TESTING TERRACES:
MANAGING AND SUSTAINING
THE AGRARIAN ENVIRONMENT
IN THE MALTESE ARCHIPELAGO

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This thesis is submitted for the degree of Doctor of Philosophy
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DECLARATION

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the preface and specified in the text. It is not substantially the same as any work that has already been submitted before for any degree or other qualification except as declared in the preface and specified in the text. It does not exceed the prescribed word limit (80000) for the Archaeology and Anthropology Degree Committee.

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ABSTRACT

Title: Testing Terraces: Managing and Sustaining the Agrarian Environment of the Maltese Archipelago.

Author: Jeremy Marchant Bennett

Agricultural terracing, the intentional creation of stepped fields on a hillslope, is ubiquitous in a variety of arid, semi-arid and wet regions in the world. Superficially, it is observable as a significant investment in wide scale landscape alteration for agriculture. However, it represents more than the sum total of its constituent parts – appearing symbolic of the complex social dynamics intrinsically linked to environmental adaptations and technological change (Geertz 1963). As a practice which represents a fundamental step in the human appropriation of the natural landscape, agricultural terracing remains remarkably under-examined. Crucially, terraces can be considered as one of the earliest forms of landscape alteration for human gain – specifically where humans adapt the landscape to suit their needs, as opposed to by-product change. As such, terraced environments can be classed as an ‘anthroscape:’ an environmental aesthetic which is dominated by the infrastructural effects of contemporary human ecology. To this effect, the central theme of this thesis was to establish if agricultural terracing acts as a fundamental part of the resilience of fragile landscapes in the Mediterranean and beyond.

The investigation of agricultural terraces demands a rigorous and multi-faceted approach in order to elucidate a full range of scientific observations such as form, function, variation, chronology and social management. Nowhere is this more relevant than in the Maltese archipelago where terraces are, somewhat paradoxically, extant in use and enigmatic archaeologically. As such, this thesis employs an appropriate archaeological methodology to examine terraces from both geoarchaeological and social perspectives. By combining these methodologies, terrace function is objectively analysed, in terms of landscape/geomorphic process, and the attached, contributing/reflexive, social machinations can be examined. In doing so, a scientific and socially relevant understanding of terracing practices has been achieved.

This thesis utilises archaeological excavation and geoarchaeological sampling to enable an exploration of terrace soil stratigraphy and geochemistry – observing the variation down-profile, down-slope and between geological regions. Analytical methods used were Particle Size Analysis, Loss-on-Ignition, Ion Chromatography, pH and X-Ray Diffraction. These data were analysed for statistical correlation to indicate salient factors affecting terraced soils in the Maltese Islands. Developing from this, a comparison with 19th Century cadastral land quality assessment and a modern logistic regression analysis study (Alberti et al., 2018) facilitates the application of geoarchaeological observations to the
understanding of the social ecology of terraces. This is framed by an exploration of the cognitive origins of the human appropriation of environments.
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1 INTRODUCTION

“When I see a slippery slope, my instinct is to build a terrace”

John McCarthy (1857 -1943), US Politician

1.1 Preamble

Agricultural terracing, the intentional creation of stepped fields on a hillslope, is ubiquitous in a variety of arid, semi-arid and wet regions around the world. Superficially, it is observable as a significant investment in wide scale landscape alteration for agriculture. However, it represents more than the sum total of its constituent parts – appearing symbolic of the complex social dynamics intrinsically linked to environmental adaptations and technological change (Geertz, 1963). In spite of its importance as a practice which represents a fundamental step in the human appropriation of the natural environment, agricultural terracing remains remarkably under-examined.

Crucially, terraces can be considered as one of the earliest intentional forms of environmental alteration for human gain – specifically where humans adapt the landscape to suit cultural needs, as opposed change occurring as an unintentional by-product. As such, a terraced environment could be described as an ‘anthroscape:’ an environmental aesthetic which is dominated by the infrastructural effects of contemporary human ecology. Agricultural terraces are embedded in their environments, influencing local ecological systems within including human ecologies. However, the depth of this embedding has yet to be defined – to what degree to terraces influence and maintain human and environmental systems?

To this effect, the central theme of this thesis will be to establish if agricultural terracing acts as a fundamental part of the resilience of fragile landscapes in the Mediterranean and beyond.

The investigation of agricultural terraces demands a rigorous and multi-faceted approach to elucidate a full range of scientific observations such as form, function, variation, chronology and social management. Nowhere is this more relevant than in the Maltese archipelago where terraces are, paradoxically, extant in use while archaeologically enigmatic. To meet the demands of this paradox, an appropriate archaeological methodology will examine terraces from both geoarchaeological and social perspectives. By combining these methodologies, terrace function can be objectively analysed, in terms of environmental processes, and related a variety of relevant socio-cultural processes. In doing so, a scientific and socially relevant understanding of terracing practices can be obtained.
1.2 Agricultural Terracing Worldwide

The status quo for terracing research is deftly summarised by Wei et al. (2016), with their broad spectrum review of agricultural terracing worldwide. This paper has emphasised the numerous aggregate effects brought about by terracing practices; including the promotion of erosion control, runoff reduction, the accumulation of biomass, recharge of soil water and the enrichment of soil nutrients. Furthermore, the review has shown that poor design and mis-management can encourage severe degradation of the hillslope - counteracting the purpose of terrace construction. Importantly, the authors link these negative reports to issues surrounding social management, such as education and environmental legislation. Overall, this paper encapsulates the plethora of issues which must be explored within the study of terraces – an approach that this thesis will seek to develop with a precise regional study. However, it must be noted that Wei et al. (2016) conduct their study on the basis of ‘data-mining,’ exploiting meta-analyses of Google Scholar to build their dataset. In terms of academic theory, this is a highly commendable approach which should serve to as a reminder that our research often has hidden depths which can be utilised by other scholars. This paper serves to accentuate the wide reach of terracing activities, as depicted in Figure 1.1 (below), even if the dataset used is derived

![Figure 1.1: Map depicting global terracing locations based upon reporting in academic media (from Wei et al., 2016)](image-url)
from Google Scholar search results which are only representative of publications relating to agricultural terraces.

Despite the apparent significance of terraces worldwide revealed by Wei et al (2016), the Mediterranean region is relatively under-recognised within the heritage sector despite being a region of considerable agricultural antiquity. In total, only three Mediterranean locations are specifically included on the UNESCO World Heritage list for their terraced landscapes: Battir, Palestine; Cinque Terre, Italy; and the cultural landscape of the Serra de Tramuntana, Mallorca, Spain. While UNESCO designation is the ultimate accolade for a heritage landscape, there is a similar under-representation in lesser charters. Figure 1.2, below, shows a simple output from the United Nations Food and Agriculture Organization’s (FAO) Globally Important Agricultural Heritage Systems (GIAHS) register. Astonishingly, of the relatively few Mediterranean sites included, none are terraced.

At the risk of taking a eurocentric viewpoint, the considerable agricultural heritage that resides in the Mediterranean basin includes the practice of agricultural terrace and, as such, should merit greater inclusion. Grove and Rackham (2001, 107) outline the conflict between the obvious nature of terraces and their poorly understood status, stating

“agriculture has been in retreat from terraced terrain for at least a hundred years... People still know how to build terraces, and occasionally build new ones, but the great majority are nineteenth century or earlier; nobody now alive remembers when they were not there.”

An academic focus on the quantitative aspects of terracing – their measurable and comparable physical properties – is at odds with their cultural status. The retreat described above hints at changing cultural perspectives Ultimately, this thesis will reinforce the value of Mediterranean agricultural terracing,
especially in relation to social dynamics. From this, it may be possible to make a case that terraces, such as those in the Maltese Archipelago, should be recognised globally for the heritage they embody locally and beyond.
Figure 1.3: Photograph overlooking Xlendi with heavily terraced slopes in the background (image by author)
1.3 Study Locale: The Maltese Archipelago

Located only 80km to the south of Sicily, the Maltese Archipelago is a heavily terraced set of islands which have been witnesses to a considerable diversity of historic and prehistoric activity (Blouet, 1967; Cassar, 2002; Malone et al., 2009). At 316km², these islands can be viewed as a fitting microcosm for the dialogue between humanity and the environment; with population and development constantly increasing in a highly restricted/finite physical environment. Archaeological research in the past 30 years has tightened its focus on the ancient management of the landscape, and the interplay between people and their resources. Most recently, the FRAGSUS (ERC FP7 “Ideas” 323727) project (which this thesis has operated alongside) has analysed the concepts of “Fragility and Sustainability in Restricted Island Environments.” From an early stage, it became apparent that soil conservation played a vital role in the maintenance of an island community (Hammond, 2014). While this thesis operates through time, without a fixed chronology, the nature of the Maltese Archipelago provides an important context for the complex narrative of population and subsistence. A cursory glance at the agrarian landscapes of the islands (for example Figure 1.3, above) reveals the extent of landscape management that has taken place through time.

1.4 Thesis Premise

The long-term management of soil stability is central to both the FRAGSUS project and this thesis. The former had a marked focus on the prehistoric environment. The latter, however, will analyse the specific effects of terracing on and within the Maltese environment and, where possible its people too. The environmental conditions, semi-aridity with garrigue/maquis vegetation, provide conditions ideal for a study that has applicability in locations beyond Europe, including Africa and the Americas. Fundamentally, the value of this thesis will lie with the understanding of terraces conceptually, not just within the confines of the Maltese Archipelago. To accomplish this, the following thesis represents an adaptable investigation involving excavation, geoarchaeological survey and the interpretation of data within the broad timeframe of post-Temple Period Malta. This section will outline a theoretical setting which supports the interpretive element of such a multi-faceted exploration.

1.4.1 Theoretical Framework

As addressed in Section 1.1., this thesis requires a multi-faceted approach to investigate the nature of terracing. Essential to this is the theoretical context within which new investigations can be planned, executed and understood. Agricultural terraces, being an anthropic remodelling of the natural environment, necessitate a theoretical setting which incorporates elements of environmental ecology with human social practices and cognition. Utilising Butzer’s (1982) *Archaeology and Human Ecology*
and Geertz’s (1963) *Agricultural Involution*, this thesis will employ a theoretical backdrop which frames environmental and cultural processes as significant components within nested tiers of systems. Butzer provides a robust systems theory approach which frames human interaction with environmental factors. Geertz focusses on the interplay between social and agricultural systems which has much wider implications for the regional environment. Departing from these core themes, the following section will be divided into Epistemological and Anthropological settings. These sections will also introduce broad concepts, *Systems Theory* and *Posthumanism*, which will permeate later chapters and underpin relevance of this thesis to current archaeological and environmental themes.

**Epistemological Setting**

Agricultural terracing is a phenomenon which can be investigated via a broad range of academic disciplines. A suitable theoretical background incorporates the value of interdisciplinary research yet remains cognizant of the particularities of local practices. The basis for this approach arises from Butzer’s seminal work which emphasizes the dynamic interface between culture and the environment, eschewing the most static interpretations of processual archaeology. Butzer seeks to “define the characteristics and processes of the biophysical environment that provide the matrix for and interact with socioeconomic systems” (1982, 6). To advance the direction set by Butzer, and considering the nested scales described above, *The Systems View of Life* establishes a total systems framework within which multiple disciplines can situate an understanding of phenomena and their contextualities by “looking at an individual organism in the totality of its mutual interactions” (Capra and Luisi, 2014, 135). The beauty of a systems approach is that the focus can be shifted between scales, ranging from cellular through to societal – or even more grand, depending on one’s ambition. Specificity at the smallest scale of observation gives way to generalisation at the larger scales. As an increase in scale is tied to greater generalisation, an almost entropic loss of understanding occurs; the devil is in the detail is an apt anecdote. However, what must be emphasised is that the systems view allows a shifting of focus, to understand varied scales appropriately. Each defined system frames, or is framed by, another of different scale. Consequently, the terminological use of *system* can adapt to the scale required (e.g. cellular/organism: micro scale, environment/society: macro scale). Accordingly, a system in one scale can be defined as a *component* when viewed as part of a larger scale system.

At the core of systems view theory is the concept of *autopoiesis* – the maintenance of a system as a result of networked reactions which serve to restore individual components (Capra and Luisi, 2014, 134–5). In effect, this promotes the idea of self-sustaining systems which can be observed without bias. Returning to the interplay between organisms and the environment, Capra and Luisi (2014) introduce the concepts of *Structural Coupling*, *Structural Determinism* and *Social Autopoiesis*. Structural Coupling, governed by autopoiesis, is the relation between living systems and their environments on a structural level; where continual interactions promote structural change to the
system. Flowing from this, Structural Determinism posits that a system is determined by *internal* structure, as opposed to external influences – enabling a system which is both determined and unrestricted in nature. Moving this theory in manner relative to societies, Social autopoiesis draws together the seemingly juxtaposed realms of micro-systems and the complexities of broad social systems. In essence, “social networks exhibit the same general principles as biological networks... [each] is characterised by the need to sustain itself in a stable but dynamic mode” (Capra and Luisi, 2014, 137). Just as organic systems self-sustain by acquiring elements from their environment across a physical boundary, social systems self-sustain by regulating the passage of ‘elements (people/ideals/materials) through a *cultural* boundary.

Importantly, social systems exist both physically and symbolically. In the former, behaviour is regulated by the observable laws of nature, while with the latter behaviour is governed by the parameters set by the social system. The reflective nature of these organisational patterns “suggests a fundamental unity of life” (ibid.) and, as such, this should guide the need to study systems through a coalescent theory. This notion sets a systems approach within the philosophical discourse of posthumanism, which can act as the epistemological backdrop for this thesis. Butzer (1982), taking a broad view of systems theory, emphasises the need for archaeology to understand the complex interrelationships that exists between humans, cultures and environments. Moreover, it is stressed that no specific version of systems theory is adequate yet the “basic principles...are essential to integrate the environmental dimension within a contextual archaeology” (Butzer, 1982, 6).

Hodder (1995) indicates this from another angle, *wholeness*, which regards the interpretation of data in the context of external structures and information. This concept is differentiated from a systems theory wholeness – the “functional relationship between separate subsystems” (1995, 25). Instead, Hodder is emphasising the semiotic elements that permeate the links between parts of a system; therefore wholeness arises from implicit structure rather than the components themselves. Elements of structuralism – the implicit laws governing cultural processes – and processualism are apparent with this view of systems thinking. However, the implicit connections are also indicative of a much wider systems view (*sensu* Capra & Luisi 2014) which steps beyond bounded systems and encourages the conceptual imbrication of/within systems. Therefore, placing humans within this interleaving is a move away from anthropocentrism, instead allowing posthumanism to operate as a relational ontology that elucidates the extension of *human* into the wider system, and the reciprocal inclusion of extra-human concepts within.

According to Wolf (2010), posthumanism is a mode of thought which facilitates a critical reflection on the issues of speciesism and anthropocentrism, enabling a more precise description of humanity – and its embedded modes of interaction and meaning – by eschewing the “ontologically closed domain of consciousness, reasons, reflection” (2010, p.xxv) and understanding these modes by
“recontextualizing them in terms of the entire sensorium of other living beings and their own autopoietic ways” (ibid.). Eloquently, Harris and Cipolla state

“Thus posthumanism, with its flat ontology, puts science and philosophy back into the same world: rather than one focusing on ‘reality’ and the other on ‘human experience’, the wall between these two seems to have been dismantled. Science gives us important tools to attend to the vibrancy of matter, as does philosophy, and neither can be understood without the other” (Harris and Cipolla, 2017).

To draw these themes together, Harris and Cipolla (2017) praise the rise of the ontological turn as the genesis of new modes of thought for archaeology; moving beyond the dichotomy of processual/large-scale and post-processual/small-scale. Through posthumanism, archaeology can act reflexively at multiple scales by engaging systems theory as a means of understanding a phenomenon within its variety of contexts. Returning to Capra and Luisi (2014), the link between autopoiesis and cognition is drawn, with cognition being recognised as one of the internal structures which determine system/organism functions. Typically, the environment has been treated as a distinct setting, within which the realms of human activity reside. Capra and Luisi offer the consideration that environments and organisms co-emerged, citing the formation of the atmosphere as an example. As a development of this idea, they suggest that greater organism complexity facilitates a more developed environmental sensorium. Where organisms construct a habitual niche, they create and affect an environmental system and as organism complexity increases, the environmental complexity also grows – tied to the breadth of sensorium available to the organism. The most fundamental part of this is that “the environment is created by the organism, and this creation permits the existence of the living organism” (2014, 141). Thus, in complex organisms such as humans, autopoiesis is tied to both the organism and the environment – a fundamental link between two different systems.

Anthropological Setting

In an attempt to describe observations about the systems related to agricultural terracing, this thesis will engage with concepts theorised by the anthropologist and ethnographer Clifford Geertz. While this work was written at a time, and in a manner, in which posthumanism was not at the fore of the theory, the core concept of involution has value beyond anthropology and thus could be applied as a means of understanding systemic processes. Geertz, as a realist and scientist, postulated that the concept of culture should be observed as a network of encoded symbolism which provided a meaningful setting within which life is carried out; an approach typically argued, by positivists, as inherently constructivist (Ortner, 1999). Providing greater definition, Geertz describes the role of cultural systems as

“extrinsic sources of information. By “extrinsic,” I mean only that -unlike genes, for example- they lie outside the boundaries of an individual organism as such in that intersubjective world of
common understandings into which all human individuals are born... By “sources of information,” I mean only that -like genes- they provide a blueprint or template in terms of which processes external to themselves can be given a definite form. As the order of bases in a strand of DNA forms a coded program... so culture patterns provide such programs of the institution of the social and psychological processes which shape public behaviour.” (Geertz, 1973, 92)

This is an important direction which fits well within a systems approach. Sewell Jr. (1999) develops the idea of culture’s biological roots, suggesting that humans utilise a cultural format, generated by specific neural structures, to produce behaviours that meet the challenges presented by their environments. While this may appear as inherently deterministic, it is not counter to the internal structures which determine the operation of a system, as described above. There seems to be an almost intangible, but not irreconcilable, difference here between Geertz and systems theory; perhaps as a matter of scale. The Geertzian approach defines culture as an underlying blueprint which guides action, whereas systems theory would identify culture as an over-arching system which guides action as a product of associated internal (sub-) systems. Although this may be a matter of semantics it is still worthy of note.

The core principle of Geertz’s “Agricultural Involution” surrounds the concept of a culture which fails to modernise, in spite of growing external influences which could ultimately provide positive developing influences. Specifically, Geertz (1963) suggests that such a culture enters a status of ‘involution’ whereby it becomes deeply entrenched within its own ecology. Rather than evolving, the basic form of such a culture will become increasingly tenacious, with its internal machinations becoming ever more complex and/or ornate. Effectively, this process can continue indefinitely for a given set of cultural circumstances. The internal features can be diminished repeatedly within a stable ecosystem, allowing each individual to acquire their own position within society. However, should the ecosystem change (physically or conceptually), the cultural system will destabilise – ultimately placing individuals under ever increasing pressure.

In relation to the perceived effects of western colonising powers, Geertz notes the difficulty of making ‘what if’ scenario projections (1963, 130). Although justifiable in taking this stance, it is hard not to view the influence of the Dutch colonial powers as the tipping point for Javanese indigenous agriculture, especially that of the sawah regime (irrigated rice paddies). Through the colonial period, sawah agriculture was very much a ‘bend-but-don’t-break’ system which coped with the ever-increasing population. It is hard not to question whether the system would have collapsed in the absence of colonially influenced population growth. Ultimately, the process of involution may have been able to continue had it not been for destabilising population growth.

It seems apt to describe the pre-colonial state of involution as a form of stagnation. Particularly with the case of sawah agriculture, the system had no need to modernise and was capable of absorbing
significant population growth. As such, there was no drive to drastically change practices, until such times as the system arrived at a crucial turning point. With this level of stagnation, Geertz (1963, 101) suggests that social, political, religious and folk aspects of culture match the level of agricultural involution. Overall, the cultural system becomes deeply entrenched and increasingly more difficult to change.

With regard to the nature of terraces on Malta and Gozo, ‘Agricultural Involution’ provides a worthwhile consideration of the social complexity of terrace-based agriculture. In particular, the concepts of cultural responsiveness and ecological viability of agricultural practices are worthy of investigation. Java, the focus of Geertz’s (1963) study, and Malta both exemplify bounded island environments with deep colonial histories. Furthermore, historical Javanese and modern Maltese population densities (ibid.) are viable for comparison, especially regarding the social pressure on the agricultural landscape. In tandem with this, the changing pattern of land use in Malta and Gozo should also be considered as an indicator of societal adaptation. However, a primary caveat is the stark contrast between the Maltese and Javanese environments. With such different climates, there can be little doubt that terrace agriculture operated in different ways in each location. Despite this, “Agricultural Involution” can frame an enquiry into the continued usage of Maltese terracing. Ultimately, Javanese terrace agricultural practices declined and collapsed while Maltese terracing continues to be used extensively. Therefore, the lines of inquiry while must be considered regard the onset and longitudinal state of terrace usage in Malta. Furthermore, understanding why there was no technological collapse – or if terracing has undergone phases of collapse and recovery. Finally, a Geertzian framework helps pose a broad question – “did Maltese agricultural terracing practices ‘involve,’ or did an ever-changing set of external factors keep the system going, thus preventing stagnation?”

1.5 Aims and Objectives

This introduction poses a broad question regarding the impact of agricultural terracing on the resilience of fragile landscapes. In this case, resilience relates to a system’s propensity to absorb trauma and rebound to a position of stability and stasis. The following aims and objectives will explore the role terracing plays in the formation of resilient landscapes. Moving forward, having considered the locale, theory and nature of agricultural terracing, this thesis will explore the physical, geochemical and social properties of terraces and terraced soils in the Maltese Archipelago. The following set of objectives will therefore guide this thesis towards a better understanding of the nature of terracing in delicate environments.
I. Establish a chronological model for the onset and proliferation of agricultural terracing in the Maltese Archipelago.

II. Investigate how agricultural terracing contributes to the delicate resilience of fragile landscapes in Mediterranean environments, such as the Maltese Archipelago?
   a. Characterise the salient physical features of Maltese agricultural terraces.
      i. Establish an optimal method for the investigation of terraces, which includes geoarchaeological and chronological factors?
   b. Characterise the geoarchaeological and geochemical properties of terraces.
   c. Outline the relationship between social practices and the physical and chemical character of the terraces.
   d. Explore how this study is situated within wider studies of terracing in the Mediterranean and beyond.

III. How does terracing connect with modern discourse on climate change, the Anthropocene and continued social development in light of increasing human pressure on the environment?
   a. Where possible, indicate the demonstrable links between human cognition and the appropriation of the environment – thereby demonstrating the posthuman theory at the core of this thesis.

1.6 Thesis Structure

The structure of this thesis presents a holistic approach required to understand agricultural terraces from physical and social perspectives. Accordingly, the research is required to take place at a variety of scales, fitting the number of different methods utilised. Conceptually, this thesis will be structured in the style of a theoretical hourglass; opening with broader considerations about the subject matter, tightening focus through the identification of research gaps and setting methodological directions. The fieldwork chapters represent the centre of the hourglass and their resulting implications will guide and inform this thesis re-opening into broad interpretation and implications – framing this study in wider theory and discourse.

Chapter 1 has already begun to establish the conceptual directions guiding this thesis. The over-arching idea of systems theory sets the tone for a posthuman entanglement that would typically be viewed as human-environment interactions. While this distinction could be dismissed as semantics, it should be accepted as a lens through which we can understand humans as part of nature, not distinct or separate, and how they can operate as a significant geophysical force. Therefore, this chapter has already begun
to establish a route to completing Objective III. These themes will be developed further in Appendix 3 and Chapter 6.

Chapter 2 (Background) forms a corpus of information relevant to later chapters. Firstly, there is a detailed introduction the natural and archaeological story of the Maltese Islands which sets the tone for the later exploration of the interface between nature and culture. This chapter then parses the pertinent literature regarding agricultural terraces. Drawing these sections together, a statement of approach is made to provide a rationale for the methodologies reporting in the subsequent chapters. Chapter 2 therefore starts the process of completing Objectives I and IIa by examining the gaps in the archaeological narrative, critically reviewing previously published studies and developing a reflexive approach.

Chapter 3 (Testing Terraces) will explore the methodological directions required to understand the stratigraphic and geoarchaeological nature of terraces within the Maltese Archipelago; focusing on a number of excavation and sample locations in the islands. This study convincingly satisfies Objective I while also opening new lines of inquiry towards the completion of Objective II.

Developing from this, Chapter 4 (Terrace Geoarchaeology) develops the use of fieldwork from the previous chapter and presents the micro-scale analyses of soil samples collected. This chapter explores the relationship between terrace soil and the social, or ‘folk’, understanding of soil fertility. Objectives IIa-c are of primary relevance to this chapter, however the relationship between soil properties and social practices evokes concepts related to Objective III.

Chapter 5 (Agricultural Intensification) marks the return to wider scale research, exploring the relationship between population growth and agricultural change within the islands, drawing on demographic theory for support. Although, this chapter is concerned with themes associated with Objective III, there are also elements relating to Objective I presented.

Appendix 3 (Environment to Landscape Through Cognition) presents the first account of how landscape appropriation exists within human social cognition, with a particular focus on the parcelling and ownership of agricultural land. Moving from the scale of the individual to that of the group, this chapter delves into themes deeply linked with Objective III. Beyond this, the content presented brings together the epistemological and anthropological settings together with the discussion of landscape and terraces, preparing the way for the conjunction of themes explored in this thesis.

Chapter 6 (Discussion) will draw together the major findings of each preceding chapter, building synthesis of knowledge both old and new; placing the overall value of thesis in context with the aggregate knowledge from other studies. Naturally, the completion of all objectives is of paramount importance to this chapter, and to varying degrees they are entangled through the discussion.
Finally, Chapter 7 (Conclusion) will summarise the major outcomes of this thesis, disentangling the completed objectives and outlining the research implications, limitations and future investigative directions.
2 BACKGROUND

2.1 Introduction

The following chapter is a compendium of knowledge critical to the contextualisation of this thesis. This information is comprised of three main sections, beginning with Section 2.2 which presents the pertinent physical and archaeological settings, followed by Section 2.3 which specifically focusses on agricultural terrace research. Drawing this together, Section 2.4 sets the direction of study for the following chapter as a statement of conceptual intent. Therefore, this chapter will serve the dual purpose of furnishing the reader with the appropriate background information and explicitly stating the novel research direction this thesis adopted.

2.2 The Maltese Archipelago – Physical and Archaeological Background

The Maltese Archipelago is comprised of the islands of Malta, Gozo and Comino, as well as smaller islets including St. Paul’s Island, Filfla and Fungus Rock. In sum, this group amounts to no more than 316km² of land mass. For comparison, these islands would equate to just 1/5th of the total urban area for London – or fit within the shores of Lough Neagh (Europe’s largest freshwater body). Despite their apparent spatial insignificance, these islands have been a constant source of attraction for humans. This is currently reinforced by the over-3:1 ratio between annual tourist arrivals and inhabitants – with an estimated 2.5 million visitors each year, in comparison with over 490,000 residents as of 2018. Although the islands are fairly remote (see Figure 2.1 below), at least in European terms, some 80km south of Sicily, 284km east of Tunisia and 333km north of Libya, they have held much cultural significance through time. Humans have been present here since at least the 6th Millennium BC – and the islands have been possessed, contested and shared until their people claimed independence in 1964. Now, Malta is a vibrant nation – one of the smallest and most densely populated in the world, with all the trappings that the Anthropocene brings, ranging from erosion to landfill. The following chapter will introduce major aspects of the natural history of the Maltese Islands - encompassing an overview of the geological, pedological and archaeological stories that have contributed to form these islands and their inhabiting nation.

2.2.1 Geological Background

The geological origins of the Maltese Archipelago begin with the separation of Pangea and the earliest formation of the basin within which Malta now lies, c. 150Ma BP (Pedley, 1974). Within these deep reaches of time, the crust which underlies the islands underwent great shifts as the continents drifted. Most crucially the islands owe their origin to the warm seas of the Oligo-Miocene Epoch (30-5Ma BP) and the accumulation of calcareous sediment through a variety of ocean depths (Borg, 2004) that
resulted from the creation of the *Provencal or Ligurian* oceanic basin which separated Southern Europe from Northern Africa (Pedley et al., 2002). The dramatic effects of the interaction between the African and Eurasian plates created a series of geological faults, which have matured into the characteristic geomorphology visible at present. Described as “a lightly broken four-layered cake” (Pedley et al., 2002, 35), the following section outlines the relevant characteristics of each stratum, beginning with the oldest (see Figure 2.2, below, for visual reference).
Figure 2.1: The Maltese Archipelago (and its relationship to the Mediterranean region, inset).

Figure 2.2: The geology of the Maltese Archipelago (after Pedley et al. 2002).
**Lower Coralline Limestone Formation**

Of the visible geological sequence, the Lower Coralline Limestone is the oldest present in the Maltese Archipelago and comprises most of the Malta’s southern and south-western coastline (Borg, 2004). At over 140m thick in places, this stratum is characterised by a hard, pale grey stone with several embedded fossil deposits – indicative of the changing sea-levels influencing sedimentary deposition (Pedley et al., 2002). The basal layers of this stratum are predominantly beneath the seafloor. However, they are observable below sea level along the south-western cliffs, resulting from the north-eastern geological tilt. Inland, the Lower Coralline can be seen within geological rifts. Within the Lower Coralline, there exist five different limestone *facies*: Reef Limestones, formed from coralline algae; Shallow Lime Muds, accumulated in protected areas behind reefs; Cross-bedded lime sands, which existed above and surrounding reefs; Foraminiferal Limestones, sediments in deeper water ahead of reefs; and, the “Scutella Bed,” characterised by a notable accumulation of flat sea-urchins. Of these facies, the Scutella Bed marks the boundary between the Lower Coralline and Globigerina formations (Pedley *et al.* 2002).

**Globigerina Limestone Formation**

Undoubtedly the most aesthetically pleasing of all layers, the Globigerina Limestone is characterised by soft erodibility and distinctive golden hues. Varying in thickness between 20m and 250m, this stratum is typically outcrops as a series of shallow valleys and low ridges, creating a rolling effect (Borg, 2004). Primarily, this formation is comprised of microscopic planktonic fossils, Globigerina (that gives the name) and Foraminifera. This outcrop is mainly visible in the south-eastern parts of Malta, where it forms two thirds of Malta’s surface (Borg, 2004). Within this formation, there are three sub-divisions – *Lower, Middle and Upper*, each divided by two conglomerate units. The lower and upper divisions are typically pale yellow in colour, in contrast with the pale grey/off-white middle division (Pedley *et al.*, 2002). Notably, the Middle Globigerina contains chert outcrops – potentially significant for the prehistoric inhabitants of the archipelago (Chatzimpaloglou *et al.*, 2020a).

