697	Ghajn Zejtuna	Borg Gharib South	FALSE	-182.071	10120.06
698	Ghajn Zejtuna	Santa Verna	FALSE	-220.844	13107.61
699	Ghajn Zejtuna	Ggantija	FALSE	-207.244	12519.44
700	Ghajn Zejtuna	Borg Gharib North	FALSE	-181.673	10212.37
701	Ghajn Zejtuna	L-Imrejsbiet	FALSE	-186.162	10189.33
702	Ghajn Zejtuna	Xewkija	FALSE	-251.334	11935.38
703	Ghajn Zejtuna	Triq ix-Xabbata	FALSE	-214.998	12863.75
704	Ghajn Zejtuna	Ta' Marziena	FALSE	-280.757	13649.32
705	Ghajn Zejtuna	Borg L-Imramma	FALSE	-175.365	11468.1
706	Ghajn Zejtuna	Bugibba	FALSE	-922.978	4721.37
707	Ghajn Zejtuna	Tal-Qadi	FALSE	-1817.141	5865.03
708	Ghajn Zejtuna	Ta' Hammut	FALSE	-1696.164	7426.08
709	Ghajn Zejtuna	L-Iklin	FALSE	-2861.027	10045.15
710	Ghajn Zejtuna	Tar-Raddiena	FALSE	-3218.901	11074.57
711	Ghajn Zejtuna	Id-Debdieba	FALSE	-4148.592	15585.98
712	Ghajn Zejtuna	It-Tumbata	FALSE	-4232.676	16013.65
713	Ghajn Zejtuna	Hal Resqun	FALSE	-4712.049	17196.66
714	Ghajn Zejtuna	Kordin I	FALSE	-4813.269	15641.72
715	Ghajn Zejtuna	Kordin II	FALSE	-4851.082	15739.31
716	Ghajn Zejtuna	Kordin III	FALSE	-4955.185	16202.42
717	Ghajn Zejtuna	Tarxien	FALSE	-5143.61	17000.3
718	Ghajn Zejtuna	Kuncizzjoni	FALSE	-1086.327	7903.4
719	Ghajn Zejtuna	Ras ir-Raheb	FALSE	-1258.793	7736.79
720	Ghajn Zejtuna	Ras il-Pellegrin	FALSE	-955.802	6343.74
721	Ghajn Zejtuna	Ta' Hagrat	FALSE	-1163.533	5515.04
722	Ghajn Zejtuna	Skorba	FALSE	-1166.644	5321.24
723	Ghajn Zejtuna	Tal-Lippija	FALSE	-788.944	5357.31
724	Ghajn Zejtuna	Xemxija	FALSE	-540.43	2344.63
725	Ghajn Zejtuna	Mnajdra	FALSE	-4370.437	16860.19
726	Ghajn Zejtuna	Hagar Qim	FALSE	-4308.469	16948.89
727	Ggantija	Borg Gharib South	FALSE	-85.287	2418.36
728	Ggantija	Santa Verna	FALSE	-15.32	956.83
729	Ggantija	Borg Gharib North	FALSE	-81.253	2345.34
730	Ggantija	L-Imrejsbiet	FALSE	-86.49	2376.18
731	Ggantija	Xewkija	TRUE	5.591	1871.93
732	Ggantija	Triq ix-Xabbata	TRUE	6	3514.39
733	Ggantija	Ta' Marziena	TRUE	6	3041.33
734	Ggantija	Borg L-Imramma	TRUE	4.582	3200.23
735	Ggantija	Bugibba	FALSE	-342.029	16890.88
736	Ggantija	Tal-Qadi	FALSE	-386.714	18348.5
737	Ggantija	Ta' Hammut	FALSE	-353.687	19623
738	Ggantija	Kuncizzjoni	TRUE	6	17444.6
739	Ggantija	Ras ir-Raheb	TRUE	6	16511.9
740	Ggantija	Ras il-Pellegrin	TRUE	1.155	15712.71

741	Ggantija	Ta' Hagrat	FALSE	-421.384	16853.07
742	Ggantija	Skorba	FALSE	-420.942	17090.89
743	Ggantija	Tal-Lippija	FALSE	-192.463	15312.84
744	Ggantija	Xemxija	FALSE	-48.617	14738.04
745	Ggantija	Ghajn Zejtuna	FALSE	-298.136	12519.44
746	Santa Verna	Borg Gharib South	FALSE	-42.236	3010.29
747	Santa Verna	Ggantija	FALSE	-9.902	956.83
748	Santa Verna	Borg Gharib North	FALSE	-22.595	2906.01
749	Santa Verna	L-Imrejsbiet	FALSE	-27.505	2925.43
750	Santa Verna	Xewkija	TRUE	5.645	1596.65
751	Santa Verna	Triq ix-Xabbata	TRUE	6	2829.96
752	Santa Verna	Ta' Marziena	FALSE	-13.235	2173.16
753	Santa Verna	Borg L-Imramma	TRUE	4.249	2885.85
754	Santa Verna	Bugibba	FALSE	-63.039	17560.39
755	Santa Verna	Tal-Qadi	FALSE	-57.652	18961.15
756	Santa Verna	Ta' Hammut	FALSE	-140.599	20301
757	Santa Verna	Kuncizzjoni	TRUE	6	17669.64
758	Santa Verna	Ras ir-Raheb	TRUE	6	16697.73
759	Santa Verna	Ras il-Pellegrin	TRUE	0.887	15966.19
760	Santa Verna	Ta' Hagrat	FALSE	-32.276	17245.48
761	Santa Verna	Skorba	FALSE	-6.523	17524.7
762	Santa Verna	Tal-Lippija	TRUE	4.32	15622.85
763	Santa Verna	Xemxija	FALSE	-48.358	15280.58
764	Santa Verna	Ghajn Zejtuna	FALSE	-35.1	13107.61
765	Borg Gharib South	Santa Verna	FALSE	-165.52	3010.29
766	Borg Gharib South	Ggantija	FALSE	-125.775	2418.36
767	Borg Gharib South	Borg Gharib North	TRUE	5.22	140.8
768	Borg Gharib South	L-Imrejsbiet	TRUE	5.057	161.55
769	Borg Gharib South	Xewkija	FALSE	-68.499	2235.38
770	Borg Gharib South	Triq ix-Xabbata	FALSE	-37.993	3949.34
771	Borg Gharib South	Ta' Marziena	FALSE	-165.72	4171.89
772	Borg Gharib South	Borg L-Imramma	TRUE	4.98	2779.1
773	Borg Gharib South	Bugibba	TRUE	0.496	14550.14
774	Borg Gharib South	Tal-Qadi	FALSE	-71.787	15963.69
775	Borg Gharib South	Ta' Hammut	FALSE	-38.031	17290.76
776	Borg Gharib South	L-Iklin	FALSE	-13.017	20156.81
777	Borg Gharib South	Kuncizzjoni	TRUE	6	15158.41
778	Borg Gharib South	Ras ir-Raheb	TRUE	6	14266.66
779	Borg Gharib South	Ras il-Pellegrin	TRUE	1.087	13405.77
780	Borg Gharib South	Ta' Hagrat	FALSE	-53.661	14455.93
781	Borg Gharib South	Skorba	FALSE	-26.796	14680.21
782	Borg Gharib South	Tal-Lippija	TRUE	5.868	12962.93
783	Borg Gharib South	Xemxija	FALSE	-51.931	12324.35
784	Borg Gharib South	Ghajn Zejtuna	FALSE	-34.369	10120.06
785	Borg Gharib North	Borg Gharib South	TRUE	5.348	140.8
786	Borg Gharib North	Santa Verna	FALSE	-17.082	2906.01
787	Borg Gharib North	Ggantija	FALSE	-42.847	2345.34