The stratum is not heavily cemented because of the fine-grained nature of the Upper and Lower Globigerina, making the stone highly extractable – a quality that has been heavily exploited through time (Chatzimpaloglou *et al.* 2020b). A cursory glance at architectural features across the islands emphasises the value that is placed on the aesthetic uniformity and workability of the Globigerina.

**Blue Clay Formation**

The Blue Clay refers to a variety of argillic beds, overlying the Globigerina formation; each with differing colours and compositions (Borg, 2004). Primarily formed of Kaolinite, the stratum is highly erodible – and forms low/rounded slopes angled at 45°, with taluses which tend to slump over the underlying Globigerina (Pedley *et al.*, 2002; Borg, 2004). Pedley *et al.* (2002) suggest that this layer should be
considered a continuation of the Globigerina formation, created through similar sedimentation processes within an increasing clay component – where the boundary between the two layers is visible as a relatively small change in topography. Curiously, although the calcareous elements (plankton skeletal structures) were deposited due to the marine conditions, the argillic component originates from a land source – the erosion of uplifted areas which form the present-day mountains of northern Sicily. It is noted, however, that the finest clay particulates may have drifted to this location as a seasuspensate, and that some fraction of the clay may have been volcanic ash. Overall, this stratum exhibits a variable thickness, from complete absence in the eastern reaches of Malta to over 70m thick in the west (Pedley et al. 2002).

Borg (2004), drawing from Pedley et al. (1976), notes that this layer creates an impervious base to the overlying, water-bearing, strata, namely the Greensand and Upper Coralline levels, leading to the formation of perched aquifers in the more upland parts of the islands. Chatzimpaloglou et al. (Chatzimpaloglou et al., 2020b) assert that the soils overlying the Blue Clay are some of the most fertile and moisture-rich in the archipelago – a result of the impermeability of the stratum.

**Greensand Formation**

While not officially part of Pedley, Clarke and Galeas’ simplified ‘layer-cake’ model, the Greensand Formation is recognised as a distinctive, thin band, formed of fossil debris, Glauconite and phosphatic grains (Borg 2004). This stratum represents the final episodes of oceanic shallowing, following the deeper-water phases that created the preceding layers. Usually found in outcrops of no more than one metre in thickness (except for an 11m thick outcrop at Il-Gelmus, Gozo), this formation is relatively complex with a non-uniform distribution of Glauconite sand (Borg, 2004). The upper part of the formation can be interpreted as a transition to the overlying Upper Coralline, characterised as a hard limestone with distinctive cliff-faces. The lower portion, overlying the Blue Clay, exists as a weathered brown layer (Pedley et al., 2002). Borg (2004) describes the Greensand as forming a crust, under which cavities may form, and is often visible as large boulders in the landscape. Notably, the Greensand Formation acts as an important locus of water flow and springs (Pedley et al., 2002).

**Upper Coralline Formation**

Sharing many characteristics with its Lower counterpart, the Upper Coralline Formation is the youngest of the geological strata present on the islands. It is primarily composed of sediment from shallow marine environments – representative of multiple intertidal conditions (Pedley et al., 2002). Where exposed in the more elevated regions of the archipelago, the Upper Coralline is usually no more than 30m thick. However, in some locations along the Victoria Lines, there is an outcrop of 162m; and on Comino there is an 80m thick surface outcrop (Borg, 2004). Although generally hard and pale grey in colour, this formation has significant variation within, containing five geological facies - the Reef.
Limestone, the Tidal Flat Limestone, the Oolitic Cross–bedded sands, the Muds with large Foraminiferal Limestones and the Planktonic muds (Pedley et al., 2002). The lower section of this formation is formed of interbedded coralline algal bands and yellow marl bands, indicative of weathering. The properties of this banding have enabled extensive exploitation of this geology for lime quarrying (Borg, 2004).

**Geomorphology and Biodiversity**

The Maltese Islands have a number of distinctive geomorphological traits which have been generalised into five classes by Bowen-Jones, Dewdney and Fisher (1961):

1. **Coralline Limestone Plateaux** – representing the highest regions and well defined by escarpments. These vary in size from small raised high points, especially in north-western Gozo, to the wide raised platform of western Malta.
2. **Blue Clay Slopes** – as described above, these separate the uplands and occur in valleys which may be incised within plateau edges.
3. **Rdum** – the areas beneath cliff-faces where the coralline plateaus meet the sea.
4. **Flat-floored basins** – usually the result of tectonic faulting and sometimes infilled *wied* systems, where incised valleys contain deposits of erosive sediment.
5. **Globigerina hills and plains** – areas of low gradient slopes, especially in Malta, defined by low ridges and shallow valleys.

Beyond the detailed geomorphological narrative provided by these authors, there exists a significant corpus of study for sub-regions within the islands, which outlines the wide variety of geomorphological features (Bowen-Jones et al., 1961; Guilcher and Paskoff, 1975; Paskoff and Sanlaville, 1978; Ellenberg, 1983; Reuther, 1984; Alexander, 1988; Schembri, 1994; 1993; Hughes, 1999; Prampolini et al., 2017; 2018). Following this body of work, the Maltese Archipelago can be described as follows:

These are limestone islands with a topography of low hills, shallow valleys and plains which result from large scale tectonic folding. In the semi-arid climate of the central Mediterranean basin, this *garrigue* environment is typical of karstic morphologies – with scrubby colonisation of the bare rock surfaces. The most characteristic features are the *Rdum* – practically vertical cliff faces formed by either tectonic movement or erosion – and *Widien* (*Wied* sl.) – the naturally formed drainage channels formed by geological faulting, or Pleistocene erosion. The former landform acts as a major shelter for many of the islands’ flora and fauna, especially among eroded boulder scree. The *widien*, although not true rivers (the archipelago has no rivers), are mostly dry valleys, some with colluvial infill, with water flow only where natural springs drain, or as a result of rainfall inundation. Accordingly, the properties of these systems encourage rich biodiversity and make them attractive for agricultural purposes.
These islands contain some 1100 vascular floral species, of which 70% are indigenous and c.18% endemic to the islands, all falling into four main ecological categories – evergreen woods, maquis, garrigue and steppe (Sultana, 2004). Following Sultana (2004), these ecological zones can be described as follows:

**Evergreen woods** – a remnant niche largely characterised by Evergreen Oak (*Quercus ilex*) and Aleppo Pine (*Pinus halepensis*) which has long been eroded by human activities.

**Maquis** – a widespread vegetation group which is mainly located at the base of the *Rdum* (cliff faces) and is characterised by Carob (*Ceratonia siliqua*), Olive (*Olea europaea*), Mediterranean Buckthorn (*Rhamnus alaternus*), Lentisk (*Pistacia lentiscus*), Bay Laurel (*Laurus nobilis*) and Sandarac Gum Tree (*Tetraclinus articulata*).

**Garrigue** – is characterised by a variety of scrubby, low and aromatic flora which grow on the broad areas of exposed limestone, in the variety of geological fissures and depressions. This includes plants such as Thyme (*Thymus capitatus*), Mediterranean Heath (*Erica multiflora*), Germander (*Teucrium fruticans*), Vetch (*Anthyllis hermanniae*) as well as other smaller species.

**Steppe** – is the most widespread community, characterised by grasses, herbaceous plants, legumes, umbellifers and tuberous species – including Sea Squill (*Uriginea marittima*) and Branched Asphodel (*Asphodelus aestivus*).

Schembri (1997) groups the archipelago’s terrestrial vegetational assemblages into the following three categories:

*Major communities* – forming part of successional sequence towards the climatic climax,

*Minor communities* – these are either habitat specialised or occupying rare habitats that are rare on the islands, or are relict from previous ecological systems, surviving in refugia.

*Disturbed habitats* - occupying land which received frequent, usually anthropic, disturbance.

Further vegetation studies have been conducted by Haslam (1969), Lanfranco and Schembri (1996), Anderson and Schembri (1989) and Schembri (1993, 1997).

The composition of the islands’ fauna is primarily invertebrate, with over 2000 species of insect including nearly 600 types of butterfly and moth. There are 70 land and freshwater molluscs, of which six are endemic to the archipelago. 380 bird species have been recorded: 13 resident, 5 summer migrants, 52 winter migrants, 112 regular migrants and the remainder irregular migrants. Beyond these species, there are 19 mammals, 9 reptiles and one amphibian (Schembri 1993, 1997).
2.2.2 Climate

The Maltese climate, with its mild, wet winters and hot, dry summers is typical for the Mediterranean (Schembri, 1993; 1994; 1997; Schembri et al., 2009) and is recognised as a highly bi-seasonal climate, especially when considering the availability of water. The average rainfall is 530mm, most (85%) falling between the months of October and March, with the remaining 15% highly variable, fluctuating year by year. The mean monthly temperature range varies from 12°C to 26°C - rarely dropping to freezing, with a strong effect on plant growth (Chetcuti et al. 1992). From late March to the first third of September, the archipelago experiences an arid season, with peak aridity reached between June and August with maximum temperatures 45°C. There is a high relative humidity, ranging from 65-80%, and the islands are accustomed to wind for most of the year. Accordingly, the islands’ vegetation has adapted to the excess of water present during the wet-season and the dry season drought and heat – leading to growth through the winter and limited growth in the summer (Haslam 1969; Haslam et al. 1977). Naturally, the landscape switches between the lush verdancy during the winter months and parched bare environment during the summer months.

2.2.3 Pedology

Pedley et al. (2002) outline the relationship between the major geological formations, their overlying landscapes, and the soils contained within – positing that the soils are governed by three major factors: firstly, the differential erodibility of the rock strata; secondly, the vertical displacement of faulting which serves to enhance erosion; and, thirdly, the NE geological tilt across the islands which influenced drainage vectors. The total effect of these factors serves to generate distinctive soils across many of the geomorphological features of the islands.

Relating directly to the geological, parent material, the soils of the Maltese Archipelago are essentially quite young. Previous work (Lang, 1960; Bowen-Jones et al., 1961) has emphasised the greater general effects of human activity on soil development, in comparison with climatic influence. Recent work by French et al. (French et al., 2018) in conjunction with the FRAGSUS project, has analysed the biography of soil development in the archipelago, especially in relation to prehistoric human activities.

Utilising the Kubiënà (1958) system, Lang (1960) categorised the soils of the Maltese Islands into three main types: Terra, Xerorendzina and Carbonate Raw soils. See Figure 2.3 (below) for visual reference.
**Terra Rossa (A/Eb/Bt/C)** – sometimes referred to as Red Mediterranean Soils, these are potentially relict from the Pleistocene – having developed within a woodland or scrubland ecosystem present during the earlier Holocene (Yaalon, 1997). Mature and highly weathered, these soils are low in calcium carbonate and have little organic matter. They show minimal dry climatic affects but exhibit good structure and clay illuviation. Typically, these soils are found developed in karstic locations.

**Xerorendzinas (A/C)** – highly calcareous with low levels of organic content, these thin, immature soils are typically developed on weathered Globigerina limestone and within valley deposits.

**Carbonate Raw Soils (A/Bca/C)** – like the xerorendzinas, these also show a high proportion of calcium carbonate and low levels of organic matter. However, these soils are formed on wide variety of
geological strata - eroded Quaternary sandstones, Greensand, the lower parts of the Upper Coralline formation, Blue Clay and the Globigerina formation.

Recent studies by the MALSIS project have provided a reclassification of soils in the archipelago, following the World Reference Base (WRB) system – guidelines set out by the United Nations Food and Agriculture Organization (FAO). This study has provided a more detailed account than previous studies, showing greater pedological intricacies than previously understood. Following MALSIS, six major soil reference groups are now recognised within the archipelago: Calcisols (37%), Regosols (19%), Leptosols (15%), Luvisols (15%), Cambisols (7%) and Vertisols (7%) (Vella, 2003). Descriptions of these types, following the WRB (Food and Agriculture Organization of the United Nations, 2014) are as follows:

**Calcisols (A/Bca/C)** - soils with a significant component of secondary carbonates. They are widespread in arid and semi-arid environments and usually with highly calcareous parent materials.

**Regosols (A/C)** - poorly developed mineral soils, found in unconsolidated materials which lack a mollic or umbric horizon. They are neither very thin, overly rich in coarse fragments (Leptosols), nor sandy (Arenosols), nor containing fluvic materials (Fluvisols). Usually they are extensive in erosive environments and accumulation zones, particularly in arid and semiarid areas and in mountainous regions.

**Leptosols (A/B/C/C)** - include very thin soils formed over continuous rock and soils extremely rich in coarse fragments. Leptosols are especially common in mountainous regions.

**Luvisols (A/Eb/Bt/C)** - have a higher clay content in the subsoil than in the topsoil, resulting from pedogenetic processes (particularly clay migration) which lead to an argic subsoil horizon. Luvisols have highly active clays throughout the argic horizon and a high base saturation at depths between 50cm and 100cm.

**Cambisols (A/Bw/C)** - represent pedologies with incipient subsurface soil formation. Transformation of parent material is evidenced by structure formation, with mostly brownish discoloration, and increasing clay percentage, and/or carbonate removal.

**Vertisols (A/B/C)** - heavy clay soils with a high proportion of swelling clays. These soils form notable cracks from the surface, downwards, when they dry out. The name Vertisols (from Latin *vertere*, to turn) refers to the constant internal turnover of soil material.

Within the remit of the FRAGSUS project, French *et al.* (2018) have carried out a significant study of soils within the archipelago – including the use of micromorphology and geochemistry. Samples were collected from notable prehistoric sites and via an extensive landscape survey scheme. Furthermore, palaeoenvironmental cores were also analysed to ascertain data beneficial to the creation of the
Maltese pedological biography. They note evidence of typical ‘terra rossa’ soils in deeper, protected, fissures on the Upper Coralline Plateaux. Typically, these are accepted (van Andel, 1998) as the climax soil type for regions with similar parent materials and high-seasonal, semi-arid climates. New research within the FRAGSUS project also attests to the degradation of early Holocene, brown argillic soils, to red soils typical of the Mediterranean region – though anthropic intervention and periods of xerification (French et al. 2018).

This brown loam, with a thickness of up to 80cm, contained a greater percentage of organic matter and complexities, with multiple horizons and evidence of clay illuviation – these are interpreted as indicative of a wetter climate and of an ecosystem with higher levels of biomass. This soil is indicative of a low-density scrub/woodland type vegetation in association with the Upper Coralline, during the earlier Neolithic. By the 4th Millennium BC, and the development of the Temple Culture, there are strong indications that this brown soil was beginning to change – with significant changes noted at a variety of sites where megalithic structures protect underlying stratigraphy. Crucially, continued exploitation of these soils in conjunction with increasing aridity from 2300 cal BC onwards contributed to a notable secondary soil formation and subsequent erosion processes.

Further work carried out along the Blue Clay slopes, and in lower-lying regions, revealed an initial stability, likely promoted by the presence of scruffy-woodland, with more typical vertisol features occurring on the lower slopes. Within valley features, the upper-middle zones were subject to hillwash and aggradation (French et al., 2018; French and Taylor, 2020). Interestingly, evidence of more severe erosion arises in more recent deposits, likely associated with agricultural practices in the last few centuries. Comparison with deep cores, which evidenced a strong element of turbidity within the various landscapes, revealed a variety of erosion patterns – with an Early Neolithic (7th-6th millennium BC) phase, later prehistoric erosion and recent episodes (19th-20th Centuries AD). Of particular note is the later prehistoric segment, occurring from c. 1500 BC and throughout the 1st millennium BC. Within this period, there is a significant increase in soil erosion, suggesting that there was significant disruption of soils upslope, likely leading to the adoption of terracing as a means of stabilising the landscape.

2.2.4 Archaeological Background

Despite the relatively small size of the islands, they possess a rich and complex social history. The issue of isolation and connectivity is expounded through time – with the archipelago moving from phases of relative isolation, through outposts and trade networking, religious and colonial property – to a modern, independent and tourist focussed state. History has shown that people will always be drawn to these islands.
Revelations from the Cambridge Gozo Project and, its descendant, the *FRAGSUS* project have been a significant addition to the rich studies of the 20th Century. Although research carried out by Sir Temistocles Zammit (Zammit, 1910; 1916; 1928; 1930), and also by John D. Evans (Evans, 1954a; 1954b; 1971; 1977), should not be discredited, it is without doubt that the advent of radiocarbon dating and its application by the late David H. Trump, publicised by Colin Renfrew (Renfrew, 1972), marks a watershed moment in Mediterranean chronology. Their combined efforts placed Malta at the forefront of prehistory – enabling the claim of having the oldest freestanding stone structures in the world. Trump (Trump, D.H., 1961; Trump, 1966; 1995; 2002) and Renfrew (1972) foreshadowed the 21st Century revolution of inter-disciplinarity by combining traditional chronologies with those offered by science and absolute dating. No longer were the grand prehistoric structures the product of external actors – the Maltese Islands realised their own unique place in deep time.

Fifty years following this landmark work, building on the work of the Cambridge Gozo project (1987-1994), *FRAGSUS* continued a tradition of uniting disciplines for the benefit of archaeological understanding (Hunt et al., 2020). Through the application of Optically Stimulated Luminescence, $^{14}$C and relative dating methods – aligned with Bayesian statistical modelling – this project has created its own watershed of understanding by pushing back the earliest date for human activity on the island by several hundred years. As such, the archaeological timeline, presented below, incorporates this revised chronology.
<table>
<thead>
<tr>
<th>Cultural Phase</th>
<th>Start</th>
<th>Transition</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early human influences</td>
<td>6500 BC</td>
<td>5400 BC</td>
<td>Land clearances via sporadic wildfire episodes with possible human presence, especially from 6000 BC</td>
</tr>
<tr>
<td>Early Neolithic</td>
<td>5400 BC</td>
<td>4800 BC</td>
<td>The arrival of Agriculture and permanent settlement, including: cereal, livestock, pottery; distinctive ‘Skorba’ material culture</td>
</tr>
<tr>
<td>5th millennium hiatus</td>
<td>4800 BC</td>
<td>3900 BC</td>
<td>Significant reduction in activity</td>
</tr>
<tr>
<td>Temple period: Żebbuġ</td>
<td>3900 BC</td>
<td>3600 BC</td>
<td>Resettlement and early megalithic construction (from 3700 cal. BC); significant pottery production; rock-cut mortuary sites</td>
</tr>
<tr>
<td>Temple period: Mġarr</td>
<td>3600 BC</td>
<td>3450 BC</td>
<td>Material culture change</td>
</tr>
<tr>
<td>Temple period: Ġgantija</td>
<td>3450 BC</td>
<td>3200 BC</td>
<td>Elaboration of megalithic architecture; material culture change</td>
</tr>
<tr>
<td>Temple period: Saflieni</td>
<td>3200 BC</td>
<td>2850 BC</td>
<td>More elaborate mortuary practices</td>
</tr>
<tr>
<td>Temple period: Tarxien</td>
<td>2850 BC</td>
<td>2350 BC</td>
<td>Further development of architectural and ritualistic expression; notable increase in figurative art among other forms of material culture</td>
</tr>
<tr>
<td>Earlier Bronze Age (Tarxien Cemetery)</td>
<td>2350 BC</td>
<td>1600 BC</td>
<td>Sudden and contrasting change in mortuary practices. Cessation in development of megalithic buildings. A reduction in activities - hiatus in cereal agriculture and widespread grazing. The eventual re-intensification of agricultural practices</td>
</tr>
<tr>
<td>Later Bronze Age</td>
<td>1600 BC</td>
<td>750 BC</td>
<td>Re-establishment of cereals. Hilltop settlements</td>
</tr>
<tr>
<td>Phoenician / Punic</td>
<td>750 BC</td>
<td>250 BC</td>
<td>Wider cultural diaspora. Trade and viticulture. Possible cultural roots of Maltese language</td>
</tr>
<tr>
<td>Roman / Byzantine</td>
<td>250 BC</td>
<td>AD 870</td>
<td>Urban growth; more intensive viticulture; greater inter-regional connectivity</td>
</tr>
<tr>
<td>Arab / Norman</td>
<td>AD 870</td>
<td>AD 1530</td>
<td>Immigration; new agricultural practices including irrigation; Semitic language; fortifications</td>
</tr>
<tr>
<td>Knights</td>
<td>AD 1530</td>
<td>AD 1798</td>
<td>Urban development/redevelopment: refortification</td>
</tr>
<tr>
<td>Modern</td>
<td>AD1798</td>
<td>present</td>
<td>Growing population density; eventual abandonment of livestock herding; intensive horticulture; industrialization; independence and tourism</td>
</tr>
</tbody>
</table>

Table 2.1: A timetable of the prehistory and history of the Maltese Archipelago (after FRAGSUS (McLaughlin, Blaauw, et al. 2020))
Arrivals and the Early Neolithic

By accepting the archipelago’s liminal position within the Mediterranean world, it is understandable why there is scant evidence of Palaeolithic activity anywhere on the island. Throughout the sea-level fluctuations since the Last Glacial Maximum (Broodbank, 2013), the archipelago would have, at best, been a remote elevated headland on the southern tip of ancient Sicily — jutting into the vast distances between the European and North African littorals. For this reason, when considering the mobility and motives of Pleistocene people, it is understandable that the Maltese archipelago was essentially at the edges of the anthropic world, especially considering the lack of evidence for Neanderthals in Sicily (Lo Vetro and Martini, 2012).

Evidence dating to the Pleistocene is predominantly faunal (Marra, 2005) in nature, despite Sagona’s (Sagona, 2015) presentation of scant and tenuous remains (Mifsud and Mifsud, 1997; Frendo, 1999; Savona-Ventura and Mifsud, 1999) — such as questionable cave art (Savona Ventura and Mifsud, 2000) — and a possible Neanderthal taurodont (Despott, 1918; 1923; Keith, 1918). Although Sagona (2015) indicated the relatively close evidence of Epigravettian tools in Sicily, c.15000 BP, this does not overcome the physical disconnect from this region, brought about by rising sea-levels.

It would not be until c.6000 BC that humans left their first detectable impacts, with evidence of pollen-based disturbance. However, the presently known evidence of settlement cannot yet be dated to any earlier than 5400 BC. This early Neolithic culture brought distinctive pottery styles, Ghar Dalam and Skorba, characteristic for their locations of discovery. The artistic style shown in these materials can be likened to the Stentinello ceramics, endemic to Sicily — suggesting that contact between these landmasses was achievable and the 70km separation was surmountable by sea travel at the time.

Hiatus

Following recent work by the FRAGSUS project, including new excavation, reanalysis of previous material and Bayesian chronological modelling, a pre-Temple Period hiatus of activity has been identified. This has been interpreted as a period of wide-scale abandonment of the islands (McLaughlin et al., 2018), reflecting a wider population decline within Europe at this time (Shennan et al., 2013).

Temple Period

As shown in Table 2.1, the ‘Temple Period’ has been split into 5 distinct periods each representative of a perceived cultural fluctuation as evidenced by variations in the architectural and material remains. Pace describes this as indicative of a “diversified worldview of the archipelago’s communities” (2004, 31). However, such a worldview can only be reconstructed in part, especially considering the c.1600 years that the Temple Period spans. Each of the following phases exhibit both similarities and
differences to each other. For example, morphological similarities in artefacts can be considered a by-product of function and a long-term continuity of practice. Considering the large span of time that the archaeological record relates to, an over-reliance on these broad ceramic phases may mask hitherto unknown cultural fluctuations. The material culture and megalithic architecture are representative of a snap-shot image of phases which could be measured in generations, at best. Accordingly, it is better to consider the Temple Period as a cultural spectrum with thematic similarities across phases. These phases could therefore be interpreted as the ebb and flow of a general cultural disposition – as opposed to more strictly defined cultural difference. It is for this reason, that caution must be taken when considering the idea of diversified worldviews, communities and cultural expression – especially in a restricted and liminal environment such as the Maltese Archipelago.

Żebbuġ Phase
Noted as the time when a new group of farmers arrived in the islands, with a material culture linked with that of the San Cono-Piano Notaro cultures in Sicily (Bonanno, 2017). It remains unclear if the inhabitants were comprised of a completely new group, or an older ‘indigenous’ population now bolstered by immigration – aDNA studies may elucidate this, although the preservation conditions for mortuary remains are relatively unfavourable. There is a notable use of rock-cut tombs – reflecting a central Mediterranean similarity yet expressing local divergence (Pace, 2004). Sagona (2015) suggests an element of immigration tied to a deeper cultural memory, evidenced by reuse of particular sites. It should also be considered that, given the small size of the islands, developed locations would naturally see use and reuse – indicative of a need to reduce energy expended in the settlement of new areas. Equally so, this synthesis could also exclude the effects of a small but constant population, who may have maintained some element of contact with the wider Mediterranean, through seafaring excursions (although the lack of timber present in the archipelago makes this concept more tenuous).

Mġarr Phase
This is described as “no more than a short transitional phase” with elements of continuity and change visible in the pottery styles (Bonanno, 2017, 18). Evans (1954a) postulated that this sequence should be considered as distinct, however a more recent study by (Malone et al., 2009) has eroded this distinction. As such, the concept of regional variation (Sagona, 2015) should be questioned - where does regional variation begin and craft expression end?

Ġgantija Phase
This phase is marked by the first appearance of the Temples, taking its name from the magnificent structures present in the town of Xagħra, Gozo. These megalithic complexes are possibly reminiscent of the subterranean burial structures (Bonanno, 2017) – multi-chambered, with the creation of liminal space and elements of enclosure. One of the few prehistoric domestic contexts is dated to this period,
on the open plains of Southern Gozo – the Għajnsielem Road house (Malone et al., 2009). Importantly, the presence of developed domestic soils in conjunction with the Ġgantija megalithic complex (French et al., 2018) suggests the continued development of these hilltop environments – alongside the use of the plains indicated at the Għajnsielem Road site. Sagona (2015) indicates the widespread nature of material culture in this period, emphasising the period was visible across a broad range of locales, including within material found at the Hal-Saflieni Hypogeum. Importantly, the grandeur of the monumental architecture is representative of a cumulative effort previously unseen in the archipelago – an effort which would be echoed for nearly another millennium, to the end of the Temple Period.

Saflieni Phase
An ephemeral designation between the Ġgantija and Tarxien phases, with indications arising from stratigraphic and ceramic variability (Evans, 1954a; Trump, 2002). Sagona (2015) does not challenge this view, instead trying to support a sense of transition towards the later Tarxien ceramics. One must question the validity of this by considering how this would appear across hundreds of years. Caution must be taken when branding scant evidence as something so concrete as a named phase. This phase has also been considered as a funerary style (Malone et al., 2009).

Tarxien Phase
This represents the flourish and finality of the Temple Period, marked by important additions during this phase in a series of major megalithic sites, including Ħaġar Qim, Mnajdra, Borġ-in-Nadur, Tas-Silġ and Tarxien (Bonanno, 2017). The primary usage of the Xaghra Circle Hypogeum also fell within this period, the study of which has provided vital information about the prehistoric inhabitants of the islands (Malone et al., 2009). This continuation of megalithic construction is also associated with a florescence of material culture, with a variety of unique ceramic styles attributed to the period. In many respects, the Tarxien phase is the culmination of a trajectory established over 1000 years previously - reaching a state of perfected pottery and relief sculpture stylings (Cassar, 2002), hinted at in the previous phases.

The end of the Temple Period is often described in negative terms, such as demise or failure (Trump, 2002; Pace, 2004; Sagona, 2015; Bonanno, 2017). Though the information regarding the end of this period is scant, and framed by interpretations of intentional closure (Cazzella and Recchia, 2007) and a shift in iconography, it should be questioned whether or not archaeologists should catastrophise this transition. Sagona (2015) attempts to portray an organised, or systematised, end to this period – perhaps encouraged by a downturn experienced by the inhabitants. Given the considerable periods of time in question, juxtaposed with relatively little evidence -providing chronological snapshots- it seems equally risky to interpret a measured ‘end-to-culture’ as it is to posit a gradual decline with a growing irrelevance of that culture. Why should disaster be more desirable than the effects of time for the
explanation of cultural change? While this thesis poses no answer, it simply aims to temper the need for decisive answers. The forthcoming results of the FRAGSUS project will provide a renewed understanding of this crucial point in Maltese prehistory – indicating that although cultures change, there was not a sharp transition as considered by traditional scholars. In particular, the pollen data show a clear continuation of farming activity in the Maltese landscape, evidencing a continued inhabitation of the archipelago (Farrell et al., 2020).

**Bronze Age**

The onset of the Bronze Age in the archipelago displays a marked change in cultural traits. Across the Tarxien Cemetary, Borg-in-Nadur and Bahrija phases, the inhabitants of the islands lived and expressed themselves in a manner that contrasts with the preceding Temple Period. Settlement was confined to the hill and mesa-tops, away from the more accessible plains utilised previously. Cassar (2002) suggests that this is indicative of a population living with an increased level of existential threat – signs of a more connected Mediterranean world. The earliest phase of the Bronze Age brought with it reuse of ‘historic’ sites, along with cremation burials and unique ceramic styles – however the transition to the Middle Bronze Age is problematic, appearing to happen without hiatus yet arriving with notable differences (Sagona, 2015). In particular, the occurrence of fortified locations is notable in the Borg-in-Nadur (Middle Bronze Age) phase. Pace (2004) places these sites within the realms of the palatial complexes seen across the Mediterranean and Aegean diasporas. Lastly, the Bahrija phase, can be described as overlapping the preceding phase – more of a style than a culture (Trump, 2002). Bonanno (2017) posits that this may suggest a minor influx of new inhabitants to the islands, peacefully co-existing on pre-existing sites.

Central to the understanding of the Bronze Age is the question of its origins, especially for the Early and Middle phases. Pace (2004) draws on the symbolic use of the landscape, particularly identifying dolmens, as an indicator of stronger cultural linkage to wider Mediterranean contexts. In many respects, this linkage then places the inhabitants in a situation where there is an intrinsic connection to ebb and flow of socio-economics beyond the shores of the archipelago (Sagona, 2015). It is yet to be determined if this connection arose in this period, or if it has existed through time – albeit in a more intangible manner. Regardless, from the Bronze Age onwards, the archipelago’s role in the Mediterranean would only continue to grow through time.
One of the critical moments in the development of the archipelago was the arrival of a Phoenician influence within these islands – perhaps layered onto the indigenous Borg-in-Nadur people (Sagona 2015). Aside from continuing along a spectrum of increasing contact with the outside world, this period marks the transition into the realms of history, as it is likely that major elements of the Maltese language can be traced to the Phoenician activities in the islands (Bonanno 2017). What may have started as indirect trading, characterised by shoreline deposits of goods with trade not requiring interpersonal activity, developed into the presence of permanent Phoenician colonies – the cities of Melite and Gaulous. Alongside recorded literacy, this influence brought new material, architectural and religious styles – intermixing with aspects of the established communities (ibid.) while also being incorporated onto existing sites (Sagona 2015). Bonanno (2004) suggests, with much romanticism, that the Phoenician influence sets the archipelago apart from the trajectories found in neighbouring Sicily, in a similar fashion to the distinctions found with the prehistoric archipelago. Through this period, the Maltese islands become well established in the maritime world of the Mediterranean – with the islands providing trade and respite for Phoenician sails (Sagona 2015). However, in 573 BC, the defeat of Tyre effectively cut off western Phoenician colonies from the Levant – coinciding with the growing strength of Carthage. From 550 BC to 218 BC, the Maltese islands were described as Punic – recording the political separation of Phoenicians from the Levant that became the Roman term for Phoenician descendants in the west.

At the outbreak of the Second Punic War, in 218 BC, the Maltese Islands were occupied by Rome and incorporated into the Sicilian province (Cassar, 2002). Bruno (2009) provides a concise account of historical commentary on the period, including Diodorus Siculus, Cicero and Pliny. Malta received largely the same treatment as Sicily (Bonanno, 2004), governed within the Sicilian jurisdiction. Cassar (2002) suggests that the islands were prosperous, with around 30 agricultural estates, many of which were particularly focussed on olive production. The changes brought about during the Roman period include the organisation of the landscape and the intermingling of Roman language and religion (Cassar 2002). In many respects, the description of the indigenous people, within Acts 28:2, as barbarous – stems from the use of barbaroi, referring to those beyond the linguistic realms of Greece and Roman. This could imply are sense of cultural overlap, as opposed to complete change. It was not until AD 212 that the Maltese islands would achieve full citizenship of the Roman Empire – within which it they would remain until designated as part of the Byzantine Empire in the 6th Century AD (ibid.).

Sagona (2015) attempts to describe the ‘Roman-ness’ of the Maltese archipelago, portraying the transition from Punic customs to Roman customs as rather straightforward. The islands were considered, as recounted by Cicero, as a sanctuary from the politics of Rome (ibid.). It seems likely
that, while maintaining elements of regional identity, the islands were well prepared for Roman control since Phoenician colonisation efforts were a marker of the slow transition towards supra-regional incorporation. The archipelago’s geographical position, strategic and economic values possibly helped cement its role as a not-insignificant factor in wider Roman strategy, especially as Carthage waned. Perhaps this is supported by its early Roman incorporation at the start of the Second Punic War.

**Byzantine Period**

In AD 535, the Maltese Islands were incorporated into the Byzantine Empire, along with Sicily, under the direction of Justinian from Constantinople. It is suggested that the islands contained a mix of barbarians, Vandals and Ostragoths – with a Christian burial rite only becoming visible from the fourth and fifth centuries AD (Bonanno, 2004). Bruno (2009) notes that Byzantine sources are indicative of a decent rapport between the Maltese islands and Sicily – and that Malta was one of twelve episcopal seats within the eparch of Sicily. Bonnano (2004) notes evidence of a Jewish community, and its structure, as well as the establishment of a Christian basilica at the oft-occupied site of Tas-Silġ. Cutajar (2004) notes that there is little evidence of Byzantine domesticity inland – with sites mostly located in the vicinity of the natural harbours. Perhaps this suggests that development during this period may have been largely strategic/tied to infrastructure – with hinterlands overseen by the indigenous people of the islands. From the period of war against the Goths and Vandals to the Arab period, c. 350 years, there is no historic mention of the Maltese Islands (Bruno, 2009).

**Arab Period**

Despite growing Arab/Saracen strength in the Mediterranean – evidenced by a recorded expansion of raiding parties – the Maltese Archipelago did not enter the Arab domain until AD 871. Perhaps, according to Cassar (2002), this was a testament to the fortification of the preceding Byzantine era. Further to this, Cassar suggests that the short period in which there is an Arab presence, coupled with restricted military numbers available to the Muslim rule, could indicate a population which fled Sicily and found refuge in the archipelago. Importantly, archaeological remains, including Sicilian and North African fine wares, indicate an Arab population that sat comfortably within the dynasties of Fatimid and Kalbid.

Following an initial siege, in AD 869 by Emir Ahmed which was repelled by the Byzantine garrison, a successful second attempt occurred during the following year. Arab accounts described that success as a massacre, with neither goods nor people spared – yet following this conquest, the Arabs did not seek to become established in the archipelago. It would take a further 180 years until Muslim
settlement took place in c.AD 1048 (Bruno, 2009). Cutajar (2004, 58), posits that a lack of identifiable “linguistic substratum” from earlier periods suggests a swift and hostile appropriation of the islands, corroborating the written sources. Material evidence suggests much similarity with Sicily, with concentrations of finds in the vicinity of Mdina – where Arab occupation occurred at sites utilised by the Byzantine inhabitants. In essence, the Arab population may have simply inhabited the sites and infrastructure vacated by the Byzantines, as well as developing new rural clusters (Cutajar 2004). The considerable presence of Sicilian and Tunisian ceramics suggests established trade networks (Cassar, 2002) which would have been supported by resource extraction (Cutajar, 2004) supporting the local population.

**Norman Period and the Late Middle Ages**

The Maltese Islands first entered the domain of the Normans in AD 1091 under Count Roger. The islands were acquired by way of a razzia, yet the Arab population were permitted to remain in residence, where the islands consequently maintained a position within the Muslim diaspora (Cassar, 2002). This initial incorporation followed Count Roger’s thirty year campaign to conquer Sicily; and was followed by Roger II’s thorough occupation in AD 1171 (Cutajar, 2004). The Norman period included the firm establishment of the Christian church in the archipelago (Cutajar 2004), which set the tone for an inter-mingling of Christian, Jewish and Muslim peoples (Cassar 2002). This period also saw the use of some feudalistic methods to manage the islands, with the foundation of the county of Malta; yet the incomplete nature of the feudalism protected the jurisdiction of the monarchy in Malta (Cutajar 2004).

Norman control continued until the late twelfth century AD, when the islands passed to the Swabian dynasty, inheritors of the Sicilian monarchy. During this period, the Germanic rule sought to centralise the control of the islands through further feudal control and ultimately evict the remaining Arab population (Cutajar 2004).

Following this period, control of the Maltese islands progressed through much turbulence due to their close links with the Kingdom of Sicily. This included periods of annexation and re-annexation during the respective reigns of Empress Constance and Emperor Frederick II of the Holy Roman Empire (Cassar 2002). Successive periods of Angevin and Catalan-Aragonese rule followed, a change brought about by factors including a militant Roman Church and The War of the Vespers (Dalli, 2004). A notable change in this time was the establishment of the universitas – the local citizen-based governing institutions – providing the islands with an element of autonomy (Cassar 2002). Dalli (2004) suggests that the social structure of the islands involved a typical division between authority -property owning élites and legal figures- and subordinate peasantry.
AD1500-1800: Knights Hospitallers and French Occupation

After an extended period of Aragonese Crown rule, from 1397 to 1530 (Dalli, 2004), the Maltese Archipelago entered the domain of the Order of Knights of the Hospital of Saint John of Jerusalem – a vassal state to the Kingdom of Sicily. In 1524, the Order sent *uomi saggi*, wise men, to Malta to assess the potential suitability for the islands to become a future headquarters for the Knights (Rix, 2015). Following the presentation of the islands by Emperor Charles V of Spain, after the Order’s retreat from Rhodes in 1523 (Bradford, 1961), the first priority of the incoming Knights was to reinforce the local defences (Rix 2015). The infrastructural improvements included the development of defences in the Grand Harbour, particularly at Birgu, and the construction of the Auberges - hostelry for each of the *langues* or language groups present on the islands, within the Order.

This period, punctuated by the Great Siege of 1565, was one of continual changes in the development of Maltese social, cultural and infrastructural spheres (Cassar, 2004). Primarily these changes included the establishment of a Grand Master – a figurehead role which was partly *primus inter pares* and, paradoxically, also that of a feudal ruler. By 1536, Malta was granted the power to mint its own coinage, the *Maltese Scudo* (Cassar 2004). The first Grand Master, L’Isle Adam, established the Magisterial Law Courts in 1553, which had the effect of weakening the well-established local *Università* (Cassar 2002). The Great Siege of 1565, by Suleiman the Magnificent, was intended to oust the Order from Malta and to establish security for Ottoman shipping lanes in the Mediterranean (Rix 2015). Between May and September 1565, the Knights were besieged by the Ottomans, at various locations including Fort St Elmo (present day Valletta), Birgu, Senglea and Fort St Angelo. Following the arrival of reinforcements from Sicily, the Ottomans made a strategic withdrawal. The heavy damage sustained at Birgu led to the foundation and reinforcement of the city of Valletta -taking its name from the Grand Master, Jean Parisot de Valette- beginning in 1566. This city, overlooking the Grand Harbour, ascended to the role of capital and thrived – surviving a further Ottoman attack in 1614 (Cassar 2004).

Despite the overall success of the Knights in Malta, indicated by solid population growth, the later years of the Order were characterised by an increasing disparity between the opulence of the Order and dissatisfied Maltese (Cassar 2004). Following the changing political structure of Europe in the eighteenth century, the Order, which was reliant on France for support, was found to be financially impracticable (Cassar 2002). The occurrence of the French revolution served to place the Order within the realms of old aristocracy and religious institutions – symbolic of the trappings French society was attempting to distance itself from. In 1798, following bureaucratic resistance by a diminished Order presence, Napoleon Bonaparte took the island after six days of conflict. However, French interests in the islands were neither planned for, nor financially sustainable and it took only three months for the
French leadership to disaffect the local population. Uprisings began against the French garrison, and help was requested from the British Royal Navy – whose support ultimately led to French capitulation on 5th September 1800 (Rix 2015).

**The British Period**

The years following French capitulation could be seen as an acceleration towards independence and the reinforcement of a national identity. Initially, the British may have been reluctant to have control of the islands, however Napoleon’s interests served as an inspiration for a continued, and primarily military, British presence (Rix 2015). Much of the later history of the archipelago was tied to British colonial interests, following the Treaty of Paris in 1814 which formally granted control of Malta to the British. In 1878, a Royal Commission recommendation suggested that English should become the primary language for the islands, particularly for education, culture and the courts. In doing so, this would further integrate Malta into the British Empire. The effects of Empire were felt heavily in the early 20th Century when Malta served as a major hospital location in the Mediterranean during World War I and as vital dockyards for the French and British fleets in the region. These war related efforts served to provide much employment for the local population. Following the Great War, there was a significant increase in unemployment and severe economic pressure on the local population – which culminated in the riots of 1919. In typical colonial fashion, the stationed military forces supported local police to quell the unrest – which included the deaths of 4 Maltese. Following this incident, and building on earlier calls for political reform, Malta elected its first Prime Minister in 1921, Joseph Howard. Following the language debate, sparked in 1878, the Maltese political sphere began to fragment into party groups – largely along the line of pro-British and pro-Italian. Howard was a member of what would later become the Nationalist Party. This political fractionation served to reinforce the language question. English officially became the National language in the 1930s – against a backdrop of socio-political language divisions, where Italian was spoken by Upper and Middle classes, and Maltese by the working majority.

Global unrest during World War II placed Malta in a very crucial position within the European Theatre. Benito Mussolini had openly planned to incorporate Malta within greater Italy – leading to some pre-emptive improvement of civil defences in the Islands, notably bomb shelter construction. Although neutral for the first months of the war, the islands became a target following Italy’s union with the Axis in 1940. As a consequence, Malta suffered some of the heaviest bombing of the war, with air raid sirens being sounded over 3000 times between 1940 and 1943. Malta’s strategic position and perpetual resilience were demonstrated during the second Great Siege, since shipyard activities and Allied naval sorties continued throughout this period. In 1942, the islands were awarded the George Cross by King George VI, in recognition of the Maltese tenacity and resilience. Fittingly, on September
8th 1943, on the same date that the Great Siege of 1585 ended, the Italian Navy surrendered in the Grand Harbour.

Following the conclusion of the war, a new constitution for Malta was enacted in 1947 – including universal suffrage for everyone over the age of 21. The years following the new constitution included the continued strengthening of the question of National Identity – where even characters such as Dom Mintoff were a vocal proponent of Maltese union with the UK. Following a political crisis on this very issue, a cross-party will for national independence became apparent, and as such Malta declared itself an independent state on September 21st 1964. It would be a further ten years until, ironically, Mintoff would preside over the removal of the British Crown as the official head of state, replacing this role with a parliamentary appointed president. Ultimately, despite Mintoff’s continued vocal support for Maltese nationalism, the nation joined the European Union in 2004 as a full member, and the Eurozone in 2008. Throughout the trials of the 20th and 21st Centuries, Malta has continued to flourish – being granted the title of European Capital of Culture in 2018. Arguably, it was already a capital of culture 5000 ago.

2.3 Background to Agricultural Terracing

Although the study of agricultural terracing is a relatively small sector of archaeology, there is a slowly expanding corpus of literature that address a variety of differing approaches to their understanding. Furthermore, this corpus of literature is spread across the terracing practices of the world, as presented via Wei et al. (2016) in Chapter 1 and below. Reflecting this, the following literature review draws on studies from this body, absorbing a wide variety of methodologies and insights from work completed in environments including and beyond that which this thesis examines. In doing so, an original methodological direction has been identified. This has been presented and justified in Section 2.4.

To address a multi-faceted literature base, this section observes several core themes to which papers can be attributed, thereby assisting the synthesis of information. There exists a predominant, yet unsurprising, focus on the physical properties of terraces and, reflecting this, the first themes covered are morphology and stratigraphy. Following this, an assessment of the chronological approaches to terracing will precede.

2.3.1 Terrace Morphology

Butzer (1982, 150) succinctly describes terraces as “conspicuous” features which are constructed to “retard runoff and soil erosion.” These features are comprised of a short, stone wall, with a posterior/up-slope build-up of soil – following the contours of a slope. Although, Butzer’s description
is adequate, it should be viewed as an aggregate of a plethora of terrace forms. When segregated, the nature of terrace morphology is more complex. Treacy and Denevan (1994) present their adapted general terrace typology, which loosely summarises the terracing forms encountered worldwide – although attention is mostly given to ‘dry’ terraces. An elaboration of their findings can be found in Table 2.2, below.

Dorren and Rey (2004) attempt to outline the variety of terracing morphologies by identifying categories of commonality, at least for European terraces. Initially, they distinguish terraces based on function; differentiating between ‘retention’ and ‘diversion’ terraces. The former enables the accumulation of sediment and run-off, with the eventual infiltration of moisture – particularly in more arid regions. The latter serve to capture and redirect run-off into specific waterways, especially in more humid regions. Moving on to construction-based categories, they distinguish channel terraces – where construction involves upslope soil extraction and downslope deposition – and ridge terraces – where soil is removed from either side of an embankment to form an elongated low terrace mound. Their third category made distinctions based on the size of the terrace base; narrow (<3m), medium (3-6m) and wide (6-12m). Finally, the shape of the terrace is used as a further element of categorisation: common, bench, contour and parallel terracing. Common terracing involves the simple design of bank and channel constructed on slopes less than 20%. In contrast, bench terraces are effectively level fields with a steeply constructed retaining wall, running close to the contour of the hillslope, usually found on gradients above 20%. The wall is typically constructed of rocks, rubble or similar materials. The terrace bench is built through a process of cutting and filling. Parallel terraces are derived from the bench terrace, where terraces are built in parallel to improve agricultural efficiency. Contour terraces closely follow the natural contour of the slope.

Emphasising the richness of morphological interpretations, Wei et al. (2016) deliver an effective synthesis of terracing studies across the world, utilising a methodology which scoured Google Scholar for specific keywords. In doing so, this paper has exposed a remarkable disparity among research into terracing – particularly when morphology is considered. Based on this, Figure 2.4 (below) illustrates the variety of terms used to describe terraced fields, emphasising the adaptability of this technology. Furthermore, it reinforces the difficulties found when trying to establish a sense of terrace typology. This paper concludes with a proposal that “scientific criteria for terracing designs should be developed” (Wei et al., 2016, 401). It is noted that coherent systems could not be fully comprehensive, given the likelihood of unique scenarios. However, it would seem valuable for there to be an inter-disciplinary agreement on the terminology used. The authors of this paper may be more ontologically poised to do so, in comparison with the constrained view of this thesis.
Table 2.2: Summary of Terrace Typologies (after Treacy and Denevan, 1994)

<table>
<thead>
<tr>
<th>Type</th>
<th>Platform</th>
<th>Wall</th>
<th>Fill Process</th>
<th>Contiguity</th>
<th>Further Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir</td>
<td>Usually sloping</td>
<td>Stone, wood, earth</td>
<td>Accretional (water-borne)</td>
<td>Segmented</td>
<td>Placed perpendicular to low-discharge intermittent streams. Enables the capture of sediment and moisture for wet-field cultivation</td>
</tr>
<tr>
<td>Barrage</td>
<td>Sloping</td>
<td>Stone</td>
<td>Accretional (erosion)</td>
<td>Segmented or serial rows</td>
<td>Cross-channel drainage terraces across large catchments. Captures water via sheetwash.</td>
</tr>
<tr>
<td>Sloping/Dry field</td>
<td>Sloping</td>
<td>Stone, earth, adobe, vegetation</td>
<td>Accretional and/or hand fill</td>
<td>Segmented or dry-serial rows</td>
<td>Common worldwide. Usually walls lean slightly towards their slope and are reinforced via build-up behind the wall. Occur in regions where precipitation is likely to cause periods of soil erosion.</td>
</tr>
<tr>
<td>Bench</td>
<td>Horizontal to gently sloping</td>
<td>Stone, earth, blocks</td>
<td></td>
<td></td>
<td>The “Inca Terrace.” High retaining walls with level platform surfaces. Closely following contours and arranged in vertical serial rows.</td>
</tr>
<tr>
<td>Valley floor</td>
<td></td>
<td>Stone, earth</td>
<td>Hand fill</td>
<td>Serial rows</td>
<td>Similar to Bench terraces. Much wider with lower walls found at the base of slopes.</td>
</tr>
<tr>
<td>Hand fill</td>
<td>Horizontal</td>
<td></td>
<td>Accretional and/or hand fill</td>
<td></td>
<td>“Padi Fields.” Horizontal with earthen banks to ‘pond’ water within. Retaining walls often contain systems for controlling water flow.</td>
</tr>
</tbody>
</table>
2.3.2 Terrace Stratigraphy

Fernandes et al. (2013) address the physical dimensionality of agricultural practices, asserting that traditional archaeological understanding of practices is two dimensional in nature; while the reality is inherently three dimensional, with standard activities involving the breaking the second dimensional plane through ploughing, planting and growing for example. By recognising the volumetric nature of agriculture, a better understanding of the functionality and productivity can be achieved through knowledge of improvement techniques. However, while the 3D nature of soil is an important assertion it is chronologically flawed. The very nature of soil is four dimensional i.e. spatial and temporal. Soil is a dynamic resource and as such it changes through time. The very nature of agricultural process is in concordance with this - soil is not persistent when used, instead it demands management and working to ensure the continued availability of nutrients and overall stability.

Recognising this important caveat is central to the formation of a renewed methodological approach to studying agricultural terraces. French and Whitelaw (1999) lay the foundations for this approach by engaging with stratigraphy that is both underlying and contained within terraces. Crucially, their results presented a notable pedological variation between these major phases and chronological separation via the presence of datable ceramic sherd. Frederick and Krahtopoulou (2000) provide a general assessment of terracing practices, within which they include a summary of stratigraphic trends – outlining that the character of the terrace (tread) fill should be inter-related with construction, tillage and use methodologies. They iterate that compositions can include natural deposits related to slope, anthropogenic fills and buried soil horizons. The authors note a common feature is a “poorly sorted matrix-supported gravelly deposit” (Frederick & Krahtopoulou 2000, 85) resulting from soil haploidization during the process of tilling – in effect a homogenisation which eliminates any evidence of stratigraphic effects. In recognition of the need to distinguish various soil profiles, this paper also includes hypothetical construction methodologies as a means of understanding resulting stratigraphy. Finally, the authors indicate that the degree of pedogenic development can act as an indicator of terrace age; with the formation of an A horizon occurring within the first 100 years, especially with the addition of anthropogenic material, and subsoil/B horizons slowly occurring over 1000 years – although the dating of soil development, through pedogenic features, is notoriously unreliable.

Krahtopoulou and Frederick (2008) develop the stratigraphic analysis of terraces and their component parts; exploring the development of soils as influenced by the construction and formation of terraces. This article sets out to “deconstruct and reconstruct the histories” (Krahtopoulou and Frederick, 2008, 552) of terrace sequences and place their understanding in the wider contexts of “preservation and visibility of the cultural record in terraced landscapes and aspects of past land use” (Krahtopoulou and Frederick 2008, 552). Crucially, the authors note that a “significant amount of earth moved by terracing and its subsequent abandonment may seriously complicate preservation, visibility, and discovery of
the cultural record, especially when more than one phase of terracing has occurred” (2008, 581). They posit that the act of abandonment of terraces may result in a phase of soil loss – either gradual or sudden. However, it remains uncertain how a terraced landscape returns to a natural form – an important consideration for long term landscape management in the Mediterranean.

Nanavati et al. (2016) present a comprehensive study of Peruvian terrace soil fertility, utilising a broad geoarchaeological programme of excavation and sampling. Predominantly, there were four soil horizons encountered – a modern plough horizon (Ap), an eluvial strata formed from terrace construction upcast, an occasional buried A horizon and, finally, a weathered bedrock. Their analysis suggested that the present soils conditions are a less stable version of the buried basal terrace fills, with the majority of fills a product of an eluvial soil, with little fluctuation in clay content – resulting from flushing by irrigation practices. Furthermore, combination of seasonal freeze-thaw, high solar radiation and the impact of soil fauna, has aided the weathering of parent material, downslope erosion and soil mixing processes.

More recently, Ferro-Vázquez et al. (2017) utilise stratigraphy to develop the concept of landscape evolution in relation to the managed agrarian environment; perhaps unintentionally echoing Frederick and Krahtopoulou (2000) whose work hypothesises how terracing influences the identification of landscape use and change. Such uses of geoarchaeological methods represent a fundamental advance in investigative methodologies which enable an understanding of how terraces fit into the complex relationship between humans and the environment. This paper reveals an unexpected stratigraphic composition which evidences the ‘preparation’ of a terrace fill by sorting small stones from the extracted soil and then reintroducing them to the ‘terrace void’ prior to the return of the now-sorted soil. This acts as a levelling stratum and helps reinforce the terrace wall. This methodology is somewhat dissimilar to construction methods proposed by others (Butzer, 1982; Treacy and Deneven, 1994). Ferro-Vazquez et al. ultimately describe erosion as an essential nemesis – which initialised a rejuvenation of the Konso, Ethiopia system by repopulating a pedologically denuded valley system.

Recent findings from the FRAGSUS ERC project (French et al., 2018) largely echo this notion. From the 4th millennium BC onwards, de-vegetational activities and a gradual increase in aridity resulted in more erosive, xeric, soils. Ultimately, the stabilising factor has been the adoption of terracing practices, especially on thin-soiled limestone slope.

2.3.3 Terrace Chronology

Vitally, it should be recognised that the perception of this relationship is not complete without the consideration of chronology. The basis for a longue durée cultural framework can be formed through the incorporation of a temporality for terraces and their associated environmental changes. Reiterating this chapter’s opening factors, terracing is a product of human intervention and is subject
to a subsequent process of natural and artificial evolution. Therefore, the application of absolute dating methods is imperative to extract the archaeological biography of terraces. Perhaps inadvertently, Frederick and Krahtopolou (2000), in discussion of how terracing affects archaeological visibility, hint at the central flaws of relative sequencing of sediments subject to erosion. While the application of 14C AMS dating (Krahtopolou and Frederick, 2008; Acabado, 2009; Ferro-Vázquez et al., 2014) has created a marked development of temporal precision, it still must be recognised as being influenced by a myriad of depositional influences. Davidovich et al. (2012) explicitly outline these flaws – primarily citing the uncertain source of datable material, associated depositional ambiguity, bioturbation and the old-wood effect. Perhaps the presence of short life, single entity organics may help alleviate some of this concern, however the depositional taphonomy still poses a major flaw.

Crucially, work taking place in Israel and the Southern Mediterranean (Avni et al., 2009; Gadot et al., 2016; 2018; Kinnaird et al., 2017) has championed the application of OSL (Optically Stimulated Luminescence) dating to the study of agricultural terraces. Fundamentally, the utilisation of this method enables a direct chronology of the deposited soil – as opposed to a relative sequence, based on materials contained within. OSL measures the absorbed light emissions from crystalline structures, particularly quartz and feldspar, contained within the deposit (Feathers, 2003). In effect, the utilisation of this method allows the dating of soil deposition and accumulation. More recently this technique has been developed (Kinnaird et al., 2011) through the use of a field-portable luminescence reader which enables a rapid assessment of the relative accumulation of sediment. Application of this technique (Turner et al., 2017; French et al., 2018; Porat et al., 2018) has demonstrated the practical efficacy of this technique, along with the establishment of a chronological biography for the terraces under study. This method holds much promise for the future of terrace studies, and the establishment of a baseline chronology for the onset of terracing in the Mediterranean super-region.

2.3.4 Geoarchaeological Studies

French and Whitelaw (1999) offer a seminal paper for a micromorphological approach to understanding terraced archaeological landscapes. Specifically, it charted a methodology for studying the stratigraphic biography of terrace complexes, including the complex description of the early terra rossa soils. By combining the archaeological observations (surface sherds) with sedimentological approaches, a complex history of site usage was created. This paper established a set of goals which are an excellent basis for the study of terraced environments. These are as follows: “1. identification of old land surfaces and in situ palaeosols; 2. assessment of the consistency or variation up- and downslope of the sediment composition of the terraces; and 3. investigation of the post-abandonment modification of the site deposits” (French and Whitelaw, 1999, 155). In short, this paper demonstrated the applicability of micromorphological approaches to intrusive terracing systems. Its application revealed soil composition and the historical sequence of activities which have influenced the soil
The strengths of this approach are found in the identification of long-term landscape management strategies, with more generalised observations about how terraces control sediments. It is expected that a greater sample size would yield observations valuable to the localised understanding of terrace function, similar to the expectations of this chapter.

Applying the theory of a geoarchaeological approach, Frederick and Krahtopoulou (2008) addressed concerns surrounding the uncertainty of terrace chronology and function – arising from interpretations based on surface surveys. The first major consideration this paper presented is in relation to typological considerations. Specifically, this is discussed in terms of nomenclature, purpose and modern methods of construction. Building on this, the various stratigraphic elements of terraces are discussed and a series of hypothetical ‘construction stratigraphies’ were postulated. This is a crucial exploration to consider when interpreting these, such that the authors considered how each method may affect the visibility of cultural material in relation to archaeological survey. Finally, this paper explored the complexities of dating agricultural terracing – approaching each physical aspect of terraces and the most applicable dating methods for each. Ultimately, the work concluded that the best methodology will employ multiple dating techniques. In short, this paper reiterated the importance of detailed terrace studies - not just acceptance of their place in the landscape. Terraces hold the potential to be far older than basic investigations would suggest – thus reinforcing the need for rigorous excavation and dating.

Progressing the themes of each of these papers, Krahtopoulou and Frederick (2008, 552) set out to “deconstruct and reconstruct the histories” of terrace sequences and place their understanding in the wider contexts of “preservation and visibility of the cultural record in terraced landscapes and aspects of past land use” (ibid.). To accomplish this, the methodology used employed a systematised programme of stratigraphic studies, sediment analysis (particle size, magnetic susceptibility, calcium carbonate content and organic carbon) and radiocarbon dating. Overall, the study provided an examination of the environmental context within which terracing is situated, as well as its implications for landscape and environmental change. It has been demonstrated that some of the complexes examined had been terraced more than once – with a relatively recent phase preceded by effort as early as the Bronze Age (early 2nd Millennium BC). Crucially, the authors noted that a “significant amount of earth moved by terracing and its subsequent abandonment may seriously complicate preservation, visibility, and discovery of the cultural record, especially when more than one phase of terracing has occurred” (Krahtopoulou and Frederick, 2008, 581). They posited that the act of abandonment of terraces may result in a phase of soil loss – either gradual or sudden. However, it remains uncertain how a terraced landscape returns to a natural form – an important consideration for long term landscape management in the Mediterranean. Although focussing on landscape scale
analysis, the methodology employed in this article represents an important progression in the scientific understanding of terraces.

Goodman-Elgar (2008) applied a rigorous investigation of terrace geoarchaeology – employing pH, electrical conductivity, nitrate, phosphorus, potassium, particle size analysis and micromorphology – across 16 test pits along 3 parallel transects (controlling for spatial variation). Results indicated that the terraces stabilised sand and aggregates thus protecting the topsoil and improving soil resilience. However, artefacts contained within buried soils suggest a large-scale movement of soil perhaps linked to Incan agricultural expansion; thus, a significant period of instability preceded the retentive value of the terraces. Of interest for the present study, the upslope and high labour-intensive terraces lead this paper to question the driving force behind their construction as the assessed productive value, since this would provide little return for the initial outlay. Terraces on the mid-slope were deemed to be relatively overused, displaying low organic matter and nutrients – with modern fertilising practices insufficient to maintain soil quality lost through farming and erosion. In summation, Goodman-Elgar presented a conclusion alluding to resilience within a fragile landscape – concepts echoed by the FRAGSUS project to which this thesis is heavily attached.

Nanavati et al. (2016) provided the most complete approach to the analysis of the geoarchaeology of agricultural terraces. Their study, based in the Ica Valley, Peru, sought evidence for buried agricultural horizons, specific farming strategies and their influence on soil fertility. Following a comprehensive test-pitting scheme, samples taken were subject to a gamut of methods: pH, electrical conductivity, soil moisture, organic/inorganic carbon, particle size analysis, phosphorous determination and soil micromorphology. The results from this work suggested that the terrace system has remained relatively stable for the past thousand years, with any significant environmental change that they detected attributed to the pre-terraced landscape. The stability provided by the terraces has facilitated sustainable farming that has not been reliant on widespread fertiliser use. This paper provides a viable template for progressing the methodology of this thesis, by focusing on the ecological biography of agricultural terraces where there is less reliance on a strict chronological grounding to frame interpretations.