788	Borg Gharib North	L-Imrejsbiet	TRUE	6	46.1
789	Borg Gharib North	Xewkija	FALSE	-3.096	2096.9
790	Borg Gharib North	Triq ix-Xabbata	FALSE	-16.601	3808.94
791	Borg Gharib North	Ta' Marziena	FALSE	-30.754	4033.9
792	Borg Gharib North	Borg L-Imramma	TRUE	5.105	2645.81
793	Borg Gharib North	Bugibba	TRUE	2.069	14655.7
794	Borg Gharib North	Tal-Qadi	FALSE	-70.34	16059.9
795	Borg Gharib North	Ta' Hammut	FALSE	-37.154	17397.33
796	Borg Gharib North	L-Iklin	FALSE	-12.615	20251.86
797	Borg Gharib North	Kuncizzjoni	TRUE	6	15188.8
798	Borg Gharib North	Ras ir-Raheb	TRUE	6	14289.67
799	Borg Gharib North	Ras il-Pellegrin	TRUE	1.093	13439.87
800	Borg Gharib North	Ta' Hagrat	FALSE	-48.003	14514.82
801	Borg Gharib North	Skorba	FALSE	-24.225	14746.29
802	Borg Gharib North	Tal-Lippija	TRUE	5.9	13006.66
803	Borg Gharib North	Xemxija	FALSE	-51.648	12408.75
804	Borg Gharib North	Ghajn Zejtuna	FALSE	-34.16	10212.37
805	L-Imrejsbiet	Borg Gharib South	TRUE	5.147	161.55
806	L-Imrejsbiet	Santa Verna	FALSE	-43.685	2925.43
807	L-Imrejsbiet	Ggantija	FALSE	-91.08	2376.18
808	L-Imrejsbiet	Borg Gharib North	TRUE	6	46.1
809	L-Imrejsbiet	Xewkija	FALSE	-24.671	2091.08
810	L-Imrejsbiet	Triq ix-Xabbata	FALSE	-43.319	3791.14
811	L-Imrejsbiet	Ta' Marziena	FALSE	-77.063	4028.55
812	L-Imrejsbiet	Borg L-Imramma	TRUE	4.939	2617.73
813	L-Imrejsbiet	Bugibba	TRUE	1.742	14638.04
814	L-Imrejsbiet	Tal-Qadi	FALSE	-71.89	16038.27
815	L-Imrejsbiet	Ta' Hammut	FALSE	-37.05	17380.1
816	L-Imrejsbiet	L-Iklin	FALSE	-12.919	20229.73
817	L-Imrejsbiet	Kuncizzjoni	TRUE	6	15149.46
818	L-Imrejsbiet	Ras ir-Raheb	TRUE	6	14249.11
819	L-Imrejsbiet	Ras il-Pellegrin	TRUE	1.062	13401.21
820	L-Imrejsbiet	Ta' Hagrat	FALSE	-52.146	14481.48
821	L-Imrejsbiet	Skorba	FALSE	-27.528	14714.82
822	L-Imrejsbiet	Tal-Lippija	TRUE	5.548	12969.89
823	L-Imrejsbiet	Xemxija	FALSE	-52.881	12382.85
824	L-Imrejsbiet	Ghajn Zejtuna	FALSE	-35.211	10189.33
825	Xewkija	Borg Gharib South	FALSE	-1.215	2235.38
826	Xewkija	Santa Verna	TRUE	5.011	1596.65
827	Xewkija	Ggantija	TRUE	6	1871.93
828	Xewkija	Borg Gharib North	TRUE	2.453	2096.9
829	Xewkija	L-Imrejsbiet	FALSE	-2.638	2091.08
830	Xewkija	Triq ix-Xabbata	TRUE	6	1867.42
831	Xewkija	Ta' Marziena	TRUE	6	1937.53
832	Xewkija	Borg L-Imramma	TRUE	2.092	1339.04
833	Xewkija	Bugibba	TRUE	1.386	16497.02
834	Xewkija	Tal-Qadi	FALSE	-86.288	17800.16

835	Xewkija	Ta' Hammut	FALSE	-36.446	19243.64
836	Xewkija	Kuncizzjoni	TRUE	6	16139.61
837	Xewkija	Ras ir-Raheb	TRUE	6	15150.14
838	Xewkija	Ras il-Pellegrin	TRUE	0.062	14453.84
839	Xewkija	Ta' Hagrat	FALSE	-35.086	15831.37
840	Xewkija	Skorba	FALSE	-21.556	16148.29
841	Xewkija	Tal-Lippija	FALSE	-1.991	14147.27
842	Xewkija	Xemxija	FALSE	-60.954	14034.19
843	Xewkija	Ghajn Zejtuna	FALSE	-42.2	11935.38
844	Triq ix-Xabbata	Borg Gharib South	FALSE	-68.821	3949.34
845	Triq ix-Xabbata	Santa Verna	TRUE	5.27	2829.96
846	Triq ix-Xabbata	Ggantija	TRUE	6	3514.39
847	Triq ix-Xabbata	Borg Gharib North	FALSE	-62.648	3808.94
848	Triq ix-Xabbata	L-Imrejsbiet	FALSE	-66.303	3791.14
849	Triq ix-Xabbata	Xewkija	TRUE	5.953	1867.42
850	Triq ix-Xabbata	Ta' Marziena	TRUE	6	1118.09
851	Triq ix-Xabbata	Borg L-Imramma	FALSE	-38.01	1424.65
852	Triq ix-Xabbata	Bugibba	FALSE	-910.977	17531.13
853	Triq ix-Xabbata	Tal-Qadi	FALSE	-895.809	18688.06
854	Triq ix-Xabbata	Ta' Hammut	FALSE	-1035.861	20268.07
855	Triq ix-Xabbata	Kuncizzjoni	FALSE	-804.415	16185.33
856	Triq ix-Xabbata	Ras ir-Raheb	FALSE	-873.425	15123.7
857	Triq ix-Xabbata	Ras il-Pellegrin	FALSE	-754.204	14586.27
858	Triq ix-Xabbata	Ta' Hagrat	FALSE	-822.689	16249.55
859	Triq ix-Xabbata	Skorba	FALSE	-807.757	16653.97
860	Triq ix-Xabbata	Tal-Lippija	FALSE	-768.735	14409.69
861	Triq ix-Xabbata	Xemxija	FALSE	-700.064	14816.89
862	Triq ix-Xabbata	Ghajn Zejtuna	FALSE	-643.45	12863.75
863	Ta' Marziena	Borg Gharib South	FALSE	-23.436	4171.89
864	Ta' Marziena	Santa Verna	TRUE	3.864	2173.16
865	Ta' Marziena	Ggantija	TRUE	5.345	3041.33
866	Ta' Marziena	Borg Gharib North	FALSE	-17.806	4033.9
867	Ta' Marziena	L-Imrejsbiet	FALSE	-21.412	4028.55
868	Ta' Marziena	Xewkija	TRUE	5.804	1937.53
869	Ta' Marziena	Triq ix-Xabbata	TRUE	6	1118.09
870	Ta' Marziena	Borg L-Imramma	FALSE	-9.581	2228.51
871	Ta' Marziena	Bugibba	FALSE	-22.716	18272.4
872	Ta' Marziena	Tal-Qadi	FALSE	-97.157	19500.51
873	Ta' Marziena	Kuncizzjoni	FALSE	-383.974	17250.26
874	Ta' Marziena	Ras ir-Raheb	FALSE	-464.141	16199.65
875	Ta' Marziena	Ras il-Pellegrin	FALSE	-384.251	15632.89
876	Ta' Marziena	Ta' Hagrat	FALSE	-449.346	17228.83
877	Ta' Marziena	Skorba	FALSE	-377.397	17607.71
878	Ta' Marziena	Tal-Lippija	FALSE	-421.504	15427.21
879	Ta' Marziena	Xemxija	FALSE	-165.492	15669.06
880	Ta' Marziena	Ghajn Zejtuna	FALSE	-42.329	13649.32
881	Borg L-Imramma	Borg Gharib South	TRUE	5.6	2779.1