Jiang et al. (2014) combined radiocarbon dating and geoarchaeological (PSA, magnetic susceptibility, organic carbon, phosphate, nitrate) methods to consider wet terrace cultivation in southern China. Through the establishment of an onset date in the mid-1300s, this paper connected the complex environmental and stratigraphic story with the recorded history and economy of the Yuan Dynasty. Notably, the stratigraphic sequence discussed resembled those described in Chapter 3, at least in terms of simplicity – their description of Ap-Bw (illuvial)-B/C is reminiscent of the aggradation found within the Blue Clay terraces in Malta, apart from the absence of illuviation. Subsequently, Jiang et al. (2017) presented a highly specific geochemical study which utilises analyses of n-alkanes – lipoid
biomarkers which maintain stability in geoarchaeological contexts – and organic carbon stable isotopes ($\delta^{13}$C$_{org}$) – a proxy for palaeoclimatic trends and for the presence of C$_3$ and C$_4$. In combination, these methods enabled an investigation of changing crop cultivation patterns and the relative stability and sustainability of the terrace system. This approach indicated the predominance of terrestrial herbaceous plants, and a predominance of C$_3$ crops – contained within four stages of soil development phases between the 15th and 19th Centuries AD. Combined with a previous study (Jiang et al., 2014), this paper provided a detailed geochemical insight into the longevity of terrace cultivation. Conceptually, the direction of all these papers frame how this chapter can advance the understanding of Maltese terraces, through the union of geochemistry and long-term historical land use.

Returning to Europe, Puy and Balbo (2013) attempted to disentangle the environmental palimpsest associated with terraces at al-Andalus, Spain. The methods utilised were pH, EC, Magnetic Susceptibility, Particle Size Distribution, LOI, micromorphology – with two samples receiving Sodium Adsorption Ratio and analysis of soluble anions and cations. Through the observation of pre-and post-terrace soils, this paper demonstrated a selective preference for saline and calcified sediments on colluvium for the construction of the first irrigated terraces – a process which left detectable traces of fire clearance and soil inversions. These methods were primarily utilised as an instrument for establishing stratigraphic details, yet also provided the basis for an assessment of changing land quality. The authors noted the high input of peasant labour required to construct and maintain these terraces, with methodologies driven to maximise the efficiency of production and use. As a result, the terraces were considered among the most productive for semi-arid regions. The contrast with Maltese terraces may be found within the different geo-political settings, where the Maltese archipelago was a marginal environment with diverse socio-political activity occurring through time, effectively creating a varied density of influence on the landscape – as opposed to remote and rural landscapes that occur on large landmasses.

Some studies have applied a limited sampling technique, focusing on spatial data rather than on stratigraphic detail. Stavi et al. (2018) assessed the effects of terrace failure on the vegetation and soil properties in the Negev drylands, Israel. Through the combination of vegetation cover assessment, soil depth measurements and surface (0-10cm) soil sampling, they revealed that intact terrace plots facilitate greater vegetation cover and soil quality when compared with collapsed terraces and non-terraced locations. Methods used were pH, hygroscopic moisture, calcium carbonate and stable aggregate content, microfauna (via rDNA extraction) and mesofauna (via light microscopy). A related study (Stavi et al., 2019), utilised the same sampling strategy (non-stratigraphic) to assess how the soil quality, pedogenesis and geomorphic processes were influenced by terrace failure. The methods employed were soil texture analysis, LOI, organic carbon, labile carbon, electrical conductivity, rock fragment content, penetration resistance and a measure of available water capacity. This study
indicates soil texture was finer in terraces which exhibited partial collapse – suggesting the erodibility of the sand fraction of the soil. Further effects of collapse included a greater resistance to soil penetration, higher soil stoniness and significantly lower soil labile carbon – all likely resulting from the erosion of loose surface deposits. The combination of these papers highlights the exacerbating effects of anthropic geomorphic processes – creating lasting positive ecological benefits where terraces are maintained, in contrast with the detrimental effects of terrace collapse and abandonment.

2.3.5 Geomorphological/Landscape Scale Studies

In many respects, the papers discussed in the previous section detail the ‘stratigraphic biography’ of terraced landscapes. Shifting focus away from terrace biography, the remaining studies observe terraces within the framework of environmental function. Tsermegas et al. posited that “there are no studies concerned with the course of erosion on currently used traditional agricultural terraces” (2012, 66). Specifically, this paper was designed to assess the effects of terraces on slope erosion. The approach utilised a detailed GPS map of geomorphology, combined with GPR transects and soil analysis to a depth of 6m. The assessment of terrace damage was carried out to “determine the stability of walls supporting the terraces” (2012, 68). The regions under examination are of granite-gneiss, karstified crystalline dolomite and crystalline schists and gneisses. Results showed that no terraces were constructed directly on the bedrock, although some did conform to the varying bedrock surface. The authors suggested that areas were selected for agriculture because of the surface stability. Careful mapping indicated that terrace walls have a “declination from the perpendicular of a few degrees in the direction of the supported terrace” (2012, 71). Terrace wall thickness was dependent on the size of stone used, with the stones arranged lengthwise along the wall – so that “the thickness of the wall was proportional to the width of the biggest stones” (ibid.). The authors established that terraces were constructed in phases, beginning with the lowest. Terrace degradation has been found to be due to a variety of factors, most important of which is the cessation of use. Although geology plays a role in the rate of degradation, erosion via rainwater and root action are the central factors. At its core, this paper assesses terraces without cultural context – although results surely pertain to social patterns and human decision making.

Continuing with the theme of environmental processes, Sandor et al. (1990) present a study of terraced fields in the mountainous arid/semi-arid Mimbres Valley, New Mexico. This extensive terracing system has excellent preservation and is found in close proximity to non-terraced and uncultivated land which was studied to aid the understanding of the long-term impacts of terracing practices. The physical location for these terraces “within certain geomorphic settings and soils suggests a set of placement criteria to achieve favourable conditions for runoff agriculture” (1990, 74). Specifically, sites are located between 1800m and 2000m, in order to exploit the best probability of acquiring surface water for crops. Terracing predominantly occurs at slope gradients between 3 and
10% (c.1.5°-5.5°), in small drainage areas c.1-8ha. Such practices lead to controllable, less damaging, runoff speeds – thus protecting crops and trapping water appropriately. Further to this, terraces are located to take advantage of argillic soils, which are “effective runoff producers and also promote higher moisture in the crop root zone because water is detained above the slowly permeable argillic horizon” (1990, 76). This regard for the natural soil properties is also observed elsewhere in the region with Hopi agricultural practices. Finally, the comparison with non-terraced and uncultivated neighbouring land has revealed that terracing practices “generally resulted in environmental degradation, including accelerated erosion, compaction, and decreased concentrations of soil organic matter, nitrogen, and phosphorus” (1990, 83).

Sandor et al. (1990) assess terraces which hold a markedly different function compared with their European counterparts. Interestingly, these terraces are situated on remarkably shallow slopes when compared with European examples. In similarity to this study, Ackermann et al. (2008) presented work which approaches terraces from the hypothesis that they may act as runoff farms. Through the combination of digital terrain analysis and precipitation mapping, they demonstrated that these terraces do enable the maximal utilisation of runoff water, even in drought years. Specifically, simulations have revealed that “230 mm of direct rainfall generates a water potential equivalent to 300 mm of direct rainfall” (2008, 930). Effectively, this ensures that terraces are always agriculturally viable. However, there exists a notable contrast with Sandor et al. (1990), whose arid/semi-arid terraces are placed on gentle slopes rather than the range of 21° to 31° in this paper. Sandor et al. (1990) suggest steep slopes equate to substantial damage of terraces due to runoff, and thus a high maintenance value. However, Ackerman et al. (2008) do not discuss this likelihood. Given the similar climate classifications between these locations, questions can be raised about the human aspect in this situation – the need for preservation/the need for low maintenance. Specifically, does the Sandor et al. (1990) system reflect management by a relatively small group of agriculturalists, where the balance between usefulness and low maintenance is crucial? In contrast, does the Ackermann et al. (2008) system represent a farming community which can cope with the high cost of maintenance, which is outweighed by guaranteed agriculture? These papers could be assessed alongside Stavi et al. (2018; 2019) for an understanding of the effects of soil texture, in relation to erosion. Equally, consideration of the Goodman-Elgar (2008) approach helps set the tone for the holistic understanding of the soil-landscape-culture matrix which is intrinsic to terracing.

Finally, merging the variety of approaches discussed above, Bevan et al. (Bevan et al., 2013) is an anthological approach to the recent study of agricultural terracing on Antikythera. Their research integrates archaeology, geoarchaeology, ethnohistory and botanical studies to elucidate perspective on agricultural terracing as a form of “landscape capital” (2013, 256). With regard to terracing and landscape structure, the authors posit that there is no discernible division between flat fields and
terracing complexes, with flat fields usually including at least one walled boundary that retains soil on a small slope. The lack of distinction between flat fields and terracing complexes makes it difficult to specify the slope angle at which terracing is deemed to have started, and the flat field systems have ceased. Spatial modelling indicates that terraces are constructed on softer, less steep, geologies, away from hard limestones, on flatter locations, generally at distance from the Antikytheran coast. Further to this, systems of terraces and flat field are generally found clustered together. This has been interpreted as “reflecting an agglutinative tendency whereby terraced plots are brought into cultivation in groups (by one or a few families) and existing terraces encourage the construction of neighbouring ones” (2013, 259). Interestingly, this paper noted an unusual form of terracing types which “run up steeply sloping tectonic trough valleys within the harder limestones” (ibid.). Such valleys have high bedrock walls on either side, with linear water gathering slopes.

In relation to terrace structure and soils, this paper suggests that terrace height/spacing correlates with bedrock geology and associated soils. Generally, the harder geologies are associated with terraces which are <50cm high and spaced quite close together (<10m). Such short terraces appear to have undergone a minimalistic initial construction, with little more than a thickening of the existing A horizon – with little preservation of buried soils and usually only one phase of use remains visible. Terraces on softer, Neogene, deposits tend to be dimensionally thicker (>1m thick and 2-3m high) and more widely spaced apart. Through detailed analysis of stratigraphy, combined with absolute dating techniques, this paper suggests a possible early experimentation with cross channel terracing during the 2nd Millennium BC. More substantial terracing activities occurred between the 4th and 1st Centuries BC. After a long period of abandonment, terraces entered another ‘Late Roman’ phase of use, between the 4th and 7th Centuries AD. Following this period, visible activity has been dated to the 12-13th Centuries AD and 18th-19th Century exploitation – with minimal 15th-16th century AD material.

Overall, this paper draws several important conclusions regarding terracing practices on Antikythera. Firstly, increased terracing practices correlate with boosted settlement and population on the island. However, there is “little evidence to support a model in which population pressure, at a small (e.g. decadal) scale, is the prime mover behind terrace construction. Likewise, there is little evidence for population pressure or terrace abandonment as a factor behind accentuated erosion patterns” (2013, 270). Secondly, in relation to abandonment and reuse of terraces, it is the longer periods of abandonment which promoted the preservation of terraces systems – with plant succession providing structural and canopy protection. Conversely, short term abandonment was characterised by flowering plants and grazing animals, which ultimately led to the erosion of terrace systems. Finally, the authors suggest that with the longer periods of abandonment, the protected signs of landscape capital can act as a major attractive force for visitors and new settlers – explaining the intermittent periods of activity observed within close locales.
Bevan et al. (2013) ultimately represents the model for a multi-faceted approach to the study of agricultural terracing. Appropriately, this paper blended scientific field techniques, anthropological considerations and absolute dating. In doing so, crucial social factors are alluded to, especially regarding the reuse of sites through time. While not strictly implying the presence of complex social dynamics involved with agrarian landscapes, this article provides a stable foundation to more detailed study.

2.3.6 Summary
This literature review serves to emphasise a variety of issues that arise with the study of terraces. Sections 2.3.1-3 have examined studies grouped into broader thematic areas. In doing so, this has helped build concepts of the ‘what, where and why’ related to this field. The diversity of applied methodologies has engendered a patchy framework of knowledge, with specific aspects of terracing receiving attention, rather than the very concept itself. These studies lack a critical dimension, namely the social context of terrace construction and use. This crucial gap will be filled by this dissertation by examining terraced environments as integrated, socially lived, landscapes. This stands apart from assessed studies which presented terraces through a series of distinct technical analyses. However, this has served to highlight a gap in the narrative of geoarchaeological and landscape related studies of agricultural terracing. No studies, to date, have presented an effective broad investigation of terracing that operates in a truly multi-scalar way. Papers presented in Section 2.3.4 are generally focussed on smaller geographical areas, drawing their data from test-pit excavations, forming micro-meso investigations. In contrast, papers from section 2.3.5 operated on a meso-macro scale, relating wider landscape factors to site scale phenomena. This situation presents an opportunity for this thesis to explore a narrative that investigates terracing at all three scalar levels and entwined with the vital social context which is typically ignored.

2.4 Approaches and Methods
Drawing this chapter to a close, this section will outline the general directions adopted by this thesis to further investigate agricultural terraces; therefore acting as a preamble for Chapters 3 and 4, which both build on gaps in the research narrative identified previously. The following sub-sections will begin with an explanation of the study locale, followed by a commentary on the perceived weaknesses in current knowledge and the opportunities they offer for this thesis. To set the context for the understanding of how terraces function, this section will examine the critical components of soil through a summary of factors which contribute to soil fertility. Finally, setting the social context, a series of cadastral maps will be introduced. These maps provide a geographically accurate and codified assessment of land productivity dating to the later 19th century. This provides a route to understanding
the perceptions of land quality within the Maltese Islands. This combination of data sources creates a unique opportunity to examine agricultural terraces in a manner that is both scientifically rigorous and culturally meaningful.

2.4.1 Research Narrative

*Why the Maltese Archipelago?*

Working alongside the ERC *FRAGSUS* Project has encouraged a scholarly dialogue focused on the changing environment of the Maltese Archipelago. The project, while primarily investigating the prehistoric inhabitants of these islands, included a research component that examined the later landscapes. In particular, this work utilised a corpus of cadastral maps from the 19th century which included assessments of land quality. Considering the project’s overarching focus on landscape use, an opportunity arose for a complementary study which considered the nature of landscape change from the end of the Temple Period onwards. The local agricultural terraces, being a dominant landscape feature and enigmatic archaeologically, were a logical fit to investigate. While uncertainty existed surrounding their time of origin, the status quo of knowledge suggested there was some antiquity to their inception. Furthermore, the fact that many terraces were still in use, while many others lay abandoned, related to the concepts of fragility and sustainability at the centre of the project. Considering the rich history of these islands, their nuanced story suggests an element of permanence to human activity which defies the environmental odds. Since terracing is a significant agricultural phenomenon across arid and semi-arid regions, their place in this archipelago deserved research which would contextualise them within the local environmental palimpsest.

*Which Research Direction?*

Having examined the body of published knowledge on agricultural terraces (Section 2.3), a gap in the research narrative is now apparent at the intersection between people and environment. Following Butzer (1982) and utilising geoarchaeology as a method of understanding human ecology, it is apt to approach terraces as part of a complex system involving people and environments. As terraces are anthropogenic features which contribute to the equilibrium of environments and the sustenance of societies, it is necessary to develop a multi-faceted research agenda. Previous studies have either isolated specific factors for investigation or employed a relatively small set of methods. Respecting the complexity of this phenomenon, this proposed research direction is one which considers the ecological function of terraces. In doing so, this thesis can account for how these landscapes are formed and their role in environmental and human contexts. The over-arching social theme can be explored by questioning how terraces may have functioned social and culturally. How were terraces perceived and operated? Such questions relate to social factors particularly when considering why terracing is required or deemed necessary. Terracing can have a variety of functions – soil management and
conservation, water catchment, and ecosystem/micro-climate control – and each of these functions could be indicative of a popular need to obtain environmental stability and/or consistent productivity from the landscape. Alternatively, the practice of terracing could be a purely opportunistic endeavour designed to create greater levels of productivity. As introduced in Section 1.5, this thesis will investigate how terraces contribute to environmental equilibrium in delicate Mediterranean landscapes. Finally, and most importantly, the issue of chronology is paramount in placing terraces within the correct social contexts. Terrace stratigraphy does not lend itself to secure relative dating methods. Only in the case of stratigraphically locked cultural material, attested by geoarchaeological methods, would a relative chronology be acceptable. The previous discussion of use/re-use of terraces highlights the weakness found with relying upon surface fill material. Undoubtedly, absolute dating methods will provide the most value to the dating of terrace stratigraphy.

2.4.2 Methodological Direction

Reflecting on the body of literature summarised earlier, a central methodological direction can be established to progress the scientific understanding of agricultural terraces, helping fill the gaps in the research narrative. In broad terms, Bevan *et al.* (2013) offered a prototypical methodology which strikes a balance between science, landscape and anthropology. Although this paper is an anthological summary of work carried out by a project, the balanced approach shown is worth emulating. Advancing this, the geoscientific methods used by Goodman-Elgar (2008) are an appropriate model to adapt for this thesis. Considering these factors, Chapters 3 and 4 will break down the study of terraces by interpreting information across multiple scales to maximise the value of this project’s resources.

Table 2.3 (below) outlines the variable uses of this approach, describing the relationship between methods and interpretive scales.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Chapter 3</th>
<th>Chapter 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meso-</td>
<td>• Terrace stratigraphy&lt;br&gt;• Cadastral map accuracy</td>
<td>• Terrace geochemistry&lt;br&gt;• Cadastral map assessments&lt;br&gt;• Geochemistry of terrace soils</td>
</tr>
<tr>
<td>Macro-</td>
<td>• Terrace construction&lt;br&gt;• Terrace chronology&lt;br&gt;• Geological factors</td>
<td>• Terrace function&lt;br&gt;• Geology and fertility&lt;br&gt;• Cultural perception of soil fertility&lt;br&gt;• Contemporary interpolation of historic data and its relationship to pedology</td>
</tr>
</tbody>
</table>

*Table 2.3: Overview of Methods and Scales for Chapters 3 and 4.*

To develop these research directions, this thesis will utilise data arising from two sources – field sampling and digitised historic maps. In the first instance, a combination of field excavation and auger sampling will provide a body of information relating to terrace construction, composition and function. Importantly, this will be tied to a series of historical cadastral maps, see Section 2.4.4, which will
provide a unique cultural perspective on the terraces examined. Derived from this data set is a modern statistical analysis which attempts to extrapolate the historic maps to both Malta and Gozo, incorporating a variety of other datasets and producing a map of perceived agricultural viability.

Samples collected in the field will be tested using a suite of geochemical techniques made available through the School of Natural and Built Environments, Queen’s University Belfast, via the kind support of Mr. John Meneely. These will be introduced in Chapter 4. In essence, these methods will provide an overview of factors pertaining to soil fertility and thus contribute to an understanding of terraces which is locally relevant and will also provide scientific context to the historic land classification, introduced below.

2.4.3 Soil Fertility

Central to thesis is the understanding of soil fertility, and its relationship to field location, construction and management. Soil properties and, by extension, fertility, are governed by interrelated physical, chemical and biological factors. By utilising geoarchaeological methods, this thesis is primarily concerned with the first two of these. However, it should be noted that the synergistic relationship between geochemical and biological factors is of significance for soil quality. Essentially, a fertile soil requires depth for roots, porosity to provide oxygen, nutrients, water, an adequate temperature and a lack of toxic elements. Beyond this, crop yield – influenced by fertility – is further defined by climate, rainfall and a variety of crop specific factors (Wild, 2003), slope, aspect and drainage. For the purposes of this discussion, since the data presented in Chapter 4 will be analysed in relation to themselves, the concept of fertility discussed will be centred upon the relative availability of soil nutrients. The tables below indicate the nutrients/elements pertinent to the discussion of soil fertility. Table 2.4 describes the major elements and their generalised roles within plants. Table 2.5 quantifies the proportion of nutrients for the effective growth of field crops, while Table 2.6 provides a broad outline of soil fertility from a geoarchaeological perspective.

Focusing on the rhizosphere - the area of soil in close physical, biological and chemical proximity to the plant root – the role of H⁺ ions is significant for plant nutrition. As outlined in Section 4.2.3, the uptake of anions and cations is affected by the relative proportions of H⁺, thus the availability of exchangeable nutrients is directly linked to the pH (Wild, 2003). Within the fine silt and clay fractions of the soil secondary minerals, such as silicates and iron/manganese oxides, these same minerals offer a significant proportion of nutrient availability to soil biota. Furthermore, the clay fraction offers sites for adsorption of nutrient-mineralising enzymes, providing a stabilising effect (Killham, 1994).

Soil organic matter, while not directly required for crop growth, provides a controlling influence on the chemical, biological and physical properties of the soil. Organic matter provides an element of physical stability to soils, alleviating the risk of erosion through the augmentation of soil structure; increasing
the supply of water to roots, aiding the growth space for roots and possibly assisting with drainage. Chemically, organic matter provides a source for the majority of Nitrogen (N), Sulphur (S) and some of the Phosphorus (P) which will become available to plants, particularly in unaided (no fertiliser/no manure) regimes; it supports the chelation of metal micronutrients, acts as a pH buffer and the increased physical stability provides protection from mineral leaching. Finally, soil fauna associated with organic matter improve the movement of water, through the creation of channels, and decompose material as part of the nutrient cycling (Wild, 2003).

With an unmanaged ecosystem, plant nutrients are returned to the soil via organic decomposition as defined by the maintenance of a balance from the naturally occurring biological cycles – in essence, a steady-state. However, in cultivated scenarios, balance is much harder to achieve – relying on the variety and intensity of agricultural practices and thus the fluctuation of the pressures on the nutrient cycles. Furthermore, the removal of crops from an agrarian ecosystem contributes to a considerable draining of the nutrient pool available within the soil – thus adequate management practices need to be established to ensure the return of nutrients, whether by ploughing/tillage practices, by long fallow periods, or by the addition of animal manures (Tivy, 2014) and restorative nitrogen generating plants such as clover and vetch.
<table>
<thead>
<tr>
<th>Atmospheric and Water borne</th>
<th>Carbon ((\text{CO}_2))</th>
<th>Molecular component for carbohydrates, lipids, nucleic acids and proteins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen ((\text{H}_2\text{O}))</td>
<td>Vital for plant metabolism, ionic balance and as a reduction agent – central to energy relations.</td>
<td></td>
</tr>
<tr>
<td>Oxygen ((\text{H}_2\text{O}, \text{O}_2))</td>
<td>Vital to all organic compounds</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Nitrogen ((\text{NH}_4^+, \text{NO}_3^-))</th>
<th>Required for numerous organic compounds e.g. proteins and nucleic acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorous ((\text{H}_3\text{PO}_4, \text{HPO}_4^{2-}))</td>
<td>Central to energy transfer and metabolism</td>
<td></td>
</tr>
<tr>
<td>Potassium ((\text{K}^+))</td>
<td>Required for osmotic and ionic regulation. A cofactor or activator for various enzymes involved with carbohydrate and protein metabolism</td>
<td></td>
</tr>
<tr>
<td>Calcium ((\text{Ca}^{2+}))</td>
<td>Cell division and membrane integrity</td>
<td></td>
</tr>
<tr>
<td>Magnesium ((\text{Mg}^{2+}))</td>
<td>Chlorophyll component and cofactor for numerous enzymatic reactions</td>
<td></td>
</tr>
<tr>
<td>Sulphur ((\text{SO}_4^{2-}))</td>
<td>Energetic reactions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Based</th>
<th>Iron ((\text{Fe}^{2+}, \text{Fe}^{3+}))</th>
<th>Central to Fe enzymes including ferredoxins (for metabolic function e.g. photosynthesis, N fixation and electron transfer) and cytochromes (respiratory electron carriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese ((\text{Mn}^{2+}))</td>
<td>Photosynthesis ((\text{O}_2) evolution). Component of enzymes arginase and phosphotransferase</td>
<td></td>
</tr>
<tr>
<td>Copper ((\text{Cu}^{2+}))</td>
<td>Part of a number of oxidase enzymes and important for photosynthesis, protein and carbohydrate metabolism</td>
<td></td>
</tr>
<tr>
<td>Zinc ((\text{Zn}^{2+}))</td>
<td>Essential to enzymes – dehydrogenases, proteinases and peptidases</td>
<td></td>
</tr>
<tr>
<td>Boron ((\text{B(OH)}_3))</td>
<td>Dehydrogenase activations, synthesis of cell wall components, cell division and development, carbohydrate metabolism</td>
<td></td>
</tr>
<tr>
<td>Molybdenum ((\text{Mo}))</td>
<td>Essential to nitrate reductase and (\text{N}_2)-fixation enzymes and the assimilation of N</td>
<td></td>
</tr>
<tr>
<td>Chlorine ((\text{Cl}^-))</td>
<td>Photosynthesis, enzyme activation, splitting water, osmoregulation in saline conditions</td>
<td></td>
</tr>
<tr>
<td>Nickel ((\text{Ni}^{2+}))</td>
<td>Essential for seed growth, metabolism, germination (Yusuf et al., 2011)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Cobalt ((\text{Co}^{2+}))</th>
<th>Enzyme production, growth and metabolism (Palit et al., 1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium ((\text{Na}^+))</td>
<td>Beneficial for (\text{C}_4) plants or where (\text{K}^) deficiencies exist. Uptake of pyruvate in chloroplasts (Maathuis, 2014)</td>
<td></td>
</tr>
<tr>
<td>Silicon ((\text{Si(OH)}_4))</td>
<td>Beneficial for plants under biotic and abiotic stress. Aids mineral uptake (Greger et al., 2018)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.4: Plant nutrients and summarised roles after Wild (2003) and Fageria and Baligar (2005)
### Table 2.5: Average concentrations of essential nutrients for adequate growth of field crops (Fageria and Baligar, 2005)

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Concentration (g kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>450</td>
</tr>
<tr>
<td>Oxygen</td>
<td>450</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>60</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>14</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.9</td>
</tr>
<tr>
<td>Potassium</td>
<td>9.8</td>
</tr>
<tr>
<td>Calcium</td>
<td>5.0</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.9</td>
</tr>
<tr>
<td>Sulphur</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Concentration (mg kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>112</td>
</tr>
<tr>
<td>Manganese</td>
<td>55</td>
</tr>
<tr>
<td>Zinc</td>
<td>20</td>
</tr>
<tr>
<td>Copper</td>
<td>6</td>
</tr>
<tr>
<td>Boron</td>
<td>22</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.10</td>
</tr>
<tr>
<td>Chlorine</td>
<td>106</td>
</tr>
</tbody>
</table>

### Table 2.6: Baseline standard of soil fertility (after Fageria and Baligar, 2005)

<table>
<thead>
<tr>
<th>Soil Factor</th>
<th>Required Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7 – 8</td>
</tr>
<tr>
<td></td>
<td>(Neutral - Slightly Alkaline)</td>
</tr>
<tr>
<td>Organic Content</td>
<td>2-4%</td>
</tr>
<tr>
<td></td>
<td>(up to 8% can be beneficial)</td>
</tr>
<tr>
<td>Phosphate (P)</td>
<td>&gt;10 mg kg(^{-1})</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>&gt;50 mg kg(^{-1})</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>&gt;600 mg kg(^{-1})</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>&gt;120 mg kg(^{-1})</td>
</tr>
<tr>
<td>Sulphate (S)</td>
<td>&gt;12 mg kg(^{-1})</td>
</tr>
</tbody>
</table>
2.4.4 Notes on the Cabrei

A focal dataset in Chapters 3 and 4 are the Cabreo maps (Cabrei) of the Maltese Islands. As noted earlier, these maps document an assessment of property and land holdings within the islands. The term Cabreo is defined in Italian dictionaries as “map of a private property, inventory or secular or religious administrations’ systematic list of assets and income” – as requested by private individuals, thus differing from cadastral maps which were a record of landholdings and land valuation which were typically used for state taxation.

Vella and Spiteri (2008) outline the origins of the term cabreo as arising in 1597 with the Knightly Orders. Specifically, these maps were drawn by the periti agrimensori, or land surveyors. Spiteri and Borg (2015) detail that this role existed in two parts – the perito and the agrimensore. The former is well documented, being recognised within judicial settings “as a technical expert in court cases concerning property litigations” (2015, 130). The latter, however, remains relatively under-examined despite having a noted role in the genesis of the rural landscapes (Spiteri and Borg 2015, 131). Vella and Spiteri (2008, 22) note the development of such documented surveys, with the earliest forms of survey existing as written documents – “terriers” or Italian “decimari”. The term cabreo became synonymous with these written accounts until the 1643 Council for the Order required the documented location of previous land acquisitions, at which point the cartographic methods became standard practice (Spiteri and Borg 2015). Vella and Spiteri (2008) provide an overview description of the qualities of the more refined cabrei of the eighteenth century. Usefully, their description can also be applied to the 1861 cabreo utilised by this study (see Figure 2.5, below, for a visual example).

“In general, a cabreo belonging to a foundation consisted of the following parts. A frontispiece followed by an introductory description about the foundation... instructions for the compilation of the cabreo... name of the person or authority calling for the compilation... a list, a veritable index, of all the urban and rural possessions described in the cabreo. The description and illustrations of the immoveable property, urban followed by rural, constitutes the central part of the cabreo. Houses in towns have scaled plans and elevations whereas plots of lands are delimited by colour banding to denote contiguous properties... The survey depicts structures and other features, including farmsteads and storage rooms, animal pens and sties, cisterns, water tanks and conduits, threshing floors. Rubble walls, paths, tracks or roads are marked to show the limit of property” (2008, 22-23).
This rigorous attention to detail provides an invaluable documentary source for historians and archaeologists alike. Crucially, the ability to georeference these maps with the modern landscape enables a direct assessment of landscape and environmental change. Contributing to this, the later cabrei include indications of land quality through colour coding; grading the land as good, mediocre and poor-quality land (ibid.). Alberti (pers. comms. 2015) described the land quality assessment as linked to field productivity – a set amount of grain would have been planted and subsequently the harvest productivity recorded. Based on this information, the land quality was then determined by the crop: yield ratio.

Figure 2.5: An example Cabreo ‘parcel’ depicting a property which includes various land qualities ranging from good (green) to poor quality (brown). Note the surveyor has drawn the disrupted topography of terracing, in the upper right of the map. These boundaries can be mapped to surviving features – extant field boundaries and/or natural landscape contours.
This early, systematised, approach to land quality assessment provides an excellent basis for exploring recent landscape change and the concept of persistence within a landscape. Within the framework of the FRAGSUS (Fragility and Sustainability in Small Island Environments) ERC FP7 “Ideas” project, an exploration of later landscape change is being conducted. As part of this project, Dr. Gianmarco Alberti has accomplished the considerable task of georeferencing the majority of the 1861 cabrei. Graciously, he has made this resource completely available for further study within this PhD project.

“It must be noted that the georeferencing process has been particularly time-consuming (taking several months, between March and July 2014) because, in lack of any geographic coordinate, the individuation of elements on the maps that could be used as referencing points against a georeferenced base-map has been done by a painstaking visual matching process. As a result, we have been eventually able [SIC] to give spatial references the majority of the available Cabreo’s parcels (43), excluding few very small ones. For the purpose of the model building, a further preliminary step has been taken. The georeferenced maps have been digitized in ArcGIS 10.1 with the use of vector polygons, and the quality class of each parcel has been entered into the polygons’ attribute table. The vectorialization of the parcels has also made it possible to obtain a figure of the total area covered by the data generated from the Cabreo (6.20 sq Km), which corresponds to 9.42% of the overall area of Gozo (65.78 sq. Km)” (Alberti, Grima and Vella 2014).

Figure 2.6, below, depicts this process. A close inspection of these images reveals significant landscape features which hold enough time-depth to be recognisable in the contemporary environment. When comparing recorded boundaries and their physical counterpart, it is interesting to note small discrepancies between the cabreo and reality. In some cases, the physical environment has changes sufficiently in the intervening years. In other cases, matters of perspective and ‘artistic license’ have influenced the accuracy of fields recorded in the cabrei. These issues will be covered in Chapter 3. Irrespective of slight irregularities, the cabrei offered a detailed body of data and a basis for complex statistical analyses.
Figure 2.6: An example of a georectified Cabreo (left) alongside a vectorised counterpart (right).
The central goal of this task was to enable the analysis of the variables which may determine landscape quality, as outlined in the 1861 *cabreo*. By utilising Logistical Regression, the relationship between a nominal dependent variable (*cabreo* land classification) and a variety of independent (environmental/social) variables can be modelled; with each independent variable being weighted by the probability of effect on the dependent variable.

Preliminary results, displayed in Figure 2.7 (below) reveal that aspect, elevation and slope gradient are the factors with greatest influence on *cabreo* land quality (ibid.). Further independent variables, including distance from urban centres and solar heat load, were added in an expanded model (Alberti, Grima and Vella 2014). Alberti, Grima and Vella (2014) explain that the variables, outlined in Figure 2.6, were selected on the basis of relatedness to the availability of moisture; the factor identified as central to both human and vegetational activity within the Maltese Islands. The complete list of variables utilised in the final regression model is displayed in Table 2.7 and an output map from this model is presented in Figure 2.8, below.

The authors do recognise that there are other variables which will determine soil quality and, in turn, land classification. The various omitted environmental and pedological factors (geochemistry, soil texture, drainage, wind, precipitation and climate) seem to conflict with the justification of the selected variables. The completed study (Alberti et al., 2018) provides greater detail on the role of soil as a factor influencing predicted viability. The classifications used are derived from Lang (1960) and the study values the summative assessment of soils and Lang’s commentary on the agricultural properties of each type. Furthermore, omitted pedological factors, noted in the last paragraph, are justified through the use of composite facts, where one thread of data is related and/or correlated to other omitted information. For example, elements of soil salinity (omitted) are tied to the topographical proximity to the sea (included). Table 2.7, below, indicates the utilised variables and details their more complex relationships to other factors.

A primary critique of this investigation is the lack of engagement with field science and collection of new, complementary, environmental data. Ultimately, these omissions present the opportunity to explore the geoarchaeological factors influencing soil quality and land classification and redress these omissions. However, it should also be noted that this regression model is an attempt to understand the cultural concepts of viability as opposed to the environmental determinants of fertility. Nevertheless, the role of geoarchaeology is to understand these two approaches together, not in opposition.
Figure 2.7: “Schematic summary of the results of the fitted Logistic Regression model for Gozo’s land quality as derived from Cabreo data. Arrows represent the contribution of the independent variables on the chances for ‘optimal’ land quality. Direction of each arrow indicates whether a variable contributes to raise or decrease the chances for ‘optimal’ land quality. Size of each arrow is roughly proportional to the size of each variable’s contribution to the chances for ‘optimal’ land quality” (Alberti, Grima and Vella 2014, Figure 9.)
| Variables                           | Type            | Levels                                                   | Importance                                                      |
|------------------------------------|-----------------|----------------------------------------------------------|                                                                |
| **Dependent variable**             |                 |                                                          |                                                                |
| Cabreo agricultural quality        | categorical (binary) | non optimal                                              |                                                                |
|                                    |                 | optimal                                                  |                                                                |
| **Independent variables**          |                 |                                                          |                                                                |
| Slope (degrees)                    | continuous      | water flow velocity, moisture, soil depth               |                                                                |
| Elevation (m)                      | continuous      | climate, water drainage, moisture                       |                                                                |
| Aspect (sin)                       | continuous      | insolation, evapotranspiration, moisture                 |                                                                |
| Aspect (cos)                       | continuous      | insolation, evapotranspiration, moisture                 |                                                                |
| Curvature-planform                 | continuous      | water convergence                                        |                                                                |
| Curvature-profile                  | continuous      | water flow acceleration/deceleration, erosion            |                                                                |
| Topographic Wetness Index          | continuous      | soil water content                                       |                                                                |
| Distance to fault lines (km)       | continuous      | fresh water availability                                 |                                                                |
| Distance to coastline (km)         | continuous      | sea-spray, salt-laden air                                |                                                                |
| Soil                               | categorical     | brown rendzinas                                          | hydraulic conductivity, nutrients management                   |
| Soil                               | categorical     | xerorendzinas                                            | hydraulic conductivity, nutrients management                   |
| Soil                               | categorical     | carbonate raw                                            | hydraulic conductivity, nutrients management                   |
| Soil                               | categorical     | terra rossa                                              | hydraulic conductivity, nutrients management                   |
| Soil                               | categorical     | lklin-Tad Dawl*                                          | hydraulic conductivity, nutrients management                   |
| Distance to main roads (km)        | continuous      | land accessibility                                       |                                                                |
| Distance to second. roads (km)     | continuous      | land accessibility                                       |                                                                |
| Distance to minor roads (km)       | continuous      | land accessibility                                       |                                                                |
| Distance to footpaths (km)         | continuous      | land accessibility                                       |                                                                |
| Distance to urban areas (km)       | continuous      | land accessibility                                       |                                                                |
| X coordinate (m)                   | continuous      | accounting for spatial auto-correlation                  |                                                                |
| Y coordinate (m)                   | continuous      | accounting for spatial auto-correlation                  |                                                                |

*Reference category

[https://doi.org/10.1371/journal.pone.0192039.t001](https://doi.org/10.1371/journal.pone.0192039.t001)

*Table 2.7: Table displaying factors incorporated in a Logistic Regression model, from Alberti et al. (2018)*
Figure 2.8: Output data from the Alberti et al. (2018) Logistical Regression Model. This map displays predicted agricultural viability, ranging from low (red) to high (blue), based on a variety of factors shown in Table 2.7.
2.5 Moving Forwards

This thesis will progress in a manner that both reflects a broad understanding of existing literature on agricultural terracing and respects the nature of associated research pertaining to the Maltese Archipelago. The investigations in Chapters 3 and 4 shall therefore investigate the role of terraces, at macro- and meso-scales, utilising this corpus of knowledge to advance a broad methodological direction which is both socially and scientifically meaningful. Chapter 3 will present the investigation of terraces primarily through macro-scale observations, collating excavation data and previously published material to create an overview of landscape change in the archipelago. Enriching this, Chapter 4 will mainly utilise meso-scale methods to contextualise the ecological role of terracing in relation to the cultural perceptions of soil quality. As made apparent through the fieldwork presented in both chapters, the lack of detectable micro-stratigraphy has eliminated the need for soil micromorphology. This has therefore negated the need for a micro-scale investigation within this thesis. To overcome this, key papers, such as French and Whitelaw (1999), can be extrapolated and applied to the Maltese context in conjunction with information gleaned in fieldwork associated with this thesis.
3 TESTING TERRACES

3.1 Introduction

The investigation of agricultural terraces demands a rigorous and multi-faceted approach to elucidate a full range of scientific observations such as form, function, variation, chronology and social management. Nowhere is this more relevant than in the Maltese archipelago where terraces are, somewhat paradoxically, both still in use and enigmatic archaeologically. For this reason, the appropriate archaeological methodology applied in this thesis will examine terraces from both stratigraphic and social perspectives. By combining these two methodologies, terrace function can be objectively analysed, in terms of landscape/geomorphic process and associated social dynamics. In doing so, a scientific and socially relevant understanding of terracing practices can be achieved.

Based heavily on the mandatory ‘pilot study’ for this thesis, this chapter outlines the preliminary investigations into the agrarian landscapes of the Maltese archipelago; particularly focussing on the land quality assessments of the mid-19th Century and how these are anchored in soil development as informed by the geoarchaeological record. These assessments notably exist within the cadastral or Cabreo maps of the Order of St John, among other commissions. The Italian term cabreo (from Latin capi brevium) was first used by the Grand Priory of Pisa in 1597 to describe a “collection of records consisting of a written and drawn survey of land and property holdings” (Vella and Spiteri, 2008, 21). Various notable cabrei exist; however, the 1861 version contains an excellent catalogue of well-drawn maps that have subsequently been digitised georeferenced within the contemporary landscape (Alberti et al., 2018). For this reason, these maps provide a basis for investigation into the changing agrarian landscapes of the Maltese Islands – see Section 2.4.4 for more information.

3.1.1 Aims and Objectives

The central purpose of this chapter is therefore to examine the physical properties of agricultural terraces and to understand their significance within wider agrarian landscapes. Primarily, this will require the formation of a chronological sequence for the development of terracing. Arising from this, the chapter will examine terrace stratigraphy and the relationship between the present-day landscape and that which was recorded in the 1861 cabrei. At the simplest level, this line of inquiry will examine how the terraced landscape has changed since the nineteenth century, where records permit. However, through the combination of established knowledge and new data, a more succinct understanding of landscape change can be established.

Stemming from this, an examination of the land quality assessment (Chapter 4) will be made to determine if current soil properties are reflective of the historical land classifications.
To accomplish these objectives, the implemented methodology will examine factors linking terracing and perceived land quality through two routes. Firstly, the examination of the cabrei and their land quality assessments offers a basis for the study of landscape change in the Maltese Archipelago. Through the comparison of cabreo and current topographical data, locations can be selected for the excavation of terraces which hold some level persistence in the landscape. Excavation offers the opportunity to observe crucial stratigraphic, structural and morphological traits. Secondly, geoarchaeological methods facilitate the analysis of buried soil properties as well as the cross-comparison of sediments which fall under different cabreo land classifications. Finally, the excavation of several trenches through representative terraces may reveal stratigraphically significant dateable material.

Although this study would appear to target a chronologically late phase of agricultural change (1860s to present day); this approach provides a replicable methodology for the investigation of agricultural terracing which can facilitate relative chronological interpretations. Persistent use of terracing may be a factor which helps preserve evidence of older early terracing whereby the maintenance and upkeep of sites protects underlying deposits from the threat of erosion and loss due to abandonment.

3.1.2 Preliminary Understanding of Terrace Chronology

Establishing a viable chronology for the terracing of the Maltese Archipelago is a central objective for this thesis. This is based upon the knowledge that agricultural terracing is an anthropic practice – as opposed to a naturally occurring phenomenon. Therefore, the adoption of terracing fits into a timeframe beginning around 6000 BC (Hunt et al., 2020) until the 19th Century AD, where a developed terraced landscape has been historically documented (see Section 2.4.4.). Accordingly, this chapter, and the wider thesis, will narrow a c.8000-year timeframe into a series of likely periods within which significant terracing progress is achieved. Wei et al. (2016) present a generalised global chronology which can inform the current discussion. Primarily, their mention of early terracing in Battir, Palestine and in Ibb, Yemen (Hammad and Børresen, 2006; Barker et al., 2013) provides an early benchmark for the start of the practice, at around 5000 years ago. While Palestine is on the edges of the Mediterranean world, and the Phoenician influence on the Maltese Archipelago is not insignificant, the terraces of Yemen are of tenuous relevance here. However, what this paper illustrates is the propensity for terracing culture at this time. Reflecting on literature reviewed in Chapter 2, the is uncertainty regarding the occurrence of prehistoric terracing in the Mediterranean and Aegean with such information requiring highly specific taphonomic conditions to preserve them in the archaeological record (French and Whitelaw, 1999; Krahtopoulou and Frederick, 2008). Some research has indicated a rapid post-abandonment degradation of terraces (Porat et al., 2018) which supports the need for a unique set of circumstances to preserve evidence of early terracing. Reiterating conclusions of Chapter 2, geoarchaeology offers the potential to unpick convoluted stratigraphic
evidence and provide viable candidate sequences for absolute dating, with OSL in particular. Returning to the Near-East, apart from the uniquely early landscape of Battir, Palestine, OSL studies indicate a largely historic narrative for terracing (Avni et al., 2013; Gadot et al., 2018; Porat et al., 2018) stretching from the Byzantine period through to abandonment phases 100-200 years ago. Showing a similar pattern in the regions around Jerusalem, there is no evidence for pre-Roman or Hellenistic terracing – 500 BC to 0 AD – but an abundance of historic terracing activities in the Late Middle Ages – 15th to 18th Centuries – associated with Crusaders, Mamluk and Ottoman periods (Gadot et al., 2016). Moving closer to the Maltese Archipelago, the Polcevera Tablet, dating to 117 BC, mentions the use of contour terracing (Agnoletti et al., 2019) while dates for the construction of terraced fields at Cinque Terre, Italy (Brandolini, 2017) begin at 1100 AD. In the Iberian Peninsula, dates range from the 8th Century AD (Puy and Balbo, 2013) – Ricote, Murcia, Spain – through the 10th to 12th Centuries AD (Nicosia et al., 2014) – Basque region – and 13th, 15th and 17th Centuries AD (Kinnaird et al., 2017) for Catalonian terraces.

While this summary sets a general chronological picture, it also emphasizes the hazy origin of terraces at some time post-Bronze age but pre-Middle Ages. Undoubtedly, each region will have a localised chronology which is a product of the particular social and environmental factors at play. However, this broad summary incorporates particular vectors that may influence the Maltese Archipelago – especially the Near East (Phoenician influence and Medieval geopolitics) and the Italian Peninsula. Locally, there is a limited body of knowledge to parse to help refine the chronology of terracing (see Table 3.1. below). This will be expanded upon in Section 3.4 and 6.4.
<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early – Mid-Holocene</td>
<td>Formation of Blue Clay ‘shelf’</td>
<td>Erosion of Upper Coralline stratum produces a shelf-like feature on the underlying Blue Clay. This is a natural terrace-like feature.</td>
</tr>
<tr>
<td>Late Neolithic – Iron Age</td>
<td>Early terraced features</td>
<td>Terrace-type soils present at Ġgantija (French et al., 2018). Alteration of physical environment via quarrying of rock as evidenced by megalithic sites.</td>
</tr>
<tr>
<td>Classical</td>
<td>Viticulture Landscape</td>
<td>Ubiquitous cultural manipulation of Coralline and Globigerina is well established. Establishment of olive growing and oil press sites from before the 1st Century BC (Anastasi and Vella, 2018).</td>
</tr>
<tr>
<td>Medieval</td>
<td>Expansion of agricultural terraces on ‘hard’ geology</td>
<td>Expansion of landscape to support pressures of increasing population through time (see Chapter 5).</td>
</tr>
<tr>
<td>Early Modern</td>
<td>Appropriation of marginal land</td>
<td>Terracing (now visibly abandoned) constructed at marginal locations on where soil development is naturally constrained.</td>
</tr>
<tr>
<td>19th/20th Centuries</td>
<td>Abandonment of unsuccessful terraces</td>
<td>The subsequent vacation of terraces which were constructed relatively recently.</td>
</tr>
</tbody>
</table>

Table 3.1: Pre-existing information pertaining to the chronology of agricultural terraces in the Maltese Archipelago
3.2 Methods

This chapter is primarily a macro-scale study focusing on the issues surrounding terraces and the later landscapes of the Maltese Islands, as explored through excavation and stratigraphic analysis. The following methodology will examine agricultural terraces which are documented within the 1861 cabrei, thus enabling an investigation of both terrace stratigraphy and the land quality classifications discussed previously. The following section will include the original planned methodology and the field adapted method which was ultimately utilised; as fieldwork began, planned methods had to be radically altered because of unforeseen difficulties.

3.2.1 Research Agenda

This methodology investigates a central set of concepts which contribute to the wider goals of this PhD thesis.

1. How do present day terraces physically relate to their historically documented counterparts?
2. How do the Cabrei classifications relate to the soils found with the terraces?
3. Is there discernible chronological framework for the adoption of terracing within the Maltese Archipelago?

The primary aim of this investigation was to observe the stratigraphic composition of agricultural terraces which were documented in the Cabrei. Such terraces were given a land classification value, as described in Section 2.4.4. This research direction would therefore examine the relationship between the contemporary field boundaries and historically documented boundaries. To achieve this aim, slot trench excavations were carried out over multiple terraces to provide new stratigraphic information and the opportunity to take diagnostic soil samples. Overall, this exercise explored the accuracy of the historic mapping, tested the relationship between terraces and geology, and aided the interpretation of terrace construction.

3.2.2 Notes on Original Plans

The original plan for the fieldwork was to include three locations, each selected based on the parameters outlined below. However, practical oversights severely curtailed the amount of work that could be carried out. Primarily, acquiring land owner permission occurred on an ad hoc basis, in conjunction with Sovrintendenza tal-Patrimonju Kulturali, the Maltese Superintendence for Cultural Heritage (SCH). Culturally speaking, there is hesitation among landowners regarding government intervention in their land. Permissions were rarely a problem, but some of the quests to acquire them were very time consuming. Secondly, the hire of a mechanical excavator and driver was also very time insensitive and therefore constrained the already limited time afforded for fieldwork.
Remedies to this could have been a longer fieldwork period, or more advanced planning in conjunction with the SCH. However, lengthy fieldwork experience in the Maltese Islands has reinforced knowledge of the pressing workload the SCH has to deal with – and supporting a minor intervention with a PhD student is very much deprioritised. Finally, a longer fieldwork season would have incurred a greater financial cost and would therefore have compromised the integrity of the overall PhD goals.

3.2.3 Site Selection

The initial stage of fieldwork preparation involved a desk-based assessment of locations suitable for archaeological intervention. To improve investigative efficiency, each location would examine terraces which fall under differing cabreo land classification zones. By doing so, this location would provide stratigraphic information relating to terraces and soil samples which could be utilised in an assessment of the differing land quality classifications outlined in the cabreo.

The target areas were selected based on three main factors: cabreo land classification, persistence of field boundaries and site accessibility. Primarily, this investigation required locations which offered terraces, that were both currently visible and at the time of the cabreo maps, and which fell under different land classifications. To identify these locations, a visual assessment of cabreo parcels in was carried out using a cabreo polygon layer in conjunction with high resolution satellite imagery. The comparison of the historical record with the contemporary images enabled the identification of three locations in the Xagħra/In-Nuffara valley, see below. This region of Gozo was originally mooted as a focal location for this PhD due to the close proximity of FRAGSUS project sites which were to provide logistical support. Furthermore, this valley presented an accessible range of geological strata to examine, flanked by important later prehistoric archaeological sites.

Original Proposed Sites

During the fieldwork conception, three locations in the environs of Xagħra were selected for study (see below (Figure 3.1) for the general Xagħra area map depicting the three planned transects, and the subsequent transect specific maps). Each map depicts a linear transect, along which a number of terraces were to be tested – ideally those which still exist in the landscape. The decision regarding the number and position of trenches was to be made after the preliminary site visit and survey.

Transect A (SE Xagħra – Weid il-Hanaq – see Figures 3.2 and 3.3)

This transect overlies a series of terraces which fall under a Buona cabreo classification. It is situated on the SE shoulder of the Xagħra hillslope and is accessible from the Xagħra-Ramla Bay road. Not only does this area offer easy access, it also presents several potentially relict terrace boundaries, as depicted in the cabreo maps.

Transect B (WSW In-Nuffara Upper Slope – see Figure 3.4 and 3.5)
This transect targets an uncertain region of the cabreo classification, where the inaccuracy of the original cabreo map could not be easily georeferenced to the modern ortho-photos. In spite of this difficulty, some distinctions in the cabreo appeared to relate to potentially relict field boundaries visible today. On this basis, transect B offered the potential to test three cabreo zones – Inferiore, Mediocre and Buona. Access was available to the site via the main approach path on the western side of In-Nuffara, north of the racetrack.

Transect C (SW Xagħra – see Figure 3.6 and 3.7)

The final transect is located over a large area classified as mediocre. Access to the land is relatively difficult when compared with the previous locations. The shortest route involves moving from the plateau edge, west of Santa Verna, downslope along farm tracks. Along this traverse, there are several potentially relict terrace boundaries which would be worthy of examination.

These sites were selected to coincide with logistical support available from the FRAGSUS project which planned to be conducting excavations on the Xagħra plateau.

Adapted Methodology

Initially, the proposal submitted was to be executed in July 2015, in conjunction with the FRAGSUS summer field season. A permit was granted in July, and some limited work took place in the form of radar and laser scanning at Transect A. However, because of other pressures, completion of this work was delayed until October 2015. With the assistance of Ella Samut-Tagliaferro (FRAGSUS Field Officer) and the SCH, this project sought the permission for access from the various landowners and tenant farmers. This process required multiple visits and much detective work to piece together the complex ownership story for each location.

Unfortunately, this endeavour was not completely successful. Requests for access at Transect A were met with a negative response, verging on hostility. The planned work at Transect B, after a highly time-consuming attempt to trace ownership, was abandoned because of time constraints. Thankfully, the ownership of Transect C was easily traced and highly supportive of work taking place in fields adjacent to those planned (referred to as Transect C1, see Figure 3.7). Work proceeded as planned in October 2015, albeit without the planned laser scan (prohibitive transport costs).

Following the adjustment of sites, the field methodology shifted to an exploration of terrace stratigraphy on the Blue Clay slopes. Accordingly, the detailed process was as follows:

1. Site reconnaissance and inspection
2. Excavation of trenches
   a. Machine excavation
   b. Manually cleaning
   c. Recording
i. Field notes
ii. Plan and Section drawings
iii. Digital photography
d. Bulk samples taken at 10cm intervals for geochemical analyses
e. Micromorphology samples (where applicable)
f. Machine backfilling

3. Machine improvement of field infrastructure
   a. Augmented field access route
   b. Removal of unwanted cactus plants – making another terrace viable for future use.

Inherent Limitations

This methodology, being the formative attempt at fieldwork for the thesis, is packaged with some notable drawbacks. Primarily, the geographical limitation of this fieldwork challenges the applicability of these results to the entire archipelago. With the original plans, the number of sites falling under each classification was not broad enough to substantiate a generalised interpretation of the relationship between the cabrei and detectable soil characteristics. Furthermore, the abridged methodology only compounds this issue as the actual number of locations was further constrained. Also connected to this is a lack of sites which fall on geologies other than the Blue Clay, thus negating the opportunity to examine terrace stratigraphy in these conditions. In spite of these, it should be restated that this fieldwork was part of a pilot project that would be adapted to suit following field seasons. In essence, this PhD project needed a formative fieldwork exercise to develop from and conducting excavations was the appropriate route to an initial understanding of the local terrace composition.
Figure 3.1: Proposed Xaghra excavation sites - July 2015.
Figure 3.2: Transect A
Figure 3.3: Maps depicting Transect A upon the original georectified Cabreo image (above) and the derived vector layer (right).
Figure 3.4: Transect B
Figure 3.5: Maps depicting Transect B upon the original georectified Cabreo image (above) and the derived vector layer (right).
Figure 3.6: Transects C and C1
Figure 3.7: Maps depicting Transects C and C1 upon the original georectified Cabreo image (above) and the derived vector layer (right).
3.3 Results

The following section presents the results of the proposed excavations along Transect C1, as described above. After a brief inspection of the Transect C location, a set of four consecutive terraces were confirmed as the location for investigation. In summary, three trenches were excavated to test the structure and interrelationships of the terrace system. Although stratigraphy was very bland, there was sufficient evidence to suggest a construction methodology for different terrace types. The first and third trenches revealed the remains of wall footings, while trench two appeared to examine a terrace which ‘floats’ within the larger system. Small bulk soil samples were taken at 10cm intervals within each trench for intra- and inter-site comparison. This aspect of the study was completed following additional fieldwork in 2017 and is described within the next chapter (Chapter 4). No micromorphological samples were collected because of a lack of stratigraphic complexity, and no evidence of micro-stratigraphy worth examining. Finally, each trench had one elevation drawing and a plan drawing where necessary. Photographs were taken and used to create a structure from motion (SfM) [coloquially and incorrectly referred to as photogrammetry] 3D model, where possible.

3.3.1 Trench 1

Trench 1 revealed the footing of a now destroyed terrace wall; situated just behind the crest of the modern terrace bank. This footing appears to be placed on a cut ‘shelf’ in the Blue Clay geological strata. The stratigraphy, as shown below, was relatively simple to decipher. The top stratum (10-40cm depth) is a loosely structured Ap (plough horizon) SiCL (Silt Clay) with moderate floral remains in the form of root balls and cereal stalks. This layer primarily overlies the compacted SiCL B/C horizon. However, in the proximity of the slope crest, a stony layer lies below the Ap and between the B/C – containing a poorly sorted sub-angular/sub-rounded stones of medium to large sizes. These stones are within a slightly compacted SiCL matrix. Crucially, this layer, interpreted as wall collapse, butts against the footing of a stone wall – falling downslope from the wall in section. Generally, below the B/C lies the parent C horizon; the Miocene Blue Clay. This layer is a highly compacted and well sorted SiCL which was part excavated for the purpose of stratigraphic clarity. Finally, beneath the B/C in the upper part of the trench, a stony layer appears to lie behind the footing of the wall and above the Blue Clay. Directly beneath the collapse layer, it is likely that there is a buried A1 horizon – assuming the wall fell onto a topsoil surface. Since the nature of the soil promotes a shallow Ap, it is likely that a buried A1 would be hard to detect as it would be compact and similar in composition to the B/C.
Figure 3.8 (left): SfM 3D image showing the stratigraphy described above. To aid comparison with the section drawing (below), the dashed red line indicates the surface. The orange shading indicates an area of spoil brought into perspective by the imaging technique.

Figure 3.9 (right): Section drawing depicting the first 4m of Trench 1. The section contained the archaeologically relevant stratigraphy, with the remainder of the trench conforming to the Ap – B/C – C stratigraphy as described.
Figure 3.10: North facing images showing the wall footing, associated stony layer and collapse.

Figure 3.11: South facing image showing the wall footing, associated stony layer (triangle) and collapse (oval).

Figure 3.12: Plan drawing showing the footing of the terrace wall at the northern extent of Trench 1.

Plan showing the North end of Trench 1.
Revealing the footing of terrace wall
Scale 1:20
Drawn by J.M.B.
Drawn on 09/10/2015
3.3.2 Trench 2

This trench tests the relationship between terrace II (beneath Trench 1 [with terrace I located at the start of Trench 1]) and III (within the northern extent of Trench 3). Interestingly, these terraces are separated by a ‘floating bank’ and an associated break of slope. The bank can be described as floating since it does not connect with any other field boundary, lying instead within a larger terrace bench. Based on the initial survey, this bank was either not recorded or was created after the 1861 cabreo.

The stratigraphy matches the same general pattern recorded in Trench 1 i.e. Ap – B/C – C. A thin (20-40cm) Ap horizon is present as loose, poorly sorted SiCL with fine-medium rounded pebbles. This layer covers a more compact B/C horizon (SiCL with fine rounded pebbles). As with Trench 1, the Blue Clay C horizon was partly excavated for stratigraphic clarity. The upper part of the slope is a non-distinct, friable SiCL colluvium, with large stone inclusions. Although some of the largest stones appear to rest within the B/C horizon, this is due to the material similarities between soil horizons and the relative compaction of sediments. In short, the B/C may be an accumulation of layers which are not distinguishable, thus accounting for the large stones with the terrace. Equally so, the same factors may have also influenced the interpretation of the Colluvium and B/C boundary. Finally, it can be noted, perhaps as expected, that the B/C increases in compaction with depth, with pockets of more compact/clay-rich occurring occasionally. As depicted in Figure 3.16, below, there is possible evidence for multiple phases of terrace modelling. Area 1 could be interpreted as representing the basal level of the construction of the first phase of terracing, where area 2 either represented a 2nd effort to model the terrace or a collapse of the first phase. Finally, area 3 may represent another attempt at constructing this terrace. In conjunction, these features represent a gradual shift southward, downslope, all of which are overlain by eroded colluvium as indicated in Figures 3.13/3.14. It is important to note that this field is not present on the cabreo (Figure 3.7), and thus can be interpreted as a late/recent attempt at modifying the slope – with visible and considerable change occurring in the last c.150 years.
Figure 3.13: Trench 2 East facing section showing the relationship between Terrace II/III and the floating bank.

Figure 3.14: East facing section of Trench 2 SfM 3D image showing the relationship between Terrace II/III and the floating bank.
Figure 3.15: Interpretive diagram of Trench 2, highlighting possible phases of terrace modelling.
Figure 3.16: Photograph of east facing section in Trench 2. Stone accumulation is indicated by the red oval.

Figure 3.17: Trench 2 Orthophoto SfM 3D image.
3.3.3 Trench 3

This trench investigated the relationship between terraces III and IV, which appear to be separated by a wall similar to that of Trench 1. The length of this trench enabled the acquisition of two sets of soil samples, one from each terrace. Overall, the stratigraphic sequence follows the same pattern as found with the previous two trenches.

A shallow (c.20cm) Ap horizon overlies a (c.60cm) B/C which overlies the Blue Clay C horizon. Within terrace IV, there is a noticeable dark, humic deposit – likely resulting from recent agricultural activity. The most notable feature, as with Trench 1, is the footing of the terrace wall, present in the middle of the trench. This consists of large, rounded boulders, inter-mixed with smaller stone. This feature appears to be filling a cut in the C horizon.

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*Figure 3.18: Plan and section drawings of Trench 3.*
Figure 3.19: North facing image of the wall footing within Trench 3.

Figure 3.20: South facing photograph of Trench 3 showing the wall footing, in the centre of the image.
3.3.4 Summary of Results

Three trenches, across four terraces revealed a valuable stratigraphic sequence, with multiple features evidencing terrace biographies, despite being devoid of cultural material. This excavation served to outline the sequence one can expect when testing the Blue Clay slopes of Malta and Gozo. Trenches 1 and 3 revealed one potential construction methodology, while Trench 2 has provided an insight to the changing nature of terraces within the past 150 years.