882	Borg L-Imramma	Santa Verna	TRUE	1.321	2885.85
883	Borg L-Imramma	Ggantija	TRUE	6	3200.23
884	Borg L-Imramma	Borg Gharib North	TRUE	6	2645.81
885	Borg L-Imramma	L-Imrejsbiet	TRUE	4.474	2617.73
886	Borg L-Imramma	Xewkija	FALSE	-16.888	1339.04
887	Borg L-Imramma	Triq ix-Xabbata	FALSE	-37.159	1424.65
888	Borg L-Imramma	Ta' Marziena	FALSE	-62.99	2228.51
889	Borg L-Imramma	Bugibba	FALSE	-33.531	16122.36
890	Borg L-Imramma	Tal-Qadi	FALSE	-81.286	17305.82
891	Borg L-Imramma	Ta' Hammut	FALSE	-45.45	18861.9
892	Borg L-Imramma	Kuncizzjoni	TRUE	6	15116.7
893	Borg L-Imramma	Ras ir-Raheb	TRUE	6	14091.72
894	Borg L-Imramma	Ras il-Pellegrin	TRUE	0.558	13470.63
895	Borg L-Imramma	Ta' Hagrat	FALSE	-31.975	15009.67
896	Borg L-Imramma	Skorba	FALSE	-3.17	15381.34
897	Borg L-Imramma	Tal-Lippija	TRUE	6	13232.39
898	Borg L-Imramma	Xemxija	FALSE	-69.316	13455.53
899	Borg L-Imramma	Ghajn Zejtuna	FALSE	-33.809	11468.1

7.7 Visible portions when temple heights are set to 3 m

The following table lists the part of the target that is theoretically visible when temple heights are set to 3 m, for the 82 cases of visibility (visible = TRUE) that were identified (ref. 2.4.3). The FID (Field Identification Number) of the visible (TRUE) in this table are extracted from the FID in the table Appendix 7.8 and further explained in sections 2.3.3 and 2.3.7. The table is sorted according to visible portions (Target Size) from lowest to highest values in metres.

FID	Source	Target	Visible	Target Size	Distance
176	Tar-Raddiena	It-Tumbata	TRUE	0.219	5468.02
140	Tas-Silg	It-Tumbata	TRUE	0.229	6385.37
39	Id-Debdieba	Tar-Raddiena	TRUE	0.307	5745.07
191	L-Iklin	Tar-Raddiena	TRUE	0.374	1029.42
212	Ta' Hagrat	Ras il-Pellegrin	TRUE	0.502	2809.85
210	Ta' Hagrat	Kuncizzjoni	TRUE	0.624	3239
385	Ta' Marziena	Santa Verna	TRUE	0.864	2173.16
119	Kordin III	Kordin II	TRUE	0.909	523.93
175	Tar-Raddiena	Id-Debdieba	TRUE	0.926	5745.07
87	Kordin I	Kordin II	TRUE	1.114	141.42
103	Kordin II	Kordin I	TRUE	1.176	141.42
231	Ras il-Pellegrin	Kuncizzjoni	TRUE	1.193	1792.94
343	Santa Verna	Borg L-Imramma	TRUE	1.249	2885.85
233	Ras il-Pellegrin	Ta' Hagrat	TRUE	1.37	2809.85
396	Borg L-Imramma	L-Imrejsbiet	TRUE	1.474	2617.73
335	Ggantija	Borg L-Imramma	TRUE	1.582	3200.23
260	Ras ir-Raheb	Kuncizzjoni	TRUE	1.782	1191.99
181	Tar-Raddiena	Tarxien	TRUE	1.856	5927.81
59	Hal Resqun	Tarxien	TRUE	1.865	2308.53
367	L-Imrejsbiet	Borg L-Imramma	TRUE	1.939	2617.73
351	Borg Gharib South	Borg L-Imramma	TRUE	1.98	2779.1
369	Xewkija	Santa Verna	TRUE	2.011	1596.65
347	Borg Gharib South	L-Imrejsbiet	TRUE	2.057	161.55
359	Borg Gharib North	Borg L-Imramma	TRUE	2.105	2645.81
360	L-Imrejsbiet	Borg Gharib South	TRUE	2.147	161.55
31	It-Tumbata	Tarxien	TRUE	2.148	2892.55
198	L-Iklin	Tarxien	TRUE	2.196	6956.74
346	Borg Gharib South	Borg Gharib North	TRUE	2.22	140.8
377	Triq ix-Xabbata	Santa Verna	TRUE	2.27	2829.96
386	Ta' Marziena	Ggantija	TRUE	2.345	3041.33