3.4 Collation of ‘Hard Geology’ Terrace studies in Malta.

Following the conclusion of fieldwork in 2015, this project was well informed regarding the agricultural terraces that existed within the regions of ‘soft’, Blue Clay, geology. Ordinarily, the excavation of Blue Clay terraces is uncommon, so this exercise provided a valuable insight which was otherwise unobtainable. However, it left the project lacking insight into the stratigraphy of terraces within hard limestone regions. Although continuing a programme of excavations as part of a subsequent season may have been the expected progression, such an exercise was not necessarily cost effective and a decision was made to shift the data collection methodology – as will be discussed below. However, pragmatic work during the 2016 FRAGSUS season, along with support from colleagues at the SCH has allowed this thesis to incorporate a small body or research relaying the stratigraphy found in a hard geology setting.

3.4.1 Wied Mġarr ix-Xini Project

The Wied Mġarr ix-Xini survey project began in 2005 with the aim of exploring the geomorphological setting for a concentration of wine presses located within the eponymous valley, on South-eastern Gozo. This project extracted a landscape palimpsest, dating between the Phoenician and pre-Roman eras, that included elements of agricultural economy and religious function; the locale was shaped into an agrarian landscape which included routeways, quarrying, fields, structures, irrigation features and harbour construction. The conjunction of 15 wine presses, with crop production areas and transportation links is described as a “microcosm of the broader ancient economy of the Mediterranean world” (Pace and Azzopardi, 2008). Within a deeper consideration of the religious landscape, Azzopardi (2014) draws attention to the complementary economic activities, such as quarrying for dry-stone walling, in areas adjaceted to the Ghar ix-Xih sanctuary. A significant element of rock-cutting included the preparation of terrace beds and the setting of steps and footpaths – affirming a communication route with the Mġarr ix-Xini harbour.
The interpreted history of the site, as shown in Figure 3.21, focuses on the use of a naturally formed cave being appropriated for use as a religious sanctuary. Although manipulation of the rock face occurred through time, the later creation of a terrace is of interest here (indicated by the red arrow). This terrace is attributed to the Late Punic period and serves to delineate the southern part of the site. Azzopardi (2014) suggests that this site saw a height of activity between 100BC and AD100, possibly coinciding with the addition of cut features into the cave wall. Of interest, the stepped nature of this sanctuary is essentially a system of small terraces. The basal clay layers, in the upper levels evidence the preparation of the bedrock surface – a practice which is recorded in relation to the manipulation of the stone surface on agricultural terraces. While the terrace described here may not have been for agricultural purposes, it does provide an insight regarding the stratigraphy of terraces on limestone (see Figure 3.22, below). In this case, the sequence appears to be relatively simple with a matrix supported rubble levelling the terrace to the footing the wall, which is constructed on a bedrock protrusion. The upper layers appear to include elements of terrace wall collapse, though this could conceivably relate to later agricultural practices on site, with the movement of boulders/rock-fall in association with ploughing.

Figure 3.21: Interpretive reconstruction of Ghar ix-Xih site (Courtesy: University of Malta, Department of Classics and Archaeology).
Moving to the wider region of Mġarr ix-Xini, Azzopardi states “their laying out of a terraced shrine replicating and being in harmony with the surrounding naturally terraced terrain, to the extent that the shrine could be viewed as a microcosm of the surrounding landscape” (ibid., 228) – suggesting a level establishment to the surrounding agricultural terraces (see Figure 3.23, below). Curiously, the terraces directly beneath the shrine offer a microcosm for the agro-geological setting for the islands, with the upper fields falling on the Blue Clay, giving way to a few Globigerina terrace benches and ultimately then to Lower Corraline terraces on the lower break of slope. This setting is likely to have taken advantage of the water run-off coming from the levels above the shrine, providing irrigation to the terraces, especially those overlying the Globigerina. The sense of connectivity is developed by the notion of an embedded landscape of production (Pace and Azzopardi, 2008; Azzopardi, 2014), where the presence of vine presses occurs in close proximity to a harbour setting and agricultural ground. Considering sites further along the Mġarr ix-Xini valley, Tal-Logġa and Tal-Knisja both offer further suggestions of the preparation of the hard limestone surface ahead of terracing practices. Azzopardi notes an interpreted connection between wine production and ritual activity at these sites. In particular, excavations at Tal-Knisja revealed sherds from a 6th-5th Century BC drinking cup, found within a rock fissure underlying a terrace – perhaps as a deliberate deposit. The site at Tal-Logġa, exhibited evidence of quarrying prior to its establishment as an agricultural field – with “the oldest surviving stretch of the field’s boundary wall (... datable to the Byzantine period)... extracted from the same place” (ibid.).

In summary, the palimpsest microcosm of the Mġarr ix-Xini valley has revealed ancient and embedded lifeways that encompass religious and economic practices. Of particular interest, this landscape
provides vital clues regarding the nature of terrace construction, from both ritual and secular perspectives. Through the observation of terraced features at a number of sanctuary sites, dating between 700 BC and AD 500, Azzopardi’s thesis, cultivates the sense that the practice of terracing (ritual or agricultural) was embedded in the cultural practices at the time.
Figure 3.23: Possible ancient access (in red) to the Mgarr ix-Xini harbour. Route passes underneath the sanctuary site of Ghar ix-Xih, downslope and across three geologies (after Azzopardi 2014; Google Earth Pro 2019)
3.4.2 Tal-Istabal, Qormi

The site of Tal-Istabal falls within the proposed development of Tal-Bajjad, Qormi – on the island of Malta, near the natural harbour of Marsa. “The site has a number of features of historic importance within it, namely a number of late Roman rock-cut tombs, cart-ruts, part of an ancient wall, the foundations of a mill room dating to the Knights’ Period and an old building with an original coat of arms and two niches on the corners of the facade” (Malta Planning Authority, 2017, 3.7). The site, depicted below (Figure 3.24), consists of three terrace benches and a broad area next to the Knight’s period building/lodge (NE of site). The central mill room was linked, via a narrow-constructed channel, to a substantial underground arched cistern. Overall, this site represents a glimpse at a medieval agri-scape, especially in close conjunction to one of the major natural harbours within the archipelago. For the purposes of this discussion, the removal of soil from these fields has provided an opportunity to observe the construction of terraces on the Globigerina bedrock. Figures 3.25 and 3.26 exemplify the creation of wall footings, with the cutting of a terrace ‘shelf’ upon which the wall is built of stone ‘ashlar’ blocks. This methodology effectively places the foot of the retaining wall on the same plane as the soil it is conserving.
Figure 3.24: Google Earth images showing the site of Tal-Istabal, Qormi. Top-left 2013, Bottom-right 2016.
Figure 3.25: Image showing the construction of a terrace wall with a quarried bedrock footing (image courtesy of Malta Temple Rescue).

Figure 3.26: Image showing the construction of a terrace wall on a prepared limestone surface, including sections of double-skin walling (image courtesy of Malta Temple Rescue).
Figure 3.27: Aerial overview of Tal-Qares site (bordered in red), post-excavation and prior to development
3.4.3 Tal-Qares, Mosta

The site of Tal-Qares, Mosta (depicted in Figure 3.27, above) received a programme of archaeological evaluation between 2010-14, by the Superintendence of Cultural Heritage, prior to the planned excavation of bedrock and subsequent development of the site. Three of the four fields at the site were successfully examined, with a range of archaeological features being reported, including “extensive archaeological remains belonging to an ancient rural settlement” (Cutajar and Spiteri, 2014, 8). The remains described include water management systems, a kiln, domestic ceramics, agricultural vine trenches and quarrying practices – along with rubble walls constructed as a later point when the area was converted into a field. The process of conversion, is most pertinent to this discussion as it provides an indication of bedrock preparation activities (discussed within Chapter 5). As shown in Figure 3.28, below, efforts have been made to level the surface of the bedrock – likely requiring the use of a hard metal spike or a pick to chip away at the stone. The patterns of the striations may indicate some element of the methodology, perhaps with areas being worked in one direction to expose a shallow quarry face which then facilitated the flaking of bedrock chunks in a perpendicular direction. The marks depicted below, appearing to range from c.0.5 – 1.25m, are heavily clustered on what appears to be a relatively uneven area of the outcrop. This close grouping is unlike quarrying practices encountered elsewhere on site, and across the islands – lacking the distinctive well spaced parallel channels used to define the shape of ashlar blocks.

Figure 3.28: Image depicting shallow bedrock cutting to prepare a level surface (image courtesy of Malta Temple Rescue).
3.5 Interpretation of Results

The initial fieldwork approach for this thesis has succeeded in demonstrating the difficulties of manipulating the Blue Clay slopes. The manual archaeological excavation of the trenches would have been insurmountably laborious and a severe risk to personal health and safety. This difficulty is encountered as the silt clay Ap/B and B/C horizons are ultimately derived from the parent C horizon – the eponymous Blue Clay. Incorporating these experiences into an archaeological framework, two possibilities have been inferred: 1.) strong metal tools were required to cut the wall footing and; 2.) a large and coordinated input of labour was required to do this.

In the first instance, the likelihood is that copper and bronze tools were simply too malleable to cut effectively the highly compacted material. On this basis, it is at least the work of iron, if not steel, tools that would have been required. Considering this, any estimation for the onset of the appropriation of Blue Clay slopes should not have fall within in pre-Roman times – since the arrival of metal shod ploughs and mould boards would have been a crucial development (Margaritis and Jones, 2009) that would enable working heavy soils such as the vertisols encountered on these slopes. As a general approximation, such slopes may have first been reshaped from the Knights’ Period, onwards – where there was significant social and political impetus to support such construction. Considering the cabrei maps, there is an element of continuity of landscape morphology depicted between older maps and the set discussed previously (Alberti 2015, pers. comms.) – with locations representing an embedded palimpsest of farming practices (Alberti et al., 2014).

However, the most likely scenario is that the Blue Clay slopes were developed from the 18th Century AD onwards. Landscape studies by the FRAGSUS project (French and Taylor, 2020), incorporating OSL dating methods, indicate that slopes in Gozo’s Ramla Valley have only been cultivated in a meaningful way over recent centuries – with aggressive erosion linked features appearing, resulting from agricultural practice on higher slopes. Secondly, since terracing should be considered as being an all-or-nothing venture it should be derived that a workforce (either small and persistent or large) was involved. Any piecemeal construction of terracing would exacerbate the erodibility of neighbouring unterraced land. This is further reinforced since terracing follows the natural contours of the slopes. Thus, the manipulation of the land follows a form which cannot be deviated from without environmental consequences.

With these factors in mind, the Blue Clay terraces will have formed in two possible ways: 1.) walls were built and downslope colluviation created terrace benches or 2.) a considerable phase of clay cutting and dumping created the terrace system. The former possibility is unlikely as the Blue Clay is extremely cohesive, moisture retentive and relatively slow to erode; comparison between modern ortho-imagery and the cabrei (verified by excavation results) has shown a movement of only c.1.5m since 1861.
(terminus ante quem). Considering the stratigraphic information revealed in this chapter, especially the shallow ploughsoil and the highly compacted B/C layer, it is reasonable to assume that the creation of these Blue Clay terraces involved processes of cutting and dumping of the Blue Clay.

In effect, the terraced landscape may have been carved from the Miocene geology. Ongoing research by French and Taylor (FRAGSUS project) has included several phases of auger surveying within the Blue Clay geological region of Gozo. Their work largely confirms the hypothesis that the B/C represents a redeposition of the Blue Clay – which becomes structurally different as a product of this process. The absence of buried plough horizons contributed to this. Regardless of how the B/C was formed, there is no evidence of soil formation that would otherwise suggest the passage of time as the terraces are built up.

Returning focus to Trench 2, this chapter’s excavation provided an indication of terrace functionality and change. The discovery of the ‘floating bank’ suggests that this field does not follow the characteristics found in other walled terraces. The presence of a stony accumulation beneath the bank, coupled with the lack of wall footing, indicates that this terrace may have been created through the continued use of the larger ‘bounded’ field within which it floats. Considering the topography and size of the ‘parent’ field, it is likely that this bank first arose as an accumulation of large stones and rocky material pulled up through ploughing. It is assumed that the pre-mechanised ploughing technique utilised a U-shaped tread pattern, for efficiency and for ease of slope navigation. For this reason, any unwanted material that was ploughed up would be brought to either side of the field (i.e. the upper or lower terrace walls) on the external plough traverses. However, with internal traverses, this material would accumulate in the centre of the field. Such a process, along with subsequent tillage, would account for the accumulation of variously sized stones under this bank. Through time, these deposits would aggregate into a bank since the process of ploughing would take place around the accumulation of stones.

Considering the nature of terraces constructed on limestone bedrock, it is logical to conclude that among these, some of the earliest terraces on the islands may be found. Evidence from the Mgarr ix-Xini project indicates the construction of agricultural terraces from c. 500 BC – with terraced sanctuary sites pre-existing in cultural knowledge (Azzopardi, 2014). Given the dearth of hard metal tools within the Bronze Age, and when only copper tools are evident locally, it can be surmised that tools suitable for the specific manipulation of bedrock would be available only from the Phoenician period onwards – this would also fit with the onset of sanctuary construction. Supporting this, the FRAGSUS project (French and Taylor, 2020) has noted the movement of xeric and calcitic soils, suggesting disruption of bare slopes and the likely construction of terraces soils from the mid 2nd – 1st Millenium BC. The expansion of terraces into the barren xaghri land, usually in Coralline regions, is known to have taken
place in the 19th and 20th Century and, although incentivised, these attempts were largely unsuccessful (Bugeja, 2018). The combination of these insights would suggest that Globigerina regions were likely seen as optimal for the construction of agricultural terraces – given the relative ease of manipulation of the bedrock. While quarrying practices are exceptionally ancient in the islands, much of the Coralline limestone quarrying may have been opportunistic – taking advantage of the naturally fissured friable properties of the stone. In contrast, the Globigerina has been consistently used for its aesthetic properties. Linking this to the terraces, it is plausible that the fine detail preparations required to level a Coralline bedrock surface – such as exemplified at Tal-Qares - would have been less desirable than such efforts with Globigerina. A final extrapolation of factors can be made with regard to the geological division between the Upper Coralline and the Blue Clay. Here the erosion of the encrusted cliff edge forms a natural shelf on the upper levels of the Blue Clay. Although a thin stratum of Greensand is present between these two geological layers, it is highly erodable and would quickly disappear. In effect, this process creates a natural terrace morphology, supplied with water infiltrating through the Upper Coralline with exfiltration onto the Blue Clay surface via the Greensand.

3.5.1 Timeline of Agricultural Terrace Development for the Maltese Archipelago

Based on the interpretations above, a model for terrace proliferation on the islands can be proposed (see Table 3.2, below). This model builds upon the established background knowledge presented in Table 3.1. The major caveat to this model is the lack of absolute chronological data available. Although the earliest and latest elements can be proposed with some certainty, there is much uncertainty within phases II – IV. Despite recorded population increase through the Middle Ages, the nature of agricultural intensification is uncertain. Cultural trends, discussed in Chapter 5, suggest that a direct correlation between subsistence requirements and landscape utilisation did not exist. So, in summary, a predictable scalar increase of agricultural land, and terraces, is unlikely to relate accurately to the agrarian story of the Maltese Archipelago.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Period</th>
<th>Description</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Early – Mid-Holocene</td>
<td>Formation of Blue Clay ‘shelf’</td>
<td>Erosion of Upper Coralline stratum produces a shelf-like feature on the underlying Blue Clay. This is a natural terrace-like feature.</td>
</tr>
<tr>
<td>II</td>
<td>Late Neolithic – Iron Age</td>
<td>Early terraced features</td>
<td>Terrace-type soils present at Ġgantija (French et al., 2018) and terraced (non-agricultural) features at Mgarr ix-Xini (Azzopardi, 2014).</td>
</tr>
<tr>
<td>III</td>
<td>Classical</td>
<td>Viticulture Landscape</td>
<td>Adoption of natural locations (Stage I) and use of outcrop edges (Azzopardi, 2014). Ubiquitous cultural manipulation of Coralline and Globigerina is well established. Establishment of olive growing and oil press sites from before the 1st Century BC (Anastasi and Vella, 2018).</td>
</tr>
<tr>
<td>IV</td>
<td>Classical – Medieval</td>
<td>Expansion of agricultural terraces on ‘hard’ geology</td>
<td>Expansion of landscape to support pressures of increasing population through time (see Chapter 5).</td>
</tr>
<tr>
<td>V</td>
<td>Early Modern</td>
<td>Appropriation of marginal land</td>
<td>Constraints on erosion in Blue Clay valleys (French and Taylor, 2020) and historical incentivisation for cultivation of barren garrigue land (Maltese: xagħri) (Bugeja, 2018).</td>
</tr>
<tr>
<td>VI</td>
<td>19th/20th Centuries</td>
<td>Abandonment of unsuccessful terraces</td>
<td>Present day mix of utilised and vacant terraces, visible across the archipelago.</td>
</tr>
</tbody>
</table>

Table 3.2: A chronological model for the establishment and proliferation of agricultural terraces across the Maltese Archipelago.
3.6 Methodological Direction

Although the fieldwork carried out succeeded in providing an overview of Coralline and Blue Clay terrace construction and stratigraphy, the methods applied were ultimately not sufficient to provide an effective commentary on the role of terraces across the islands. Accordingly, a methodological shift must occur in the future, to enable the acquisition of data in an efficient and cost-effective manner. Furthermore, the issue of chronological framework must be addressed.

3.6.1 New Methodology

To acquire a meaningful dataset, the current fieldwork has emphasised the difficulties of excavating agricultural terraces to elucidate the structure and function of the fields, and their relationship with the geology. This chapter has served to provide a broad overview of the likely morphological traits that would be found with test-pit survey work. To be efficient with time and money, this project needs to advance to a less invasive and more rapid form of data collection. This methodology, explained in detail in Chapter 4, employs the use of soil augering to collect a profile of sediment samples. Through the propulsion of soil to the surface after the fashion of an Archimedes screw (Rapp and Hill, 2006), a soil auger enables a rapid investigation of stratigraphy. While some compaction of samples may occur, the portability of kit is perfect for lone fieldwork in open terrain. To suit this new direction, the following chapter will establish a specific research direction which will maximise the value of this new methodology.

3.6.2 Chronological Ideal

Unfortunately, neither the fieldwork described in this chapter, nor the new methodology just described can offer any definitive analysis of terrace chronology. As discussed in Section 2.3.3, absolute chronological methods are vital to outline the onset and development of agricultural terracing. Following the excavation of Blue Clay terraces, there is little evidence of any pertinent stratigraphy which would provide organic material worthy of radiocarbon dating. Furthermore, considering the understanding of Limestone terrace construction, there are obvious issues with the chronology of construction phases (Section 3.5), raising the conceptual query of what is defined as the point at which a terrace is established. Even with the hypothetical presence of stratigraphically secure datable material, this question remains central to the understanding of an individual terrace’s chronology. Finally, the natural biography of a terrace essentially devalues a single date for a field – reducing the long-term story of the field and landscape to a single point in time; ignorant of wider landscape ecology. The application of OSL dating, particularly including relative luminescence chronology, would provide precise dates that were not reliant on the presence of cultural material; the accumulation and burial of sediments would be the factor under investigation. Considering the long-term nature of
colluviation, it is apt to incorporate a method which quantifies the process of accumulation in conjunction with ‘fixed-point’ samples for absolute chronology.

Reflecting on this, the ideal chronological methodology should combine the targeted accuracy of OSL with relative luminescence sequencing - contributing to a ‘gold standard’ dating method for agricultural terraces. To enrich this method, such a project would involve a two-phase strategy. Following the selection of an appropriate location, a transect of test-pits would be excavated along a terraced slope – the specific number would be related to the overall slope length. Within each test-pit, a relative luminescence sequence would be established, utilising a portable luminescence reader. Based on the availability of quartz and feldspar, OSL sample tubes would be collected – ideally targeting the interpreted basal layer of the terrace deposits. In conjunction with this approach, a valley bottom test-pit exercise would be carried out. This would enable an assessment of the fluctuation in sedimentation processes within the valley sequence. It is hypothesised that onset of terracing would create a detectable change in the stratigraphy within the valley floor. By employing the same methods within this trench, a comparison between the terrace specific pits could be made. The success of this method would not only lie with the dating of terraces and more generalised valley sedimentation, but also as the method would be inter-validating as the comparison of results would establish the viability of the valley test-pit approach. If this valley sediment method repeatedly demonstrates effectiveness as a chronological proxy for the onset of terracing practices, then it would be recommended that the direct terrace test-pitting avoided for subsequent investigations.

3.7 Conclusion

This chapter opened with the intent of creating and testing a viable methodology for the investigation of agricultural terrace stratigraphy, as a means of elucidating the complex geomorphic and social processes associated with the practice. Specifically, this chapter sought to establish the persistence of terraced landscapes in the Maltese archipelago, since the 19th Century, alongside which an examination of the relatedness between soil properties and historically assessed land quality was to be conducted. While the work carried out was both successful and essential to this thesis, the central line of enquiry has not been met; instead, a realignment of methodology has now been generated to continue this investigation.

Only one of three proposed transects was investigated, due to the complex ownership and access issues that have arisen from the Maltese diaspora outside the islands. Although this limited the possible range of findings from this fieldwork, it did not prevent the development of important interpretations. The excavation of three trenches, within fields marked on a cabreo map, demonstrated the stratigraphy and morphology of Blue Clay terraces. In summary, the stratigraphy encountered displayed some evidence of construction, collapse and weather processes, with no
evidence of cultural layering. There has been a small, downslope, ‘creep’ in the location of the terrace boundary, due to erosion; and the creation of a ‘floating’ terrace wall was noted, resulting from agricultural practices. Within a single transect, it has been shown that there are demonstrable indicators of both persistence and change, since the 19th Century. However, more excavation would be required to make a statement applicable generally.

The initial fieldwork was unable to conduct excavations on limestone terraces because of the constraining factors encountered. Therefore, this chapter has brought together limited evidence from external projects that have encountered terracing – either agricultural or ritually linked. These hard geology terraces have been shown to require a significant element of bedrock preparation – wall footings and details bed preparations – prior to use. There is uncertainty regarding the long-term viability of terraces on Coralline bedrock; however, the more workable Globigerina seems to provide more long-term viability of fields. To progress this thesis, it has been proposed that fieldwork should continue using an auger sampling strategy – continuing to extract soil samples from terraced transects mapped within the cabrei. As detailed in the following chapter, this methodology facilitated further stratigraphic analyses alongside a geochemical examination of terrace function, particularly focussing on the assessed land quality from the cabrei.
4 THE GEOARCHAEOLOGY OF AGRICULTURAL TERRACES IN THE MALTESE ARCHIPELAGO

4.1 Introduction

Agricultural terraces represent an intricate fusion of natural processes and human cultural engineering. Their existence may well echo the human actions that, over millennia, have brought about the Anthropocene Epoch. Fundamentally, agricultural terraces epitomise a human dissatisfaction with an environment – indicating a need to reshape the natural state of the geomorphology. They are a physical statement that direct change is required for desired functionality, as opposed to arising from by-product change which occurs through long term cultural patterns. In a sense, a terraced environment is an “anthroscape - an environmental aesthetic which is dominated by the infrastructural effects of contemporary human ecology” (Bennett, 2015).

Although terraces are formed by human action, their existence is still subject to the natural environmental processes expected for their location. This presents an opportunity to explore the ecological value of agricultural terraces. In effect, it is conceivable to develop a scientific phenomenology of terracing – rooted in the understanding of terrace function in relation to soils. Therefore, this study aims to establish a measure of ecological value for agricultural terraces, at a variety of scales, using geochemical analysis (soil pH, electrical conductivity, magnetic susceptibility, multi-element analysis and loss-on-ignition, X-ray diffraction) as a factual basis. The use of these methods has allowed a quantifiable overview of each terrace’s pedological state. Through downslope inter-comparison, it has been possible to understand terrace functionality; and through inter-regional comparison, geological comparisons can have been made. Ultimately, the broad-scale understanding has informed a measure of individual terrace quality.

Overall, the following chapter will lay the basis for this approach, through the analysis of over 350 soil samples from different geological regions in the Maltese Archipelago. Through the observation of previously published methods, this chapter will outline a holistic method required to understand the ecological value of a terraces at different scales. Finally, the statistical analysis of this data will lay the foundation for extracting the story of terrace viability in the Maltese islands.

The central questions to this chapter, an extrapolation of the wider thesis, are as follows:

I. Do detectable geoarchaeological factors relate to the reported cadastral land quality assessments (discussed in Chapter 3)?
II. Does a logistical regression model (Alberti et al., 2018), which claims to predict agricultural viability, relate to measurable soil composition and nutrient content?

III. How well does the regression model relate to the land value assessments that form a constituent variable?

4.2 Methods

Reflecting on Section 2.4, and the findings from Chapter 3, there is a notable gap in the research narrative and a sense of the appropriate methodology to address this has arisen. The next section will outline a novel investigative approach the geoarchaeology of agricultural terraces, applicable to the Maltese archipelago and beyond. By adapting the methods utilised in the previous chapter, the following methodology will facilitate a spatially diverse, minimally invasive investigation of terrace stratigraphy and geochemistry – in conjunction with the re-established understanding of cultural factors i.e. Cabrei cadastral maps.

4.2.1 Site Selection

This section will detail the justification for specific sites selected and tested, as approved by the SCH. Overview maps (see Figures 4.1 – 4.4) depict the spread of these sites across the archipelago and present them in relation to aerial, Cabreo and logistical regression model data (see Section 2.4.4). Appendix 1 contains a compendium of site-specific maps and sample imagery which this section will refer to (appendix figures carry the prefix “A.x” – this section will direct to these specifically). Specific site details will also be presented in Section 4.3.1, followed by the results of sampling. This will include spatial and geospatially derived information pertinent to the investigation.
Figure 4.1: Map displaying the locations sampled within this chapter with aerial imagery and Cabreo classification vector layer.
Figure 4.2: Map displaying the locations sampled within this chapter, with a hillshade DTM and Logistical Regression Model overlay.
Figure 4.3: Map displaying the Malta locations sampled within this chapter, with aerial imagery and Cabreo classification vector layer.
Figure 4.4: Map displaying the Malta locations sampled within this chapter, with a hillshade DTM and Logistical Regression Model overlay.
Transect C

This site was investigated within the previous chapter and was sampled in a manner compatible with this chapter’s subsequent methodology. This transect is located over a large area classified as mediocre along which there are several potentially relict terrace boundaries which would be worthy of examination. See Section 3.2.3 (Figures 3.6 and 3.7) and Appendix 1 (Figures A.70 -71).

Buskett Gardens/In-Nuffara/Is-Sruġ/Mellieħa/Mġarr/Santa Lucija/ Żebbuġ

Selected for the high variability in Cabrei classification zones. Each zone represents an opportunity to study differing arrangements of classification zones as well as collectively ensuring that the complete gamut of classifications is sampled. Other notable factors are outlined below:

- **Buskett Gardens** – an aerial image inspection indicated a greater surface cover of trees and shrubbery. This provided an unusual form of vegetation cover which could be isolated as a variable relating to terrace function. Sample locations were spread across multiple Cabreo and LR model values. See Figures A.1-2.

- **In-Nuffara** – this transect targeted an uncertain region of the cabreo classification, where the inaccuracy of the original cabreo could not be easily georeferenced to the modern orthophotos. Regardless of this, certain distinctions in the cabreo appeared to relate to potentially relict field boundaries still visible today. On this basis, this site (formerly Transect B from Chapter 3) offered the potential to test three Cabreo classifications – Inferiore, Mediocre and Buona. Furthermore, the final two fields under investigation could act as a control since they do not directly fall under a cabreo polygon but can be assumed to relate to buona class fields. These locations have a LR model score between 0.2 and 0.4, which contrasts with the variety of cabreo classifications. See Section 3.2.3 (Figures 3.4 and 3.5) and Appendix 1 (Figures A.6-7).

- **Is-Sruġ** – selected for a mixture of cabreo classes which contrast with their associated LR model values (0.4-0.8). See Figures A.14-15.

- **Mellieħa** – allowed sampling of the Infima classification, with LR model values between 0 and 0.2). See Figures A.37-8.

- **Mġarr** – provided the opportunity to sample coastal terraces on a hard geology, with cabreo classifications of mediocre and cattiva. LR model values here, in contrast with the cabreo, are relatively high – between 0.6 and 0.8. See Figures A.24-5.
• Žebbuġ – presented a gamut of cabreo classifications which overly a transition between Blue Clay and Globigerina geologies. LR model values range between 0.2 and 0.6, in a manner with contrasts with the cabreo range. See Figures A.72-3

• Il-Ġebel tal-Mistra – inspection of aerial imagery indicated this location has are relatively high level of argi/horticultural activity, with an unusual set of field boundaries being visible also. The developed system of field walls and irrigation channels merited investigation regarding agricultural intensification and its effect on soil development. Furthermore, this location acts as another control location for the project, since the fields under examination, although enclosed by walls, are not terraced. See Figures A.31-2.

Tal-Merħla

Selected as it falls under an area of high agricultural viability (0.8-1 LR model scores). This location has no associated cabreo information and will act as a control for the model and for this project’s sampling. The site was also selected for ease of access. See Figure A.50-1.

4.2.2 Field Methods

Within each proposed location, a transect was selected, based on availability of access and current field usage. Along this transect, each terrace received one bore hole, usually at the mid-point of the terrace bench. The locations were recorded with a handheld GPS for accurate (±3m) capture of the sampling location (WGS1984). The intention was to sample using the auger head as the means of collecting a 10cm depth of sample. This continued until the bed rock was reached, or an insurmountably deep stratum was found. Each sample was then arrayed in order and photographed (presented in Appendix 1). The soil was then collected and split into 10cm intervals, maintaining the sampling resolution from previous fieldwork. Samples were appropriately sealed and labelled, in anticipation of return shipment to the UK. The borehole was then backfilled with material, such as pebbles and topsoil, from the field surface.

4.2.3 Laboratory Methods

Upon return to the Charles McBurney Geoarchaeology Laboratory, Cambridge, the collected soil was sub-sampled and examined using a suite of geochemical tests which took place in the School of Natural and Built Environments, Queen’s University Belfast. The completion of these tests facilitates an understanding of how agricultural terraces influence the function of soils and their subsequent analyses is framed within a discourse related to the social nature of the cabreo classifications. The following section outlines the individual methods used and the lab process that was used.
**pH**

The scale of pH relates to the measure of concentration of hydrogen ions in a solution, on a logarithmic scale of 0-14. In simple terms, solutions of 0-6 are acidic, 6-7 is neutral, and 7-14 are alkaline. In relation to soils, pH is influenced by the relative concentrations of CO₂ within soil air, the concentrations of salts and colloidal particles (Bolan and Kandaswamy, 2005). Higher concentrations of CO₂ equate to lower pH, specifically in proportion to the logarithmic value of the partial pressure of CO₂. Linked to this, the relative concentrations of salts influence the diffusion gradient of anions and cations; along with the presence of colloids which determine relative diffusion rates of K⁺ and Cl⁻. In sum, soil pH is directly responsible for the ionic form, mobility, solubility and concentration of micronutrients, and their resulting uptake by vegetation (Fageria et al., 2002). Within archaeology, the understanding of soil pH can elucidate facts regarding the biography of a stratum. The acidification of soil can be a result of several process including: deposition of acids and acid-forming substances, use of nitrogen fertilisers, nitrogen fixation, leaching of cations, and increased depositions of organic matter (Wild, 2003). Such causes can be directly linked to human activity, such as the spread of ash, plant matter and manuring (French, 2015).