352	Borg Gharib North	Borg Gharib South	TRUE	2.348	140.8
70	Tarxien	Hal Resqun	TRUE	2.483	2308.53
26	It-Tumbata	Id-Debdieba	TRUE	2.504	1562.67
85	Kordin I	It-Tumbata	TRUE	2.564	3219.27
332	Ggantija	Xewkija	TRUE	2.591	1871.93
392	Borg L-Imramma	Borg Gharib South	TRUE	2.6	2779.1
101	Kordin II	It-Tumbata	TRUE	2.603	3322.04
116	Kordin III	It-Tumbata	TRUE	2.622	3118.87
340	Santa Verna	Xewkija	TRUE	2.645	1596.65
69	Tarxien	It-Tumbata	TRUE	2.759	2892.55
389	Ta' Marziena	Xewkija	TRUE	2.804	1937.53
193	L-Iklin	It-Tumbata	TRUE	2.855	6372.82
40	Id-Debdieba	It-Tumbata	TRUE	2.938	1562.67
381	Triq ix-Xabbata	Xewkija	TRUE	2.953	1867.42
88	Kordin I	Kordin III	TRUE	2.967	578.01
28	It-Tumbata	Kordin I	TRUE	2.968	3219.27
82	Kordin I	L-Iklin	TRUE	2.994	5606.08
24	It-Tumbata	L-Iklin	TRUE	3	6372.82
29	It-Tumbata	Kordin II	TRUE	3	3322.04
30	It-Tumbata	Kordin III	TRUE	3	3118.87
38	Id-Debdieba	L-Iklin	TRUE	3	6494.07
66	Tarxien	L-Iklin	TRUE	3	6956.74
67	Tarxien	Tar-Raddiena	TRUE	3	5927.81
83	Kordin I	Tar-Raddiena	TRUE	3	4579.94
98	Kordin II	L-Iklin	TRUE	3	5708.86
99	Kordin II	Tar-Raddiena	TRUE	3	4684.45
113	Kordin III	L-Iklin	TRUE	3	6161.19
114	Kordin III	Tar-Raddiena	TRUE	3	5133
118	Kordin III	Kordin I	TRUE	3	578.01
136	Borg in-Nadur	Tas-Silg	TRUE	3	2668.11
146	Tas-Silg	Borg in-Nadur	TRUE	3	2668.11
178	Tar-Raddiena	Kordin I	TRUE	3	4579.94
179	Tar-Raddiena	Kordin II	TRUE	3	4684.45
180	Tar-Raddiena	Kordin III	TRUE	3	5133
192	L-Iklin	Id-Debdieba	TRUE	3	6494.07
195	L-Iklin	Kordin I	TRUE	3	5606.08
196	L-Iklin	Kordin II	TRUE	3	5708.86
197	L-Iklin	Kordin III	TRUE	3	6161.19
251	Kuncizzjoni	Ras ir-Raheb	TRUE	3	1191.99
333	Ggantija	Triq ix-Xabbata	TRUE	3	3514.39
334	Ggantija	Ta' Marziena	TRUE	3	3041.33
341	Santa Verna	Triq ix-Xabbata	TRUE	3	2829.96
355	Borg Gharib North	L-Imrejsbiet	TRUE	3	46.1
363	L-Imrejsbiet	Borg Gharib North	TRUE	3	46.1
370	Xewkija	Ggantija	TRUE	3	1871.93
373	Xewkija	Triq ix-Xabbata	TRUE	3	1867.42
374	Xewkija	Ta' Marziena	TRUE	3	1937.53
378	Triq ix-Xabbata	Ggantija	TRUE	3	3514.39

382	Triq ix-Xabbata	Ta' Marziena	TRUE	3	1118.09
390	Ta' Marziena	Triq ix-Xabbata	TRUE	3	1118.09
394	Borg L-Imramma	Ggantija	TRUE	3	3200.23
395	Borg L-Imramma	Borg Gharib North	TRUE	3	2645.81

7.8 Visible relationship between temples with 3 m height

This table shows all theoretically visible (TRUE) or non-visible (FALSE) parts of 400 temple relations set at a 3 m temle height (ref. 2.3.3). This analysis was the initial data for dectecting the TRUE visible sites for further examinations of temple intervisiblity using human acuity (see sections 2.3.3 and 2.3.7).

FID	Source	Target	Visible	Target Size	Distance
0	Hagar Qim	L-Iklin	FALSE	-77.18	9256.71
1	Hagar Qim	Tar-Raddiena	FALSE	-81.185	8742.95
2	Hagar Qim	Id-Debdieba	FALSE	-21.198	3603.12
3	Hagar Qim	It-Tumbata	FALSE	-16.134	5023.93
4	Hagar Qim	Hal Resqun	FALSE	-18.895	5632.42
5	Hagar Qim	Kordin I	FALSE	-45.677	8210.85
6	Hagar Qim	Kordin II	FALSE	-39.118	8322.89
7	Hagar Qim	Kordin III	FALSE	-39.021	8142.79
8	Hagar Qim	Tarxien	FALSE	-16.843	7834.55
9	Hagar Qim	Mnajdra	FALSE	-12.899	537.45
10	Hagar Qim	Borg in-Nadur	FALSE	-121.025	7852.36
11	Hagar Qim	Hal Ginwi	FALSE	-91.307	9698.97
12	Mnajdra	L-Iklin	FALSE	-1196.987	9449.64
13	Mnajdra	Tar-Raddiena	FALSE	-1177.364	8984.76
14	Mnajdra	Id-Debdieba	FALSE	-477.051	4038.2
15	Mnajdra	It-Tumbata	FALSE	-642.756	5497.57
16	Mnajdra	Hal Resqun	FALSE	-661.446	6147.38
17	Mnajdra	Kordin I	FALSE	-1077.948	8663.21
18	Mnajdra	Kordin II	FALSE	-1075.872	8778.11
19	Mnajdra	Kordin III	FALSE	-1050.139	8613.93
20	Mnajdra	Tarxien	FALSE	-962.717	8330.63
21	Mnajdra	Hagar Qim	FALSE	-0.272	537.45
22	Mnajdra	Borg in-Nadur	FALSE	-774.657	8382.36
23	It-Tumbata	Ta' Hammut	FALSE	-134.054	9946.76
24	It-Tumbata	L-Iklin	TRUE	3	6372.82
25	It-Tumbata	Tar-Raddiena	FALSE	-10.398	5468.02
26	It-Tumbata	Id-Debdieba	TRUE	2.504	1562.67
27	It-Tumbata	Hal Resqun	FALSE	-4.305	1285.79
28	It-Tumbata	Kordin I	TRUE	2.968	3219.27
29	It-Tumbata	Kordin II	TRUE	3	3322.04
30	It-Tumbata	Kordin III	TRUE	3	3118.87
31	It-Tumbata	Tarxien	TRUE	2.148	2892.55
32	It-Tumbata	Mnajdra	FALSE	-62.125	5497.57
33	It-Tumbata	Hagar Qim	FALSE	-0.441	5023.93
34	It-Tumbata	Borg in-Nadur	FALSE	-58.879	5100.25

35	It-Tumbata	Tas-Silg	FALSE	-0.382	6385.37
36	It-Tumbata	Xrobb I-Ghagin	FALSE	-22.221	7864.71
37	It-Tumbata	Hal Ginwi	FALSE	-23.222	5872.86
38	Id-Debdieba	L-Iklin	TRUE	3	6494.07
39	Id-Debdieba	Tar-Raddiena	TRUE	0.307	5745.07
40	Id-Debdieba	It-Tumbata	TRUE	2.938	1562.67
41	Id-Debdieba	Hal Resqun	FALSE	-12.297	2610
42	Id-Debdieba	Kordin I	FALSE	-18.321	4629.34
43	Id-Debdieba	Kordin II	FALSE	-10.683	4746.91
44	Id-Debdieba	Kordin III	FALSE	-28.715	4613.95
45	Id-Debdieba	Tarxien	FALSE	-5.068	4453.38
46	Id-Debdieba	Mnajdra	FALSE	-60.54	4038.2
47	Id-Debdieba	Hagar Qim	FALSE	-14.995	3603.12
48	Id-Debdieba	Borg in-Nadur	FALSE	-114.004	6080.44
49	Id-Debdieba	Tas-Silg	FALSE	-50.858	7729.69
50	Id-Debdieba	Xrobb I-Ghagin	FALSE	-86.674	9210.62
51	Id-Debdieba	Hal Ginwi	FALSE	-71.233	7223.51
52	Hal Resqun	L-Iklin	FALSE	-181.949	7404.03
53	Hal Resqun	Tar-Raddiena	FALSE	-174.932	6444.8
54	Hal Resqun	Id-Debdieba	FALSE	-28.77	2610
55	Hal Resqun	It-Tumbata	FALSE	-24.407	1285.79
56	Hal Resqun	Kordin I	FALSE	-35.692	3218.59
57	Hal Resqun	Kordin II	FALSE	-30.26	3275.78
58	Hal Resqun	Kordin III	FALSE	-20.997	2897.35
59	Hal Resqun	Tarxien	TRUE	1.865	2308.53
60	Hal Resqun	Mnajdra	FALSE	-52.256	6147.38
61	Hal Resqun	Hagar Qim	FALSE	-1.278	5632.42
62	Hal Resqun	Borg in-Nadur	FALSE	-74.85	3841.75
63	Hal Resqun	Tas-Silg	FALSE	-35.281	5143.23
64	Hal Resqun	Xrobb I-Ghagin	FALSE	-65.155	6625.35
65	Hal Resqun	Hal Ginwi	FALSE	-53.913	4633.18
66	Tarxien	L-Iklin	TRUE	3	6956.74
67	Tarxien	Tar-Raddiena	TRUE	3	5927.81
68	Tarxien	Id-Debdieba	FALSE	-2.053	4453.38
69	Tarxien	It-Tumbata	TRUE	2.759	2892.55
70	Tarxien	Hal Resqun	TRUE	2.483	2308.53
71	Tarxien	Kordin I	FALSE	-34.269	1489.24
72	Tarxien	Kordin II	FALSE	-22.337	1451.35
73	Tarxien	Kordin III	FALSE	-21.344	928.29
74	Tarxien	Mnajdra	FALSE	-73.229	8330.63
75	Tarxien	Hagar Qim	FALSE	-0.767	7834.55
76	Tarxien	Borg in-Nadur	FALSE	-132.226	4487.81
77	Tarxien	Tas-Silg	FALSE	-154.084	4453.57
78	Tarxien	Xrobb I-Ghagin	FALSE	-238.169	5811.24
79	Tarxien	Hal Ginwi	FALSE	-155.463	3977.75
80	Kordin I	Tal-Qadi	FALSE	-172.824	9779.31

81	Kordin I	Ta' Hammut	FALSE	-154.922	8684.84
82	Kordin I	L-Iklin	TRUE	2.994	5606.08
83	Kordin I	Tar-Raddiena	TRUE	3	4579.94
84	Kordin I	Id-Debdieba	FALSE	-10.923	4629.34
85	Kordin I	It-Tumbata	TRUE	2.564	3219.27
86	Kordin I	Hal Resqun	FALSE	-17.057	3218.59
87	Kordin I	Kordin II	TRUE	1.114	141.42
88	Kordin I	Kordin III	TRUE	2.967	578.01
89	Kordin I	Tarxien	FALSE	-3.939	1489.24
90	Kordin I	Mnajdra	FALSE	-89.621	8663.21
91	Kordin I	Hagar Qim	FALSE	-33.744	8210.85
92	Kordin I	Borg in-Nadur	FALSE	-100.127	5968.75
93	Kordin I	Tas-Silg	FALSE	-142.663	5813.15
94	Kordin I	Xrobb l-Ghagin	FALSE	-368.71	7089.68
95	Kordin I	Hal Ginwi	FALSE	-156.608	5363.5
96	Kordin II	Tal-Qadi	FALSE	-177.795	9875.65
97	Kordin II	Ta' Hammut	FALSE	-150.36	8757.79
98	Kordin II	L-Iklin	TRUE	3	5708.86
99	Kordin II	Tar-Raddiena	TRUE	3	4684.45
100	Kordin II	Id-Debdieba	FALSE	-5.058	4746.91
101	Kordin II	It-Tumbata	TRUE	2.603	3322.04
102	Kordin II	Hal Resqun	FALSE	-14.431	3275.78
103	Kordin II	Kordin I	TRUE	1.176	141.42
104	Kordin II	Kordin III	FALSE	-1.719	523.93
105	Kordin II	Tarxien	FALSE	-1.578	1451.35
106	Kordin II	Mnajdra	FALSE	-66.743	8778.11
107	Kordin II	Hagar Qim	FALSE	-10.884	8322.89
108	Kordin II	Borg in-Nadur	FALSE	-93.497	5938.7
109	Kordin II	Tas-Silg	FALSE	-259.778	5725.08
110	Kordin II	Xrobb l-Ghagin	FALSE	-477.235	6989
111	Kordin II	Hal Ginwi	FALSE	-209.162	5280.54
112	Kordin III	Ta' Hammut	FALSE	-148.515	9262.67
113	Kordin III	L-Iklin	TRUE	3	6161.19
114	Kordin III	Tar-Raddiena	TRUE	3	5133
115	Kordin III	Id-Debdieba	FALSE	-14.948	4613.95
116	Kordin III	It-Tumbata	TRUE	2.622	3118.87
117	Kordin III	Hal Resqun	FALSE	-12.92	2897.35
118	Kordin III	Kordin I	TRUE	3	578.01
119	Kordin III	Kordin II	TRUE	0.909	523.93
120	Kordin III	Tarxien	FALSE	-6.907	928.29
121	Kordin III	Mnajdra	FALSE	-63.35	8613.93
122	Kordin III	Hagar Qim	FALSE	-15.121	8142.79
123	Kordin III	Borg in-Nadur	FALSE	-168.513	5416.1
124	Kordin III	Tas-Silg	FALSE	-46.802	5244.74
125	Kordin III	Xrobb l-Ghagin	FALSE	-85.091	6538.01
126	Kordin III	Hal Ginwi	FALSE	-59.772	4790.87