Bolan and Kandaswamy (2005) note that plants can thrive in more alkaline conditions – where nutrient uptake would be hampered normally – when they have a concentration of CO₂ in close proximity to their roots, as is normally the case with low porosity soils such as clays and organic-rich pasture soils. This is of value when considering the geological and pedological status of the Maltese Archipelago, as discussed in Chapter 2.

**Magnetic Susceptibility**

In general terms, the magnetic susceptibility of a material is determined by its propensity for acquiring magnetism from an external source. Within soils, this factor is governed by the relative quantities of magnetic minerals present within a sediment. The minerals with the greatest influence on susceptibility readings are haematite (α-Fe₂O₃), maghaemite (γ-Fe₂O₃) and magnetite (Fe₃O₄) (Rapp and Hill, 2006). Processes of interest to archaeologists which influence the magnetic susceptibility include: the presence of maghaemite from biological action involving the alternation of oxidation and reduction conditions, and episodes of burning which alter ferric minerals – particularly reducing haematite to magnetite (Goldberg and Macphail, 2006).

**Particle Size Analysis**

Acting as a controlled and quantitative complement/alternative to field-based soil texture analysis, particle size analysis provides a precise spectrum of grain sizes present in a sample (Ayala et al., 2015). The granular nature of sediment exists as a “continuum, from fine (clay, generally <2µm) through
granules (gravel and stones), coarse cobbles and boulders.” (Goldberg and Macphail, 2006, 336). Laboratory practice can involve the use of graded analytical sieves, usually employed for the coarse end of the spectrum. Alternatively, automated systems, such as the Malvern Mastersizer, can be used to outline the detailed quantities of soil fractions. Utilising these methods, the relative proportions of particle size in a sample can be accurately attributed to a texture class, related to geological, geomorphological and depositional factors. This core geoarchaeological technique is therefore beneficial for examining aspects of sedimentation and pedogenic processes – with factors such as sediment sorting and clay translocation of central importance to this thesis.

**Loss-on-Ignition**

Loss-on-Ignition is the primary laboratory method used for determining the quantity of organic matter present within soils (SOM). The central principle of the method is the high-temperature firing of samples to carbonise the organic matter present; where the weight difference between input and output represents the quantity of organic matter (Ayala et al., 2015). For sediments with over 10% organic matter, the results of LOI are accurate to 1-2% for organic matter and carbonate. Sediments which are either clay- or diatom-rich, the effect of water of hydration – which is lost during the carbonate burn (1000°C) - result in errors of up to 5% analyses of carbonates and/or a “false positive” reading of carbonate content within carbonate-free sediments.

**Ion Chromatography**

This method, falling within the designation of liquid chromatography, is utilised to determine the relative proportions of ionic solutes within a solution, such as anions, cations, low-molecular-weight organic acids and bases, and transition metals (Jackson, 2000). The primary method of determination is Ion-exchange where ions and polar molecules are separated based on their affinity with an ion exchange module. This thesis is reliant on the principles of anion (negatively charged ions) and cation exchange (positively charged ions) – where a sample’s ionic interaction with an exchange resin (which holds the opposite charge to the target ions). Samples are passed through exchange columns and are absorbed by the resin, following which eluent (ion extraction fluid) is passed through the column. The measured ion retention times determine the concentrations of ions within the sample (Tabatabai and Frankenberger, 1996; Tabatabai et al., 2004). The aqueous extraction of samples is reliant on the high solubility of ions, facilitating their removal from solid samples and ensuring the limited addition of extraneous peaks to the final chromatograms (Jackson, 2000). Table 4.4, below, summarises the ions relevant to this technique and which can be used as an indication of soil fertility within samples.
**X-ray Diffraction**

X-ray Diffraction (XRD), an advance in the method of optical mineralogy, enables a consistent differentiation between crystalline minerals within a sample and, with varied data collection, the crystalline structure, atomic distances and elemental substitutions can be obtained (Weiner, 2010). Powdered samples are targeted by x-ray beams, projected at various angles, and the diffracted beams are subsequently measured which, via comparison of interference effect, that allows the measurement of the space between crystalline planes which represent specific atomic lattices (Garrison, 2014). The diffraction measurements of powders allow the measurement of shared space between planes, and these are recorded as an intensity profile based on the angle of diffraction. Peaks, referred to as Bragg’s peaks – after Bragg’s law – correspond to the specific atomic planes available with a phase and their position and their intensity facilitates mineral identification and quantification (Artioli, 2017). The combined patterns of diffraction from unknown samples can be analysed comparatively with databases, such as from the International Centre for Diffraction Data (ICDD) or the Crystallography Open Database (COD) (Berthold and Mentzer, 2017).

This method is applied to provide a greater level of soil characterisation, in addition to the methods provided above. Wilson (1999) reports the value of a quantitative overview of soil clay mineralogy as vital to the understanding of pedogenesis. Although there is some suggestion that a quantitative analysis can be highly variable, only viable as an estimate (Kahle et al., 2002), it is nevertheless a useful means of creating a geochemical identity for each sample – providing an extra discriminatory factor of analysis within this chapter.

**Laboratory Strategy**

I. Selection of sub-samples, based on the represented soil horizons
II. Samples dried – 48hrs at 40°C
III. Samples ground with mortar and pestle, sieved at 1mm fraction

<table>
<thead>
<tr>
<th>Cations</th>
<th>Anions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺ (Sodium)</td>
<td>F⁻ (Flourine)</td>
</tr>
<tr>
<td>NH₄⁺ (Ammonium)</td>
<td>H₂PO₄⁻ (Dihydrogen Phosphate)</td>
</tr>
<tr>
<td>K⁺ (Potassium)</td>
<td>NO₂⁻, (Nitrogen dioxide)</td>
</tr>
<tr>
<td>Mg²⁺ (Magnesium)</td>
<td>Cl⁻ (Chloride)</td>
</tr>
<tr>
<td>Ca²⁺ (Calcium)</td>
<td>Br⁻ (Bromide)</td>
</tr>
<tr>
<td></td>
<td>NO₃⁻, (Nitrate)</td>
</tr>
<tr>
<td></td>
<td>SO₄²⁻ (Sulphate)</td>
</tr>
</tbody>
</table>

Table 4.1: Summary of detectable ions available through aqueous extraction, after Amin et al. (2008)
IV. 20g of 1mm subsample extracted for geochemical use

V. Particle Size Analyses (automatically using a Malvern Mastersizer)

VI. Magnetic Susceptibility (Bartington MS2 and MS2B sensor used)
   a. Standardised sample container filled (38.93cm³)
   b. Measurement taken; sample returned to sample bag
   c. Results adjusted by the calculated thermic drift

VII. Loss-on-Ignition
   a. An unspecified amount was added to a crucible of known weight
   b. Samples placed in oven for 24hrs at 400°C
   c. Samples reweighed and crucible weight subtracted.
   d. Fired sample discarded

VIII. Ion Chromatography (Dionex ICS2000)
   a. 5g of sample is diluted in 25ml of distilled water
   b. Solution agitated in an orbital shaker at 200rpm for 30mins
   c. Solution fractionated in centrifuge at 2800 rpm for 3min
   d. Liquid fraction filtered (2μm) and bottled
   e. Samples run through simultaneous anion and cation exchange.

IX. pH (Thermo Scientific Orion Star A215 pH/conductivity meter)
   a. pH meter calibrated using pH 4.00/7.00/10.01 buffer solutions
   b. Measurement taken during preparation of chromatography samples prior to stage VIII.c.

X. X-Ray Diffraction (Phillips PANalytical X’Pert Pro (XRDS))
   a. Samples ground and sieved to produce a <1mm powder
   b. Sample compressed into XRD sample holders
   c. Samples loaded into XRD
   d. Run time of 5 mins per sample (190 samples x 5min = 15hrs 50mins)

4.2.4 Presentation of Results

The results will be presented in the following section (4.4) of this chapter. This will begin with the presentation of site information, drawn from a GIS database compiled to support this thesis, utilising data acquired from the FRAGSUS project and material collected independently. Following this, a breakdown of results will be presented, including descriptive statistics for each geoarchaeological factor and a site-by-site overview of results. The complete body of raw Geoarchaeological and geochemical results will be presented in Appendix 2, following the sample location maps and site photos. Finally, the results will be analysed in Section 4.4.
4.3 Results

This section will formally present the results of geochemical analyses of sampled soils. Section 4.3.1. will summarise the sites, outlined in Table 4.2 below, alongside pertinent geospatial information. Section 4.3.2. describes the geoarchaeological results through their descriptive statistics, as a means of presenting contextual observations for the whole dataset.

<table>
<thead>
<tr>
<th>Site Code</th>
<th>Location Name</th>
<th>Sample Photos (Appendix 1)</th>
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</thead>
<tbody>
<tr>
<td>BS</td>
<td>Buskett Gardens, Malta</td>
<td>A.3-5</td>
</tr>
<tr>
<td>IN</td>
<td>In-Nuffara, Gozo</td>
<td>A.8-13</td>
</tr>
<tr>
<td>IS</td>
<td>Is-Sruġ, Gozo (nr. Xagħra)</td>
<td>A.16-23</td>
</tr>
<tr>
<td>MG</td>
<td>Mġarr, Gozo (nr. Xatt l-Ahmar)</td>
<td>A.26-30</td>
</tr>
<tr>
<td>MIS</td>
<td>Il-Ġebel tal-Mistra, Gozo (nr. Daħlet Qorrot Bay)</td>
<td>A.33-36</td>
</tr>
<tr>
<td>ML</td>
<td>Mellieħa, Malta (nr. Imbordin)</td>
<td>A.39-49</td>
</tr>
<tr>
<td>MR</td>
<td>Tal-Merħla, Malta (nr. Il-Baħrija, Rabat)</td>
<td>A.52-55</td>
</tr>
<tr>
<td>SL</td>
<td>Santa Lucija, Gozo (nr. Ghajn Abdul)</td>
<td>A.58-69</td>
</tr>
<tr>
<td>TRA.C (Transect C)</td>
<td>Slopes of Xagħra, Gozo</td>
<td>No images</td>
</tr>
<tr>
<td>ZB</td>
<td>Żebbuġ, Gozo (nr. Sagħtrija)</td>
<td>A.74-80</td>
</tr>
</tbody>
</table>

Table 4.2: A translation of site codes to their respective location names.

4.3.1 Site Information

This section presents the accumulated information (Table 4.3, below) pertaining to each sampling location and its environmental setting. Additional factors include the land value classification, drawn from the Cabrei and the derived measure of agricultural viability as presented by Alberti et al. (Alberti et al., 2018). This information should be related to the images and data presented in Appendices 1 and 2.
<table>
<thead>
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<th>Site ID</th>
<th>JB#</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation (m)</th>
<th>Geology</th>
<th>Soil Type</th>
<th>Cabreo Classification</th>
<th>Regression Model Value</th>
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<td>1-4</td>
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<td>14.2553</td>
<td>107.47</td>
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<td>0.779292881</td>
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<td>MG1</td>
<td>13-15</td>
<td>36.0193</td>
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<td>24.08</td>
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<td>36.058067</td>
<td>14.30733</td>
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<td>14.27225</td>
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<td>Carbonate Raw Soil - Fiddien series</td>
<td>control/ buona</td>
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<td>58-60</td>
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Table 4.3: Summary of geospatial factors relating to samples.

* SL10-13 are reversed in Table 6 due to methodological peculiarities.
4.3.2 Description of Results

This section will describe the results presented in Appendix 2 from two approaches. Firstly, each analytical factor will be described, based on their descriptive statistics, noting specific trends and visible outliers. Secondly, a similar exercise will be completed for on a site-by-site basis, enabling a broad understanding of the geoarchaeological processes pertaining to each site. Although both descriptive approaches draw from the same raw data, the differing perspectives facilitate a better understanding of sites and their social and geomorphological influences.

4.3.2.1 Factor Based Results

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<th>Nitrate ppm</th>
<th>Phosphate ppm</th>
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<td>423.00</td>
<td>35.88</td>
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Table 4.4: Summary statistics for geoarchaeological results. #N/A indicates that all values in this category are unique.

Particle Size

Particle size analysis, as a compositional measure, will not be described in this section as this dataset is most relevant to site-based descriptions.

pH

Across the 190 samples analysed, all samples were measured as alkaline. The lowest recorded pH was 7.96, with the highest 9.51 – a range of 1.55. The samples are well constrained with a low standard deviation. Little variation existed between the averages of results within 0.1 of difference from the mean of pH 8.7.

Magnetic Susceptibility

The large standard deviation and range indicates outlier results influencing the dataset, supported by the difference between mean and median/mode statistics. Considering this, the median and modal values may be a better indicator of average, than the mean, especially since 13 samples (6%) have values greater than 1000. The highest recorded value was 1718.45 and the lowest was 20.11 –
representing a spread of weak to strongly magnetic results. Overall, a high degree of sample variability was found within the magnetic susceptibility results.

Loss-on-Ignition
Acting as a proxy for organic content, these data comprised both organic and carbonate content. With a value range of 43.84, the minimum recorded value is 1.22 and the upper limit is 45.06. It should be noted that this upper value is the result of a single outlier, found in sample JB#69. Adjusting the descriptive statistics to compensate for this provides a new upper limit of 14.86 and a range of 13.64. The mean and median, which differed by only 0.21, show the outlier is statistically non-influential. The sample variability with these results is relatively minimal.

Chloride
The Chloride results display a range of 2698.24, with the lowest value recorded as 0. The occurrence of 0 values could be more accurately described as being beneath the detection limits of the method. This value is also modal, owing to this methodological limitation. The highest values, JB#s 23 and 25 - 2698.24 and 1995.71 respectively – are outliers. However, these are close to other relatively high values and thus merit discussion later. Excluding the two higher values and the modal results, the mean is 191.14 and the median is 83.03 (against 206.79 and 79.93). Since the results are in parts per million, this represents little relative difference and the unadjusted results can be accepted. Furthermore, the Chloride data shows a high level of sample variability.

Nitrate
A modal value of 0.00 indicated several results (8) which were beneath the methodological detection limits. Correcting for this, the lowest recorded value was 1.64, with a range of 421.30 between this value and the upper result of 423.00. The variability between the median and modal values suggests that the larger values are influencing the mean average – JB#s 140,173,28 showed Nitrate results of 423.00, 376.95 and 324.75 respectively. Once again, these results display a high level of sample variability.

Phosphate
The Phosphate results contain an exceptionally high number of sub-detection limit values, with only 14 of 190 samples with recorded values. Of the detected values, several are from proximal sample numbers, suggesting a spatial influence. This will be elaborated upon in the next section. Adjusting for the undetected values, the minimum result was 2.48 and the maximum as 35.88 – with a range 33.40.

Sulphate
The variability between the mean and median again indicates the influence of large values on the overall results. Specifically, 5 values have results ranging from 1517.86 (974.75 greater than the next
lowest value) and 7233.05. Furthermore, 8 samples were beneath the detection limit. Adjusting for the combined effect of these results, the minimum value record was 1.17 and the largest was 543.11 – producing a range of 541.94. The adjusted mean is 63.35, with the median only changing by 0.46. Both the adjusted and original sample variability values indicate a high degree of variance within the data.
Figure 4.5 (left): Box plot showing pH results against sampling location.

Figure 4.6 (right): Box plot showing Magnetic Susceptibility results against sampling location.
Figure 4.7 (Right): Box plot showing Chloride results against sampling location.

Figure 4.8 (Left): Box plot showing Loss-on-Ignition results against sampling location.
Figure 4.9 (left): Box plot showing Nitrate results against sampling location.

Figure 4.10 (right): Box plot showing Sulphate results against sampling location.
4.3.2.2 Site Based Descriptions

The following descriptions will assess the body of results on a site-by-site basis, with reference to the body of data presented in Appendix 2 and to the Box Plot diagrams presented in Section 4.3.2.1, above.

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<td>0.00</td>
<td>2.60</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.15</td>
<td>750.84</td>
<td>11.71</td>
<td>854.52</td>
<td>120.84</td>
<td>7.38</td>
<td>3621.99</td>
</tr>
</tbody>
</table>

Table 4.5: Summary statistics for Transect C

This site, on the slopes of the Xaghra plateau, Gozo, has the greatest pH range of any of the areas investigated. Within each field, the pH increased between the upper samples and the mid-profile samples and decreased in the deepest samples. There was no particular trend found with magnetic susceptibility, although it could be argued that there is a slight drop with decreasing elevation, and also with increasing depth. The upper samples of field 4 (JB#s 9 and 10) are noticeably higher than the other results for this location. Loss-on-Ignition results showed some variation, but there was no discernable trend. Soil texture was usually silty clay, with 3 clay samples and one silt clay loam (JB#8 – a deep horizon sample).

The nutrient results show an interesting pattern of notable counts in the deepest samples for each of the three fields (see Figure 4.11, below). Specifically, Chloride and Sulphate showed large increases in the lowest samples, with a slight increase through the mid-depths. Nitrates appeared to be more abundant in the upper samples of each field, while Phosphate was only detected in the upper samples of field 4 (JB#s 9 and 10) – where the magnetic susceptibility was also high.

In comparison with geospatial data (Table 4.3), all samples fall under the mediocre cabreo classification and show a gradual downslope increase in the regression model value/predicted agricultural viability.
Figure 4.11: Nutrient Results for Transect C. TRA.C 2/3/4 refer to the terraces sampled through excavation as presented in Chapter 3.
Results from Mġarr reveal some variability in pH, with no distinctive pattern emerging. Loss-on-Ignition results included one upper-horizon sample (JB#19) with a particularly low reading, with other results ranging from 4.3% to 10.8% - usually between 6-7%. Magnetic susceptibility results (Figure 4.12, below) showed some noteworthy variability, with relatively high readings for the upper and mid-depth samples for MG2 and MG5, and the upper sample of MG4.

Nutrient results (Figure 4.13, below) show a gradual increase in quantities of Chloride, Nitrate and Sulphate downslope. Within fields MG1-3, chloride and sulphate show a relative abundance in deeper samples, when compared with more shallow samples. However, fields MG4 and 5 showed much higher abundance of chloride, particularly in the former field, which had the highest abundance of this location in its upper sample (JB#23) and the second highest in its lowest sample (JB#25). Like previous fields, the lowest sample of MG4 had a higher relative abundance of sulphate and nitrate. Drawing these data together, Figures 4.8 and 4.9 show that a downslope drop in pH values is associated with an increase in nutrient abundance – particularly for the lower two fields.

Compositionally, the soils become sandier moving downslope, particularly visible in the lowest field – with the most common texture clay loam. In some of the less sandy upper field samples, the texture was more influenced by the abundance of silt. Referring to the geospatial data, field MG1-4 are classed as mediocre, while MG5 was cattiva - all of which score c.0.7 on the regression model and thus are considered highly agriculturally viable.
Figure 4.12: Magnetic Susceptibility Results for Mgarr

Figure 4.13: Nutrient Results against pH for Mgarr. Linear trendlines for pH and chloride added to aid interpretation.
Il-Ġebel tal-Mistra

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>$\text{MS (xSI)} \times 10^8$</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9.19</td>
<td>220.64</td>
<td>4.55</td>
<td>73.86</td>
<td>56.37</td>
<td>3.18</td>
<td>26.33</td>
</tr>
<tr>
<td>Median</td>
<td>9.21</td>
<td>217.71</td>
<td>3.79</td>
<td>72.31</td>
<td>37.73</td>
<td>3.03</td>
<td>21.87</td>
</tr>
<tr>
<td>Mode</td>
<td>9.33</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>0.00</td>
<td>#N/A</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.15</td>
<td>120.61</td>
<td>2.42</td>
<td>32.16</td>
<td>45.19</td>
<td>3.10</td>
<td>13.69</td>
</tr>
<tr>
<td>Range</td>
<td>0.54</td>
<td>426.00</td>
<td>9.09</td>
<td>109.48</td>
<td>143.91</td>
<td>10.09</td>
<td>51.14</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.97</td>
<td>26.38</td>
<td>2.57</td>
<td>34.86</td>
<td>14.07</td>
<td>0.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.51</td>
<td>452.38</td>
<td>11.66</td>
<td>144.34</td>
<td>157.98</td>
<td>10.09</td>
<td>67.14</td>
</tr>
</tbody>
</table>

Table 4.7: Summary statistics for Il-Ġebel tal-Mistra

The Mistra location presented variable magnetic susceptibility and nutrient results, with no specific patterns visible. For the former, there was a relatively moderate level of susceptibility when compared with other sites. Interestingly, 10 of 12 samples had detected phosphate results. Of other measures, pH and LoI had notable results. For the former (Figure 4.14, below), for MIS1-3, there is a pattern of increasing, albeit marginal, pH with sample depth. Conversely, for all fields, the %LoI decreases with sample depth (Figure 4.15, below). The soil textures for these samples are all variations of loams, with MG1 being siltier, and MG3 and 4 being more sandy.

This site, not falling under a cabreo classification and not being a terraced slope, acts as a control. Under the regression model, the agricultural viability ranges from 0.34 -0.58 – poor to medium quality. Aside from these results, this location appears to be of considerable archaeological interest, with unique field wall construction methods and long-distance irrigation systems. While no further information could be acquired about the area, it is expected that it may be of considerable antiquity and is deserving of further investigation.
Figure 4.15: pH Results for Il-Ġebel tal-Mistra

Figure 4.14: %LoI Results for Il-Ġebel tal-Mistra
In-Nuffara

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>MS ($\chi$SI) x $10^8$ m$^3$/kg</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>8.55</td>
<td>197.76</td>
<td>10.27</td>
<td>289.10</td>
<td>63.59</td>
<td>0.00</td>
<td>863.48</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>8.62</td>
<td>164.61</td>
<td>10.25</td>
<td>134.73</td>
<td>55.58</td>
<td>0.00</td>
<td>92.34</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>8.62</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>0.00</td>
<td>#N/A</td>
</tr>
<tr>
<td><strong>Std. Deviation</strong></td>
<td>0.22</td>
<td>80.74</td>
<td>1.91</td>
<td>348.21</td>
<td>41.73</td>
<td>0</td>
<td>2095.59</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>0.75</td>
<td>239.38</td>
<td>7.44</td>
<td>1131.80</td>
<td>140.69</td>
<td>0</td>
<td>7205.42</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>7.96</td>
<td>111.84</td>
<td>7.41</td>
<td>52.64</td>
<td>20.59</td>
<td>0.00</td>
<td>27.62</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>8.71</td>
<td>351.23</td>
<td>14.85</td>
<td>1184.45</td>
<td>161.28</td>
<td>0.00</td>
<td>7233.04</td>
</tr>
</tbody>
</table>

Table 4.8: Summary statistics for In-Nuffara. #N/A indicates unique values for all results in applicable categories.

The results from this location were variable, with a few notable patterns occurring. The magnetic susceptibility (Figure 4.16, below) showed a slight increase moving downslope, with sizeable increases within IN4 and a considerable decrease in IN5. Within fields IN1-3, the susceptibility decreased with depth. pH results showed a slight increase downslope. IN1-2 showed a drop in pH with increasing sample depth. Interestingly, within these fields, each of the deepest samples had a noticeably lower pH result than other samples in this location. These also coincided with high chloride and sulphate (Figure 4.17, below) results for the same samples (JB#45 and 48). For this location, the sulphates were significantly higher than the chlorides, unlike previous locations. IN4 and IN6 also showed an increase in these nutrients in their deep samples, but not to the same levels.

Compositionally, the soil textures are defined by their clay content, with most samples being clays or clay loams, with some silty clays present – with no apparent trends in the data. Considering the geospatial data (see Table 4.3), these fields transition between inferiore, mediocre and buona categories with the regression model increasing moving downslope.
**Magnetic Susceptibility Results for In-Nuffara**

![Magnetic Susceptibility Graph](image)

Figure 4.16: Magnetic Susceptibility results for In-Nuffara

**Nutrient Results against pH for In-Nuffara**

![Nutrient Results Graph](image)

Figure 4.17: Nutrient results against pH for In-Nuffara. Phosphate results have been omitted as all values were beneath the detection limit.
Is-Sruġ

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>MS (χSI) x 10^8 m^2/kg</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.71</td>
<td>370.07</td>
<td>10.50</td>
<td>24.75</td>
<td>40.53</td>
<td>2.30</td>
<td>40.07</td>
</tr>
<tr>
<td>Median</td>
<td>8.72</td>
<td>325.78</td>
<td>7.56</td>
<td>25.79</td>
<td>31.69</td>
<td>0.00</td>
<td>32.16</td>
</tr>
<tr>
<td>Mode</td>
<td>8.72</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>0.00</td>
<td>#N/A</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.12</td>
<td>151.05</td>
<td>11.02</td>
<td>17.94</td>
<td>41.55</td>
<td>7.98</td>
<td>37.35</td>
</tr>
<tr>
<td>Range</td>
<td>0.49</td>
<td>383.27</td>
<td>40.44</td>
<td>51.29</td>
<td>139.42</td>
<td>27.64</td>
<td>99.27</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.45</td>
<td>174.67</td>
<td>4.60</td>
<td>1.66</td>
<td>0.00</td>
<td>0.00</td>
<td>2.74</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.94</td>
<td>557.94</td>
<td>45.05</td>
<td>52.95</td>
<td>139.42</td>
<td>27.64</td>
<td>102.02</td>
</tr>
</tbody>
</table>

Table 4.9: Summary statistics for Is-Sruġ

The fields sampled at Is-Sruġ revealed no pattern for pH and %LoI. For the former, the results all ranged within pH 8 and for the latter, there was one noteworthy spike in sample JB#69 – with 45.05 %LoI. For IS1-2, magnetic susceptibility was relatively high, despite a lower upper sample result for IS1. Apart from a high reading for the upper horizon of IS6, the remainder of samples had lower readings – although no specific pattern is apparent. Overall, the nutrient results are quite variable, with some noteworthy observations. IS1 shows a decreasing abundance of nutrients with soil depth, although the upper sample nitrate and sulphate are the highest for the location. IS4 has an accumulation of nutrients in the lower horizons, particularly the mid-depth samples. These data are compared in Figure 4.18, below.

Soil textures at this location are primarily clay loams, with some fluctuations to both clay and to loam. The sand component usually rises with the deeper samples, which is likely to be the influence of weathered bedrock. IS1-2 are recorded as infima, with the remaining fields being buona. The regression model results range from 0.54 (IS1) to 0.67 (IS7). These values complement the cabreo classes, at least in a locally relative manner.
Figure 4.18: Nutrient results against magnetic susceptibility for Is-Sruğ
Table 4.10: Summary statistics for Santa Lucija

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>MS (χSI) x 10^8 m^3/kg</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.52</td>
<td>378.87</td>
<td>7.36</td>
<td>22.01</td>
<td>22.59</td>
<td>0.00</td>
<td>24.01</td>
</tr>
<tr>
<td>Median</td>
<td>8.55</td>
<td>358.14</td>
<td>7.53</td>
<td>12.91</td>
<td>12.25</td>
<td>0.00</td>
<td>7.34</td>
</tr>
<tr>
<td>Mode</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>0.00</td>
<td>#N/A</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.15</td>
<td>167.94</td>
<td>2.18</td>
<td>26.16</td>
<td>26.48</td>
<td>0</td>
<td>46.79</td>
</tr>
<tr>
<td>Range</td>
<td>0.5</td>
<td>630.83</td>
<td>7.19</td>
<td>83.10</td>
<td>77.55</td>
<td>0</td>
<td>169.83</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.3</td>
<td>195.40</td>
<td>3.13</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.8</td>
<td>826.23</td>
<td>10.33</td>
<td>83.10</td>
<td>77.55</td>
<td>0.00</td>
<td>169.83</td>
</tr>
</tbody>
</table>

Overall, the results for Santa Lucija are quite variable for all aspects analysed. The pH (Figure 4.19, below), while quite inconsistent, only ranged by 0.5. Magnetic susceptibility (Figure 4.21, below) was quite variable for SL1-6 and gradually decreasing downslope. Loss-on-Ignition results were variable with no discernible pattern. Some observations can be made about the nutrient data (Figure 4.22, below), despite the variability. Chloride appears increased in the upslope upper samples in SL1,3 and 5. However, further downslope, accumulations of chloride accumulate in deeper samples, particularly in SL11 and 10. Nitrates are fairly abundant in SL1-2 and are reduced from SL3-9 (although some spikes existed). From SL13-10, the abundance of nitrate is significantly higher than at any other point at this location. Sulphates follow the same pattern as the previous nutrients, although generally with lesser abundance (except for SL1). On a field by field basis, observations are as follows:

- SL1 has a relatively moderate nutrient content in the upper sample, with a particularly high sulphate content,
- SL5 has a small accumulation of chloride and sulphate in the upper sample.
- SL8 has a small accumulation of chloride and sulphate in the mid-depth sample.
- SL12-13 have spikes of nitrate in their upper samples.
- SL11 has high spikes of chloride and sulphate in the deepest horizon.
- SL10 has moderate accumulations of chloride, sulphate and nitrate in the mid to deep samples.

Compositionally, these are predominantly loams of one form or another. Between SL8-9, soils were either sandy clay loams or silty clays, indicative of in-profile sorting. This location contained a gamut of cabreo classifications (Figure 4.20), ranging from buona upslope, to mediocre, mid-low slope. After SL9, a roadway truncated the transect – this resulted in the switch in numbering as sampling was conducted from the bottom of the transect back up to the road. The cabreo classes continued to deteriorate across the road. However, the penultimate field was classed as buona and the final field
was mediocre. Observing the regression model (Figure 4.17, below), there is some variability, but with an overall increase downslope.