127	Borg in-Nadur	Id-Debdieba	FALSE	-174.864	6080.44
128	Borg in-Nadur	It-Tumbata	FALSE	-159.35	5100.25
129	Borg in-Nadur	Hal Resqun	FALSE	-143.99	3841.75
130	Borg in-Nadur	Kordin I	FALSE	-149.304	5968.75
131	Borg in-Nadur	Kordin II	FALSE	-136.8	5938.7
132	Borg in-Nadur	Kordin III	FALSE	-126.557	5416.1
133	Borg in-Nadur	Tarxien	FALSE	-83.723	4487.81
134	Borg in-Nadur	Mnajdra	FALSE	-474.635	8382.36
135	Borg in-Nadur	Hagar Qim	FALSE	-413.022	7852.36
136	Borg in-Nadur	Tas-Silg	TRUE	3	2668.11
137	Borg in-Nadur	Xrobb l-Ghagin	FALSE	-59.468	3846.85
138	Borg in-Nadur	Hal Ginwi	FALSE	-13.947	2391.79
139	Tas-Silg	Id-Debdieba	FALSE	-18.443	7729.69
140	Tas-Silg	It-Tumbata	TRUE	0.229	6385.37
141	Tas-Silg	Hal Resqun	FALSE	-6.882	5143.23
142	Tas-Silg	Kordin I	FALSE	-29.625	5813.15
143	Tas-Silg	Kordin II	FALSE	-19.319	5725.08
144	Tas-Silg	Kordin III	FALSE	-18.895	5244.74
145	Tas-Silg	Tarxien	FALSE	-8.806	4453.57
146	Tas-Silg	Borg in-Nadur	TRUE	3	2668.11
147	Tas-Silg	Xrobb l-Ghagin	FALSE	-21.352	1482.18
148	Tas-Silg	Hal Ginwi	FALSE	-6.065	513.08
149	Xrobb l-Ghagin	Id-Debdieba	FALSE	-932.163	9210.62
150	Xrobb l-Ghagin	It-Tumbata	FALSE	-829.201	7864.71
151	Xrobb l-Ghagin	Hal Resqun	FALSE	-652.503	6625.35
152	Xrobb l-Ghagin	Kordin I	FALSE	-822.584	7089.68
153	Xrobb l-Ghagin	Kordin II	FALSE	-783.024	6989
154	Xrobb l-Ghagin	Kordin III	FALSE	-724.157	6538.01
155	Xrobb l-Ghagin	Tarxien	FALSE	-729.684	5811.24
156	Xrobb l-Ghagin	Borg in-Nadur	FALSE	-523.747	3846.85
157	Xrobb l-Ghagin	Tas-Silg	FALSE	-130.204	1482.18
158	Xrobb l-Ghagin	Hal Ginwi	FALSE	-205.024	1992.79
159	Hal Ginwi	Tar-Raddiena	FALSE	-503.423	9901.81
160	Hal Ginwi	Id-Debdieba	FALSE	-209.508	7223.51
161	Hal Ginwi	It-Tumbata	FALSE	-200.34	5872.86
162	Hal Ginwi	Hal Resqun	FALSE	-148.708	4633.18
163	Hal Ginwi	Kordin I	FALSE	-275.152	5363.5
164	Hal Ginwi	Kordin II	FALSE	-252.996	5280.54
165	Hal Ginwi	Kordin III	FALSE	-235.107	4790.87
166	Hal Ginwi	Tarxien	FALSE	-171.297	3977.75
167	Hal Ginwi	Hagar Qim	FALSE	-142.269	9698.97
168	Hal Ginwi	Borg in-Nadur	FALSE	-15.258	2391.79
169	Hal Ginwi	Tas-Silg	FALSE	-0.045	513.08
170	Hal Ginwi	Xrobb l-Ghagin	FALSE	-91.151	1992.79
171	Tar-Raddiena	Bugibba	FALSE	-602.783	6884.25
172	Tar-Raddiena	Tal-Qadi	FALSE	-446.535	5224.86

173	Tar-Raddiena	Ta' Hammut	FALSE	-321.126	4481.79
174	Tar-Raddiena	L-Iklin	FALSE	-30.034	1029.42
175	Tar-Raddiena	Id-Debdieba	TRUE	0.926	5745.07
176	Tar-Raddiena	It-Tumbata	TRUE	0.219	5468.02
177	Tar-Raddiena	Hal Resqun	FALSE	-1.104	6444.8
178	Tar-Raddiena	Kordin I	TRUE	3	4579.94
179	Tar-Raddiena	Kordin II	TRUE	3	4684.45
180	Tar-Raddiena	Kordin III	TRUE	3	5133
181	Tar-Raddiena	Tarxien	TRUE	1.856	5927.81
182	Tar-Raddiena	Ta' Hagrat	FALSE	-338.263	8662.18
183	Tar-Raddiena	Skorba	FALSE	-330.377	7908.23
184	Tar-Raddiena	Xemxija	FALSE	-717.786	9012.54
185	Tar-Raddiena	Mnajdra	FALSE	-57.517	8984.76
186	Tar-Raddiena	Hagar Qim	FALSE	-5.151	8742.95
187	Tar-Raddiena	Hal Ginwi	FALSE	-30.595	9901.81
188	L-Iklin	Bugibba	FALSE	-256.95	5892.44
189	L-Iklin	Tal-Qadi	FALSE	-157.941	4197.47
190	L-Iklin	Ta' Hammut	FALSE	-272.434	3606.54
191	L-Iklin	Tar-Raddiena	TRUE	0.374	1029.42
192	L-Iklin	Id-Debdieba	TRUE	3	6494.07
193	L-Iklin	It-Tumbata	TRUE	2.855	6372.82
194	L-Iklin	Hal Resqun	FALSE	-0.633	7404.03
195	L-Iklin	Kordin I	TRUE	3	5606.08
196	L-Iklin	Kordin II	TRUE	3	5708.86
197	L-Iklin	Kordin III	TRUE	3	6161.19
198	L-Iklin	Tarxien	TRUE	2.196	6956.74
199	L-Iklin	Ta' Hagrat	FALSE	-185.427	7780.78
200	L-Iklin	Skorba	FALSE	-131.358	7001.02
201	L-Iklin	Tal-Lippija	FALSE	-231.772	9942.65
202	L-Iklin	Xemxija	FALSE	-158.152	7990.3
203	L-Iklin	Mnajdra	FALSE	-52.463	9449.64
204	L-Iklin	Hagar Qim	FALSE	-2.79	9256.71
205	Ta' Hagrat	Bugibba	FALSE	-403.155	6010
206	Ta' Hagrat	Tal-Qadi	FALSE	-364.135	5100.04
207	Ta' Hagrat	Ta' Hammut	FALSE	-502.687	7300.44
208	Ta' Hagrat	L-Iklin	FALSE	-209.191	7780.78
209	Ta' Hagrat	Tar-Raddiena	FALSE	-258.776	8662.18
210	Ta' Hagrat	Kuncizzjoni	TRUE	0.624	3239
211	Ta' Hagrat	Ras ir-Raheb	FALSE	-39.189	3839.07
212	Ta' Hagrat	Ras il-Pellegrin	TRUE	0.502	2809.85
213	Ta' Hagrat	Skorba	FALSE	-17.054	863.51
214	Ta' Hagrat	Tal-Lippija	FALSE	-66.534	2182.66
215	Ta' Hagrat	Xemxija	FALSE	-260.883	3529.62
216	Ta' Hagrat	Ghajn Zejtuna	FALSE	-294.437	5515.04
217	Skorba	Bugibba	FALSE	-97.003	5236.39
218	Skorba	Tal-Qadi	FALSE	-139.165	4241.61

219	Skorba	Ta' Hammut	FALSE	-156.17	6438.65
220	Skorba	L-Iklin	FALSE	-10.656	7001.02
221	Skorba	Tar-Raddiena	FALSE	-35.635	7908.23
222	Skorba	Kuncizzjoni	FALSE	-5.788	4062.29
223	Skorba	Ras ir-Raheb	FALSE	-165.099	4701.65
224	Skorba	Ras il-Pellegrin	FALSE	-175.685	3654.22
225	Skorba	Ta' Hagrat	FALSE	-49.894	863.51
226	Skorba	Tal-Lippija	FALSE	-220.342	2944.69
227	Skorba	Xemxija	FALSE	-82.799	3134.89
228	Skorba	Ghajn Zejtuna	FALSE	-134.4	5321.24
229	Ras il-Pellegrin	Bugibba	FALSE	-131.589	8397.78
230	Ras il-Pellegrin	Tal-Qadi	FALSE	-116.829	7805.51
231	Ras il-Pellegrin	Kuncizzjoni	TRUE	1.193	1792.94
232	Ras il-Pellegrin	Ras ir-Raheb	FALSE	-31.057	1405
233	Ras il-Pellegrin	Ta' Hagrat	TRUE	1.37	2809.85
234	Ras il-Pellegrin	Skorba	FALSE	-6.619	3654.22
235	Ras il-Pellegrin	Tal-Lippija	FALSE	-44.102	1036.64
236	Ras il-Pellegrin	Xemxija	FALSE	-45.649	5203.9
237	Ras il-Pellegrin	Ghajn Zejtuna	FALSE	-219.817	6343.74
238	Tal-Lippija	Bugibba	FALSE	-464.321	7415.4
239	Tal-Lippija	Tal-Qadi	FALSE	-562.482	6939.61
240	Tal-Lippija	Ta' Hammut	FALSE	-710.581	9149.6
241	Tal-Lippija	L-Iklin	FALSE	-788.886	9942.65
242	Tal-Lippija	Kuncizzjoni	FALSE	-1.83	2586.83
243	Tal-Lippija	Ras ir-Raheb	FALSE	-131.266	2435.62
244	Tal-Lippija	Ras il-Pellegrin	FALSE	-4.697	1036.64
245	Tal-Lippija	Ta' Hagrat	FALSE	-170.242	2182.66
246	Tal-Lippija	Skorba	FALSE	-199.448	2944.69
247	Tal-Lippija	Xemxija	FALSE	-155.622	4170.62
248	Tal-Lippija	Ghajn Zejtuna	FALSE	-225.397	5357.31
249	Kuncizzjoni	Bugibba	FALSE	-75.763	9241.75
250	Kuncizzjoni	Tal-Qadi	FALSE	-218.639	8279.48
251	Kuncizzjoni	Ras ir-Raheb	TRUE	3	1191.99
252	Kuncizzjoni	Ras il-Pellegrin	FALSE	-6.626	1792.94
253	Kuncizzjoni	Ta' Hagrat	FALSE	-28.126	3239
254	Kuncizzjoni	Skorba	FALSE	-39.545	4062.29
255	Kuncizzjoni	Tal-Lippija	FALSE	-106.084	2586.83
256	Kuncizzjoni	Xemxija	FALSE	-104.823	6426.27
257	Kuncizzjoni	Ghajn Zejtuna	FALSE	-216.496	7903.4
258	Ras ir-Raheb	Bugibba	FALSE	-236.119	9683.92
259	Ras ir-Raheb	Tal-Qadi	FALSE	-263.151	8936.61
260	Ras ir-Raheb	Kuncizzjoni	TRUE	1.782	1191.99
261	Ras ir-Raheb	Ras il-Pellegrin	FALSE	-3.445	1405
262	Ras ir-Raheb	Ta' Hagrat	FALSE	-60.848	3839.07
263	Ras ir-Raheb	Skorba	FALSE	-59.415	4701.65
264	Ras ir-Raheb	Tal-Lippija	FALSE	-93.335	2435.62

265	Ras ir-Raheb	Xemxija	FALSE	-219.196	6583.54
266	Ras ir-Raheb	Ghajn Zejtuna	FALSE	-489.126	7736.79
267	Tal-Qadi	Bugibba	FALSE	-18.922	2025.91
268	Tal-Qadi	Ta' Hammut	FALSE	-153.673	2213.7
269	Tal-Qadi	L-Iklin	FALSE	-68.652	4197.47
270	Tal-Qadi	Tar-Raddiena	FALSE	-164.079	5224.86
271	Tal-Qadi	Kordin I	FALSE	-457.189	9779.31
272	Tal-Qadi	Kordin II	FALSE	-454.817	9875.65
273	Tal-Qadi	Kuncizzjoni	FALSE	-361.595	8279.48
274	Tal-Qadi	Ras ir-Raheb	FALSE	-586.207	8936.61
275	Tal-Qadi	Ras il-Pellegrin	FALSE	-293.088	7805.51
276	Tal-Qadi	Ta' Hagrat	FALSE	-267.922	5100.04
277	Tal-Qadi	Skorba	FALSE	-176.693	4241.61
278	Tal-Qadi	Tal-Lippija	FALSE	-189.275	6939.61
279	Tal-Qadi	Xemxija	FALSE	-122.185	3957.78
280	Tal-Qadi	Ghajn Zejtuna	FALSE	-124.839	5865.03
281	Ta' Hammut	Bugibba	FALSE	-322.782	2746.62
282	Ta' Hammut	Tal-Qadi	FALSE	-192.82	2213.7
283	Ta' Hammut	L-Iklin	FALSE	-99.507	3606.54
284	Ta' Hammut	Tar-Raddiena	FALSE	-268.872	4481.79
285	Ta' Hammut	It-Tumbata	FALSE	-623.899	9946.76
286	Ta' Hammut	Kordin I	FALSE	-422.069	8684.84
287	Ta' Hammut	Kordin II	FALSE	-399.833	8757.79
288	Ta' Hammut	Kordin III	FALSE	-443.99	9262.67
289	Ta' Hammut	Ta' Hagrat	FALSE	-333.663	7300.44
290	Ta' Hammut	Skorba	FALSE	-258.196	6438.65
291	Ta' Hammut	Tal-Lippija	FALSE	-804.163	9149.6
292	Ta' Hammut	Xemxija	FALSE	-607.641	5892.34
293	Ta' Hammut	Ghajn Zejtuna	FALSE	-1066.33	7426.08
294	Bugibba	Tal-Qadi	FALSE	-69.212	2025.91
295	Bugibba	Ta' Hammut	FALSE	-69.436	2746.62
296	Bugibba	L-Iklin	FALSE	-101.812	5892.44
297	Bugibba	Tar-Raddiena	FALSE	-167.417	6884.25
298	Bugibba	Kuncizzjoni	FALSE	-218.166	9241.75
299	Bugibba	Ras ir-Raheb	FALSE	-353.506	9683.92
300	Bugibba	Ras il-Pellegrin	FALSE	-214.897	8397.78
301	Bugibba	Ta' Hagrat	FALSE	-145.442	6010
302	Bugibba	Skorba	FALSE	-102.202	5236.39
303	Bugibba	Tal-Lippija	FALSE	-176.282	7415.4
304	Bugibba	Xemxija	FALSE	-2.43	3542.91
305	Bugibba	Ghajn Zejtuna	FALSE	-123.273	4721.37
306	Xemxija	Bugibba	FALSE	-58.404	3542.91
307	Xemxija	Tal-Qadi	FALSE	-140.013	3957.78
308	Xemxija	Ta' Hammut	FALSE	-33.666	5892.34
309	Xemxija	L-Iklin	FALSE	-122.079	7990.3
310	Xemxija	Tar-Raddiena	FALSE	-198.702	9012.54

311	Xemxija	Kuncizzjoni	FALSE	-65.835	6426.27
312	Xemxija	Ras ir-Raheb	FALSE	-128.735	6583.54
313	Xemxija	Ras il-Pellegrin	FALSE	-29.897	5203.9
314	Xemxija	Ta' Hagrat	FALSE	-107.751	3529.62
315	Xemxija	Skorba	FALSE	-42.946	3134.89
316	Xemxija	Tal-Lippija	FALSE	-43.006	4170.62
317	Xemxija	Ghajn Zejtuna	FALSE	-157.821	2344.63
318	Ghajn Zejtuna	Bugibba	FALSE	-925.978	4721.37
319	Ghajn Zejtuna	Tal-Qadi	FALSE	-1820.141	5865.03
320	Ghajn Zejtuna	Ta' Hammut	FALSE	-1699.164	7426.08
321	Ghajn Zejtuna	Kuncizzjoni	FALSE	-1089.327	7903.4
322	Ghajn Zejtuna	Ras ir-Raheb	FALSE	-1261.793	7736.79
323	Ghajn Zejtuna	Ras il-Pellegrin	FALSE	-958.802	6343.74
324	Ghajn Zejtuna	Ta' Hagrat	FALSE	-1166.533	5515.04
325	Ghajn Zejtuna	Skorba	FALSE	-1169.644	5321.24
326	Ghajn Zejtuna	Tal-Lippija	FALSE	-791.944	5357.31
327	Ghajn Zejtuna	Xemxija	FALSE	-543.43	2344.63
328	Ggantija	Borg Gharib South	FALSE	-88.287	2418.36
329	Ggantija	Santa Verna	FALSE	-18.32	956.83
330	Ggantija	Borg Gharib North	FALSE	-84.253	2345.34
331	Ggantija	L-Imrejsbiet	FALSE	-89.49	2376.18
332	Ggantija	Xewkija	TRUE	2.591	1871.93
333	Ggantija	Triq ix-Xabbata	TRUE	3	3514.39
334	Ggantija	Ta' Marziena	TRUE	3	3041.33
335	Ggantija	Borg L-Imramma	TRUE	1.582	3200.23
336	Santa Verna	Borg Gharib South	FALSE	-45.236	3010.29
337	Santa Verna	Ggantija	FALSE	-12.902	956.83
338	Santa Verna	Borg Gharib North	FALSE	-25.595	2906.01
339	Santa Verna	L-Imrejsbiet	FALSE	-30.505	2925.43
340	Santa Verna	Xewkija	TRUE	2.645	1596.65
341	Santa Verna	Triq ix-Xabbata	TRUE	3	2829.96
342	Santa Verna	Ta' Marziena	FALSE	-16.235	2173.16
343	Santa Verna	Borg L-Imramma	TRUE	1.249	2885.85
344	Borg Gharib South	Santa Verna	FALSE	-168.52	3010.29
345	Borg Gharib South	Ggantija	FALSE	-128.775	2418.36
346	Borg Gharib South	Borg Gharib North	TRUE	2.22	140.8
347	Borg Gharib South	L-Imrejsbiet	TRUE	2.057	161.55
348	Borg Gharib South	Xewkija	FALSE	-71.499	2235.38
349	Borg Gharib South	Triq ix-Xabbata	FALSE	-40.993	3949.34
350	Borg Gharib South	Ta' Marziena	FALSE	-168.72	4171.89
351	Borg Gharib South	Borg L-Imramma	TRUE	1.98	2779.1
352	Borg Gharib North	Borg Gharib South	TRUE	2.348	140.8
353	Borg Gharib North	Santa Verna	FALSE	-20.082	2906.01
354	Borg Gharib North	Ggantija	FALSE	-45.847	2345.34
355	Borg Gharib North	L-Imrejsbiet	TRUE	3	46.1
356	Borg Gharib North	Xewkija	FALSE	-6.096	2096.9

357	Borg Gharib North	Triq ix-Xabbata	FALSE	-19.601	3808.94
358	Borg Gharib North	Ta' Marziena	FALSE	-33.754	4033.9
359	Borg Gharib North	Borg L-Imramma	TRUE	2.105	2645.81
360	L-Imrejsbiet	Borg Gharib South	TRUE	2.147	161.55
361	L-Imrejsbiet	Santa Verna	FALSE	-46.685	2925.43
362	L-Imrejsbiet	Ggantija	FALSE	-94.08	2376.18
363	L-Imrejsbiet	Borg Gharib North	TRUE	3	46.1
364	L-Imrejsbiet	Xewkija	FALSE	-27.671	2091.08
365	L-Imrejsbiet	Triq ix-Xabbata	FALSE	-46.319	3791.14
366	L-Imrejsbiet	Ta' Marziena	FALSE	-80.063	4028.55
367	L-Imrejsbiet	Borg L-Imramma	TRUE	1.939	2617.73
368	Xewkija	Borg Gharib South	FALSE	-4.215	2235.38
369	Xewkija	Santa Verna	TRUE	2.011	1596.65
370	Xewkija	Ggantija	TRUE	3	1871.93
371	Xewkija	Borg Gharib North	FALSE	-0.547	2096.9
372	Xewkija	L-Imrejsbiet	FALSE	-5.638	2091.08
373	Xewkija	Triq ix-Xabbata	TRUE	3	1867.42
374	Xewkija	Ta' Marziena	TRUE	3	1937.53
375	Xewkija	Borg L-Imramma	FALSE	-0.908	1339.04
376	Triq ix-Xabbata	Borg Gharib South	FALSE	-71.821	3949.34
377	Triq ix-Xabbata	Santa Verna	TRUE	2.27	2829.96
378	Triq ix-Xabbata	Ggantija	TRUE	3	3514.39
379	Triq ix-Xabbata	Borg Gharib North	FALSE	-65.648	3808.94
380	Triq ix-Xabbata	L-Imrejsbiet	FALSE	-69.303	3791.14
381	Triq ix-Xabbata	Xewkija	TRUE	2.953	1867.42
382	Triq ix-Xabbata	Ta' Marziena	TRUE	3	1118.09
383	Triq ix-Xabbata	Borg L-Imramma	FALSE	-41.01	1424.65
384	Ta' Marziena	Borg Gharib South	FALSE	-26.436	4171.89
385	Ta' Marziena	Santa Verna	TRUE	0.864	2173.16
386	Ta' Marziena	Ggantija	TRUE	2.345	3041.33
387	Ta' Marziena	Borg Gharib North	FALSE	-20.806	4033.9
388	Ta' Marziena	L-Imrejsbiet	FALSE	-24.412	4028.55
389	Ta' Marziena	Xewkija	TRUE	2.804	1937.53
390	Ta' Marziena	Triq ix-Xabbata	TRUE	3	1118.09
391	Ta' Marziena	Borg L-Imramma	FALSE	-12.581	2228.51
392	Borg L-Imramma	Borg Gharib South	TRUE	2.6	2779.1
393	Borg L-Imramma	Santa Verna	FALSE	-1.679	2885.85
394	Borg L-Imramma	Ggantija	TRUE	3	3200.23
395	Borg L-Imramma	Borg Gharib North	TRUE	3	2645.81
396	Borg L-Imramma	L-Imrejsbiet	TRUE	1.474	2617.73
397	Borg L-Imramma	Xewkija	FALSE	-19.888	1339.04
398	Borg L-Imramma	Triq ix-Xabbata	FALSE	-40.159	1424.65
399	Borg L-Imramma	Ta' Marziena	FALSE	-65.99	2228.51