Figure 4.19: pH Results for Santa

Figure 4.20: Logistical Regression Model Values for Santa

Figure 4.21: Magnetic Susceptibility Results for Santa
Figure 4.22: Nutrient Results for Santa Lucija
Mellieha

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>MS (χSI) x 10^8 m^3/kg</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.49</td>
<td>933.52</td>
<td>7.37</td>
<td>129.99</td>
<td>41.34</td>
<td>5.64</td>
<td>22.13</td>
</tr>
<tr>
<td>Median</td>
<td>8.5</td>
<td>835.03</td>
<td>7.31</td>
<td>121.75</td>
<td>30.93</td>
<td>0.00</td>
<td>22.31</td>
</tr>
<tr>
<td>Mode</td>
<td>8.67</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>0.00</td>
<td>#N/A</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.12</td>
<td>386.77</td>
<td>2.07</td>
<td>84.53</td>
<td>25.81</td>
<td>13.21</td>
<td>7.52</td>
</tr>
<tr>
<td>Range</td>
<td>0.38</td>
<td>1037.35</td>
<td>7.62</td>
<td>296.18</td>
<td>83.15</td>
<td>35.87</td>
<td>25.69</td>
</tr>
<tr>
<td>Minimum</td>
<td>8.29</td>
<td>463.69</td>
<td>4.19</td>
<td>42.16</td>
<td>16.51</td>
<td>0.00</td>
<td>5.11</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.67</td>
<td>1501.05</td>
<td>11.81</td>
<td>338.34</td>
<td>99.66</td>
<td>35.87</td>
<td>30.81</td>
</tr>
</tbody>
</table>

Table 4.11: Summary statistics for Mellieha

The pH results (Figure 4.23, below) for this location showed little variation, with a range of only 0.38. The overall pattern shows a slight decrease in values mid-slope, before an increase in the lower fields. Magnetic susceptibility (Figure 4.24, below) was variable in places, although the general trend was decreasing susceptibility downslope – with a mid-slope increase between ML5-8. Loss-on-Ignition (Figure 4.25, below) was generally stable, between c.6 and 8%, with higher values in the upper samples of all field except ML1 and 3, where the highest values were found in the deepest layers. For fields ML2 and 3, the %LoI results were respectively the lowest and highest for this location, with the range values being found in the deepest samples. Figure 4.26, below, presents the nutrient data for Mellieha. Chloride results were highly variable, with no specific general trend other than a gentle increase downslope. ML1,3,5-6 and 8 all showed a decreasing chloride content with depth. Nitrate generally increases downslope, with a trend of reducing values with profile depth – exceptions to this are ML3-4 and 6. ML2,5, 9-11 show significant amounts of nitrate in the upper samples. Phosphate is only detected in the mid and lower samples of ML2 (JB#121-122) while sulphate shows a gentle increase downslope, with no major trends apparent.

Focusing on fields, ML2 sees a relative increase in pH and nutrients, with localised lows of magnetic susceptibility and %LoI. ML3 contains a notable spike in magnetic susceptibility, %LoI and chloride. ML5 had increased chloride nitrate and sulphate, along with a relative increase in %LoI. ML6, 9-11 had increased chloride and nitrate. Soil textures were all loams, mostly clay loams with occasional silty clay loams (ML1 and 7) and a sandy loam sample from ML11. Considering the geospatial data, all fields had particularly low regression model scores – all but one being below 0.1 – with a slight increase being observed with decreasing elevation. Fitting with this, the cabreo classifications also increase in assessed quality moving downslope.
Figure 4.23: pH results for Mellieha

Figure 4.24: Magnetic susceptibility results for Mellieha

Figure 4.25: Loss-on-Ignition Results for Mellieha
### Nutrient Results for Mellieha

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>ML1</th>
<th>ML2</th>
<th>ML3</th>
<th>ML4</th>
<th>ML5</th>
<th>ML6</th>
<th>ML7</th>
<th>ML8</th>
<th>ML9</th>
<th>ML10</th>
<th>ML11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>60.9</td>
<td>62.4</td>
<td>49.2</td>
<td>42.1</td>
<td>156.</td>
<td>79.8</td>
<td>338.</td>
<td>158.</td>
<td>95.5</td>
<td>173.</td>
<td>147.</td>
</tr>
<tr>
<td>Nitrate</td>
<td>76.6</td>
<td>68.1</td>
<td>30.2</td>
<td>99.6</td>
<td>20.8</td>
<td>28.3</td>
<td>26.4</td>
<td>34.5</td>
<td>16.5</td>
<td>38.1</td>
<td>184.</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>35.8</td>
<td>31.8</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sulphate</td>
<td>30.8</td>
<td>24.6</td>
<td>22.5</td>
<td>20.4</td>
<td>12.0</td>
<td>5.12</td>
<td>21.6</td>
<td>27.7</td>
<td>19.7</td>
<td>28.2</td>
<td>22.1</td>
</tr>
</tbody>
</table>

*Figure 4.26: Nutrient results for Mellieha*
Table 4.12: Summary statistics for Buskett Gardens

Results from the Buskett Gardens present little notable variability. Although pH values fluctuate, there is only a range of 0.33 and no discernible pattern to the variance. Both magnetic susceptibility (Figure 4.27, below) and loss-on-ignition (Figure 4.28, below) show a general downslope decrease, although the former is slightly more reduced mid-slope. The nutrient results show a higher level of variability, as presented in Figure 4.29, below. Sulphate is fairly stable, reducing slightly downslope. Nitrate has increased concentrations in the upper sample of each field. Chloride is most pronounced in the upper and lower samples of BS1, with a slight concentration in the lower sample of BS2. The soil textures are all loam, apart from the lowest sample of BS2 which was a silt loam. The cabreo classifications improve from cattiva (BS1) to mediocre (BS2-3), and the regression values begin at c. 0.2, drop to c. 0.1 and rise again to c. 0.4 – similar to the related cabreo classifications.
Magnetic Susceptibility Results for Buskett

Figure 4.27: Magnetic susceptibility results for Buskett

Loss-on-Ignition Results for Buskett

Figure 4.28: Loss-on-Ignition results for Buskett

Nutrient Results for Buskett

Figure 4.29: Nutrient results for Buskett
The pH results (Figure 4.30, below) from Żebbuġ show a slight increase moving downslope, within which there are lower deposit spikes in ZB3 and 5. Magnetic susceptibility (Figure 4.31) showed little variability, although there were relatively elevated readings for the upper sample of ZB3 and for fields ZB5-6. Loss-on-Ignition (Figure 4.32) showed a general reduction with decrease in elevation, with a notable drop for the lower sample of ZB3. Nutrient results (Figure 4.33) were relatively stable, except for a few notable results. Chlorides spiked in the lower samples of ZB1, 2, 4 and 7; with the results outside of these being relatively low in comparison. There were elevated nitrate results in the upper samples of ZB3, 5-6 and elevated sulphate results in the lower sample of ZB4 and the upper sample of ZB7. The soil texture was mainly a mix of clays and loams, characterised by a slight increase in downslope. These fields cross a gamut of cabreo classes – buona (ZB1-2), mediocre (ZB3-4) and cattiva (ZB5-7). Counter to this, the regression model values show an increase in predicted agricultural viability from c.0.2 upslope to c.0.4 downslope.
Figure 4.31: Magnetic Susceptibility results for Zebug

Figure 4.32: Loss-on-Ignition Results for Zebug

Figure 4.33: Nutrient results for Zebug
Overall, the results for this site did not present much variability. pH results (Figure 4.34, below) had a range of 0.19 – with MR2 and 4 showing decreasing pH with depth and MR1 and 3 showing the converse. Magnetic susceptibility (Figure 4.35, below) showed a gradual increase as elevation decreased, with a slight step occurring between MR2 and 3. Loss-on-Ignition results (Figure 4.36) were stable, with a range of 1.69%. Nutrient results (Figure 4.37) were relatively stable, with a spike of nitrate in the upper sample of MR3 and increase chloride in MR4. Soil textures were dominated by clay loam, although the upper samples of MR2-3 were loams, with c.3% less clay present. These fields did not fall under the cabrei, as such they act as control samples. There regression model viability is exceptionally high, with each field scoring over 0.9.
Figure 4.35: Nutrient Results for Tal-Merħla. Phosphate results omitted due to detection limits.
4.3.2.3 X-Ray Diffraction

The results for XRD will be broken into multiple components. The first section will outline the method of statistical analysis used to corral the raw XRD data into a more easily digestible format. Following this, the dendrogram and representative samples will be presented. In the final sub-section, the XRD results will be related to results from the previous section.

Ward’s Cluster Analysis

This method of cluster analysis creates satisfactory clusters which have a high degree of homogeneity. This is created via the distance of between a cluster’s members and its mean. In Ward’s method, the distance is the error sum of squares (ESS), i.e. the total sum of squared deviations or distances of all points from the means of the clusters to which they belong (Shennan, 1988).

The aim of the method is to join individuals and groups successively whereby at each step in the fusion process the ESS is the minimum possible, thus ensuring the clusters are as homogenous as possible; while at the same time creating larger and larger clusters of increasingly dissimilar elements by relaxing the definition of uniqueness.
Figure 4.38: Dendrogram of XRD results based on Ward’s Method (right).
Cluster Characterisation

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Representative Sample</th>
<th>Approximate Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JB#161</td>
<td>Calcite (magnesian)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kaolinite (clay mineral)</td>
</tr>
<tr>
<td>2</td>
<td>JB#156</td>
<td>Calcite (86%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz (14%)</td>
</tr>
<tr>
<td>3</td>
<td>JB#29</td>
<td>Calcite (94%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz (6%)</td>
</tr>
<tr>
<td>4</td>
<td>JB#80</td>
<td>Calcite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halloysite (clay mineral)</td>
</tr>
<tr>
<td>5</td>
<td>JB#149</td>
<td>Calcite (55%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz (45%)</td>
</tr>
<tr>
<td>6</td>
<td>JB#60</td>
<td>Calcite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kaolinite (clay mineral)</td>
</tr>
<tr>
<td>7</td>
<td>JB#51</td>
<td>Calcite</td>
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<tr>
<td></td>
<td></td>
<td>Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kaolinite/Montmorillonite (Clay minerals)</td>
</tr>
<tr>
<td>8</td>
<td>JB#130</td>
<td>Calcite (82%)</td>
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<tr>
<td></td>
<td></td>
<td>Quartz (18%)</td>
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<tr>
<td>Unclustered</td>
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<td></td>
<td>Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wulfenite (lead molybdate mineral)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magnetite (ferric mineral)</td>
</tr>
</tbody>
</table>

Table 4.15: Summary of XRD Cluster Analysis
Cluster 1

Figure 4.39: Diffractogram for the representative sample for Cluster 1 (JB#161)
Cluster 2

Figure 4.40: Diffractogram for the representative sample for Cluster 2 (JB#156)
Figure 4.41: Diffractogram for the representative sample for Cluster 3 (JB#29)
Figure 4.2: Diffractogram for the representative sample for Cluster 4 (JB80).
Cluster 5

Figure 4.43: Diffractogram for the representative sample for Cluster 5 (JB#149)
Figure 4.44: Diffractogram for the representative sample for Cluster 6 (JB#60)
Figure 4.45: Diffractogram for the representative sample for Cluster 7 (JB#51)
Cluster 8

Figure 4.46: Diffractogram for the representative sample for Cluster 8 (JB#130)
Figure 4.47: Diffractogram for the representative sample for Unclustered (JB#90).
Summary of XRD Results

These results show an unsurprising predominance of Calcite and Quartz in most samples – owing to the geological situation, as discussed in Chapter 2. Specifically, the calcite is arising from the limestone strata, particularly the Globigerina and, in reduced amounts, the Blue Clay (John et al., 2003). The fine to very fine quartz component, although ubiquitous, is likely arising from aeolian processes in the Mediterranean basin (Yaalon D. and Ganor, 1973; Yaalon, 1997) and from the Greensand and Coralline Limestone bedrocks (Pedley, 1976; Bianco, 1993; Pedley et al., 2002). Of the calcites present, there are occurrences of Magnesian calcite – a magnesium rich form. The next notable minerals are Kaolinite, Montmorillonite and Halloycite which are clay minerals abundant in the Blue Clay strata. Finally, within the unclustered sample there was the detection of ferric magnetite and the lead mineral wulfenite – this could be due to some form of contamination within the field, perhaps the dumping of waste material. The XRD results will be examined comparatively in the following section.
4.4 Analyses of Results

4.4.1 Correlation

As a means of synthesising the data presented in Section 4.3, the correlations presented below (Table 4.19) allows the observation of salient connections between the various factors examined. The Pearson correlation coefficient measures the strength of the linear association between two variables. Overall, there are no strong correlations present, with three moderate correlations and several weak correlations. Factors with a correlation $\pm 0.2$ or greater will be examined, except for correlations between soil particle size, as these are relative proportions.

4.4.1.1 Moderate Correlations

*Logistic Regression Model and Elevation:* There exists a moderate negative correlation between the results for the regression model at the sample locations and their elevation. Therefore, higher elevation correlates with lower perceived agricultural viability. The caveat here is that elevation is a factor integral to the formation of the regression model, as explained in Chapter 3. Effectively, this statistic confirms an aspect of the Alberti et al. (2018) paper.

*PH and Elevation:* As above, a moderate negative correlation between pH and elevation is present, indicating a lower pH with increasing elevation. Cross referencing with Table 4.7, the pH range of 1.55 indicates that this variability is limited – with no extremes. In short, this suggests that lower lying land is more alkaline.

*PH and Logistic Regression Model:* There is a moderate positive correlation between these factors, indicating that increased pH correlates with the increased perception of agricultural viability as predicted by the logistical regression model.

Examining these three correlations together reveals a potentially contradictory assessment. Reflecting on Table 2.5, the ideal pH for crop production is between 7-8, The dataset presented in this chapter shows a pH which is, on average, greater than 8 – beyond the idealised value. Considering this and the regression model as the perception of viability, we see that the lower lying areas have a higher pH and are paradoxically, when considering the pH/Regression correlation, more agriculturally viable. In short, increasing elevation correlates with less alkaline soils and a lower perceived viability. While the lower lying, more viable land is more alkaline; it is likely that other factors are affecting this trend.

*Magnetic Susceptibility and Logistic Regression Model:* A moderate negative correlation between MS and regression exists, suggesting that increased agricultural viability is associated with decreased magnetic susceptibility at the sample locations. This could be related to the negative correlation between perceived agricultural viability and elevation – with the relationship between thin elevated soils (Xerorendzinas) and poorer *cabreo* classes influencing the regression model. These soils, given
their proximity to limestone bedrock, can have notable ferric content resulting from rubification – a state of pedogenesis where iron is released from primary minerals and forms free iron oxides, coating quartz particles in soils with a thin reddish film; engendering a higher magnetic susceptibility. Such soils are ubiquitous on the hard limestone geologies of the archipelago. However, these soils are often found in abandoned terrace complexes, as part of an expansion into the xaghri (elevated wasteland) during the later 19th and 20th centuries. Their thin and stony character is therefore associated with poor agricultural viability and, as such, this is likely to influence the stated correlation.

%LoI and Clay/Sand: The %LoI holds a borderline weak-moderate positive correlation with clay and a moderate negative correlation with sand, indicating that %LoI increases as particle size decreases. This pattern could be tied to the weaker correlations between clay/sand and elevation discussed below. The organic content is likely to be concentrated in the upper levels of each field and will become distributed through agricultural practices. As an explanation of the weak positive correlation between %LoI and elevation, it could be suggested that organic matter is influenced by the sorting of soil particles, where the finer clays are associated with upper horizons and higher elevations.

4.4.1.2 Weak Corrections

Magnetic Susceptibility and pH: These factors hold a weak negative correlation which suggests that increased MS is related to decreased pH/greater acidity. It is unlikely that this correlation has any meaning, as pH relates to H⁺ concentration whereas MS is an indicator of ferromagnetic particles. Given the relationship between soils and geology, it might be expected that MS would increase in elevated areas, where the more susceptible Xerorendzinas are typically found. However, there is no correlation between MS and Elevation. It should be noted that some clay minerals, in this case the XRD detected Montmorillonite have a positive MS value (Mullins, 1977). Potentially, the relative elevation of the Blue Clay horizons, and the occurrence of susceptible clay minerals may have an influence on the relationship between elevation and MS. Alternatively, a slightly less alkaline, circa pH 8, soil may foster the formation of secondary ferromagnetic minerals through autoxidation (Dearing et al., 1996), particularly in the more freely drained Xerorendzinas.

%LoI and pH: It can be said that %LoI increases with lower pH, with a weak negative correlation. In this study %LoI was a proxy for organic matter. Typically, an increase in soil organic matter (SOM) can lead to the acidification of soils, particularly when considering the increased biological fixation of available Nitrogen and the increased uptake of plant cations (Wild, 2003).

Sulphate and pH: These factors have a weak negative correlation meaning that sulphate increases are in conjunction with pH decreases. This correlation is quite weak, but could be related to the oxidation of sulphur compounds – a process which leads to soil acidification (Wild, 2003).
**Nitrate/Chloride/Elevation:** Nitrate and Chloride hold a weak-moderate positive correlation, suggesting that they both increase together. Both these factors also have a weak negative correlation with elevation. Overall, as elevation decreases, the abundance of nitrate and chloride increases. As observed in the results section, there were several sites where these nutrients were more abundant in the lower horizons, perhaps indicating leaching within profile. Furthermore, the proximity to sea, and sea spray may further increase chloride levels present – another result of elevation change.

**Clay/Sand and Elevation:** A weak positive correlation between clay and elevation, and a weak negative correlation between sands and elevation exist. This indicates that with rising elevation, there is a higher proportion of clays and a lower proportion of sand. Although these correlations are weak, it could signify the process of particulate sorting. Since each sample’s elevation is absolute, this correlation effectively incorporates both profile depth and slope position. Erosive processes would favour the travel of larger particles down slope, and agricultural activities would aid the sorting within each field.

**Nitrate and Clay/Sand:** Nitrate has a weak positive correlation with sand and a weak negative correlation with clay. This suggests that nitrates are more abundant in sandy/coarse soil textures. Referring to the correlation between nitrate and elevation, this could be an indication of leaching within the profile.
<table>
<thead>
<tr>
<th></th>
<th>Elevation</th>
<th>Logistic Regression Model</th>
<th>pH</th>
<th>MS (xSI) x 10^8 m^3/kg</th>
<th>%LoI</th>
<th>Chloride</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Sulphate</th>
<th>Clay 0-4μm</th>
<th>Silt 4-63μm</th>
<th>Sand 63-2000μm</th>
</tr>
</thead>
<tbody>
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<td>Elevation</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>LR_model</td>
<td>-0.52</td>
<td>1.00</td>
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<td></td>
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<td>0.52</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS (xSI) x 10^8 m^3/kg</td>
<td>0.01</td>
<td>-0.41</td>
<td>-0.35</td>
<td>1.00</td>
<td></td>
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<td></td>
<td></td>
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<td>%LoI</td>
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<td>0.01</td>
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<td>0.03</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Chloride</td>
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<td>0.00</td>
<td>-0.10</td>
<td>0.04</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Nitrate</td>
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<td>0.04</td>
<td>-0.14</td>
<td>0.13</td>
<td>0.02</td>
<td>0.37</td>
<td>1.00</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Phosphate</td>
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<td>0.00</td>
<td>0.11</td>
<td>0.04</td>
<td>-0.08</td>
<td>-0.07</td>
<td>-0.01</td>
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<td>Sulphate</td>
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<td>0.07</td>
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<td>-0.13</td>
<td>0.11</td>
<td>0.30</td>
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<td></td>
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</tr>
<tr>
<td>Clay 0-4</td>
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<td>-0.17</td>
<td>-0.12</td>
<td>0.39</td>
<td>-0.02</td>
<td>-0.26</td>
<td>-0.13</td>
<td>0.16</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt 4-63</td>
<td>0.06</td>
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<td>-0.05</td>
<td>-0.10</td>
<td>0.13</td>
<td>0.02</td>
<td>0.03</td>
<td>-0.06</td>
<td>0.10</td>
<td>0.05</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Sand 63-2000</td>
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<td>-0.07</td>
<td>0.17</td>
<td>0.15</td>
<td>-0.40</td>
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<td>0.21</td>
<td>0.14</td>
<td>-0.19</td>
<td>-0.88</td>
<td>-0.53</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Table 4.16: Correlation Statistics for Geochemical Data using Pearson’s Correlation Coefficient*
4.4.2 Comparison of XRD Results with Geoarchaeological Analyses

Figure 4.48: XRD Clusters against Soil Clay Fraction

Figure 4.49: XRD Clusters against Soil Silt Fraction

Figure 4.50: XRD Clusters against Soil Sand Fraction
The comparison between XRD results, organised by clusters, with the other analysed geoarchaeological factors has revealed some interesting associations. Firstly, there was a lack of comparable results between XRD and nutrients detected through chromatography, which may suggest that parent geology is not a direct factor influencing soil fertility. However, when considering the relationship between particle size and the XRD results, geologically pertinent results have been noted. Figures 4.44-4.46 (above) show boxplots for clay, silt and sands respectively. Primarily using the box plot medians as a visual guide and in comparison, with the dendrogram (Figure 4.34), the groups of clusters show the following relationships:

- **Clay:**
  - Clusters 1, 4 and 7 have a higher proportion
  - Clusters 2 and 3 have a lower proportion
  - Clusters 5, 6 and 8 have a middling proportion

- **Silt:**
  - Clusters 1, 4 and 7 have a higher proportion
  - Clusters 2 and 3 have a lower proportion
  - Clusters 5, 6 and 8 have a middling proportion

- **Sand:**
  - Clusters 2 and 3 show a relatively higher proportion
  - Clusters 1, 4 and 7 all show a lower relative proportion
  - Clusters 5, 6 and 8 show a middling proportion

Considering these observations, Table 4.19 and Figure 4.46 (below) indicate the association between XRD analysis and the parent geology of sample sites. Interestingly, the comparison between the soil composition breakdown and the geologies does not show a typically predictable relationship. The observations that can be made are as follows:

- Clusters 1, 7, 6, 2 and 4 (respectively) are predominantly Blue Clay
- Cluster 3 is split between Blue Clay and Globigerina
- Cluster 5 is predominantly Globigerina
- Cluster 8 is predominantly Upper Coralline

Comparing these two sets of analyses, it is evident that that parent geology is not a strict indicator of soil texture.

Interestingly, the relationship between XRD and %LoI directly reflects the relationship between XRD and proportion of clay, with the box plots inhabiting the same relative positions. This suggests that the %LoI is a good indicator of SOM, with a concomitant association with clay particulates (<4μm). The carbonate content (<53μm) would typically influence the proportion of silts (4-63μm). Therefore, the XRD results indicate that that clay fraction of soils is a good indicator of SOM.
4.4.3 Comparison of Geoarchaeological Results with Cabreo Classifications

The section will examine the patterns arising from the comparison of geoarchaeological data with the cabreo classification attributed to each sample location. The discussion will be split between particle size analysis, pH/magnetic susceptibility/%LoI, and nutrients. It should be noted that, for ease of comparison, the cabreo classifications were limited to three categories, - buona, mediocre and poor (representing infima, inferior and cattiva). It is uncertain how the poor qualities differ and why the other qualities do not occur with multiple varieties. One might offer that the multiple negative qualities are indicative of a level of cultural pessimism regarding the agricultural productivity of the archipelago.

Considering the box plots in Figure 4.51 (below), it can be noted that there is a relationship between soil composition and the perceived quality of land, as reported in the cabrei. There is a positive relationship between the clay fraction and reported land quality, and a corresponding negative relationship with sand fraction. However, there is no evident relationship between silt fraction and the reported land quality. Overall, these results indicate that the positive reporting of land quality is directly related to an increased soil clay fraction and the converse can be said for increased sand. This could engender a cultural perception that clay-rich soil is more favourable, perhaps being a heavier, more moisture retentive soil which requires heavier tool use; thus, potentially influencing the historic interpretations of agricultural viability especially when considering the mediocre-poor classes. In this eventuality, the cabrei are an unsuitable measure for ancient agricultural productivity, despite relating to pre-mechanised practices. Instead, it is likely that extrapolation from the cabrei is only a useful exercise for interpreting later periods which involved labour rich investment in the landscape. These themes will be explored in greater depth within Chapters 5 and 7.

Moving to the geoarchaeological results, the comparison is less clear. pH results show no specific trend in relation to cabreo classification, with medians consistent between classes and spreads wide within classes. %LoI also shows no comparative trend between classes, with the medians and the spread of results all similar. Magnetic susceptibility results do show a relationship with cabreo classification, with a trend for increased MS for samples in non-buona classified sites. Data spreads are increasingly wide with increasing negativity of reported class – suggesting that buona sites have a specifically lower level of magnetic susceptibility in comparison to other classes.

Finally, the comparison with nutrient results (Figure 4.49, below) reveals the most notable pattern of results – all detected nutrients have a negative relationship with the positive reporting of cabreo class. Therefore, it can be said that there is increasing nutrient availability with decreasing perceived land quality.

Overall, this comparison is ambiguous, but not surprising. The increased proportion of clay with buona could have been a solid point of comparison with the previous correlation results; where increased
clay was linked to increased %LoI. However, the same comparison, when framed by the *cabreo* classification, shows no notable link between clay fraction and %LoI as related by *cabreo* class. This indicates that field productivity may not be driven by organic matter contained within the soil. Furthermore, the relative reduction of chloride, nitrate and sulphate within the clay enriched *buona* class could suggest a level of nutrient depletion within the more positively classed fields.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Blue Clay</th>
<th>Globigerina</th>
<th>Upper Coralline</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>6</td>
</tr>
<tr>
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*Table 4.17: Table showing the proportion of site geologies per XRD cluster*
Figure 4.51: XRD Clusters against Geological Formation. Shading is associated with the geological formations named. Darkest represents Blue Clay, mid-shade represents Globigerina and the lightest represents Upper Coralline.

Figure 4.52: XRD Clusters against %LoI
Figure 4.53: Box plots comparing pH/magnetic susceptibility/%LoI results with Cabreo classification.
Figure 4.54: Box plots comparing Nutrient results with Cabreo classification. Phosphate has been excluded due to low detection rates.
4.4.4 Comparison of Logistic Regression Model vs. Geochem

As outlined in Section 4.3.1., correlations were observed between the regression model and elevation, pH and magnetic susceptibility – thus as the modelled agricultural viability rises, pH rises, elevation decreases, and susceptibility decreases. However, it should be reiterated that MS and elevation are not correlated. The covariance of pH and elevation can be interpreted as a function of geology, as explained in Section 4.3.1. Aside from these correlations, Figures 4.51 and 4.52 (below) indicate that the logistic regression model holds no relationship with the detected geoarchaeological and geochemical properties of soil from test sites.

*Figure 4.55: Scatterplots showing PSA and Geoarchaeological results against their Logistic Regression Model values.*
Figure 4.56: Scatterplots of Nutrient results against their Logistic Regression Model values.
4.4.5 Comparison of Cabreo Classifications and Related Logistic Regression Model Values

As a final and conjunctive exercise, Figure 4.53 (below) plots the comparison between the modern logistic regression model of perceived agricultural viability and the 19th Century land value classifications obtained from the cabrei cadastral maps. It is immediately obvious that there is no discernible relationship between these two datasets, despite the regression model utilising the cabrei as a foundational source of information. While the medians displayed below show a slight decrease in LR value moving from buona to poor cabreo classes, the spread of results for each class was prohibitively wide.

![Box plot showing the comparison of Cabreo classifications with Logistic Regression Values.](image-url)
4.5 Synthesis

This chapter was established to generate a detailed geochemical and geoarchaeological overview of agricultural terrace function in relation to soil nutrients. Guided by the cabreo maps as a historical proxy for soil performance, 190 samples were analysed, and the results considered within a three-part framework. This framework established the central objectives of this chapter and created a matrix of investigation, whereby each dataset (this thesis/cabreo/Alberti et al. (2018) Logistic Regression Model) could be examined for potential relationships.

The first objective was to investigate if detectable geoarchaeological factors relate to the reported cadastral land quality assessments. Section 4.4.3. clearly shows a relationship between geoarchaeological results and the cabreo classifications. Considering this further, this relationship is, perhaps, converse to expectations. Given that the cabrei reflect a positive to negative perception of land quality, based on input vs. yield of grain, one might expect that these results would have shown a positive correlation between nutrients and land quality – or, failing this, no correlation. The negative correlation is interesting as it indicates that buona classed land is demonstrably poorer in detected nutrients. However, this land is also proportionally higher in clay, a vital component in the effective transfer of nutrients through soil. The negative correlation between nutrients and elevation reflects two processes – profile-depth accumulation (observed in Section 4.4.1.2.) and slope related accumulation. Considering that %LoI, (as a proxy for SOM), does not correlate with nutrients, it can be hypothesised that agricultural activities such as ploughing and rotovating serve to retrieve nutrients which leach down the profile. The turning of the soil therefore refreshes the surface nutrients, which become re-depleted seasonally, through crop growth and leaching. The correlation between %LoI and clays would support this, as it indicates a relationship between soil sorting and the higher proportion of nutrient adhesive clay.

The second objective queried the relationship between the logistical regression model (Alberti et al., 2018), which claims to predict agricultural viability, and the measurable soil composition and nutrient content. Section 4.4.4. shows a relatively stochastic relationship between the geoarchaeological, geochemical results and their associated regression model values. Although some correlations exist, these are likely the result of pedogenic factors linked to geology. Tethering these datasets together, the final objective sought to examine the effectiveness of the relationship between the regression model and the cabreo land quality classifications. It should be reiterated that the cabrei form a constituent variable of the regression value. Despite this, Section 4.4.5. observes that there is little demonstrable relationship between the recorded classifications and the modelled agricultural viability. It is conceivable that the regression model suffers from an element of conceptual, if not statistical,
overfitting. Plausibly, the use of the *cabrei* should act as both a basis and a control measure for this model. However, as Table 4.6 and Figure 4.53 indicate, there is considerable variability between the modelled viability and the recorded classification.

In conclusion, this chapter has established that geochemical methods provide a critical depth of understanding for terraced agrarian landscapes. Operating at this level of detail enables research to question the validity of historic land classifications and reinforces the need for modern statistical analyses to seek supporting data collected via physical sampling. Overall, this reanalysis of the *cabrei* has revealed a level of variation in classification that suggests non-geomorphological influences, with this spread likely the result of social factors. This theme will be explored further in Chapter 6.
5 THE INTENSIFICATION OF THE AGRICULTURAL LANDSCAPE OF THE MALTESE ARCHIPELAGO

“In this harsh environment man created the land on which he could live”

Bowen-Jones, Dewdney and Fisher (1961, 350)

5.1 Introduction

Bowen-Jones et al. in Malta: Background for Development furnish the reader with a prophetic edict which carries the threat of environmental catastrophe unless there is continual human investment.

“Everything one sees in Malta [the Maltese Archipelago], other than major topographical features, is man-made and man-maintained in existence. For this reason, there is an unstable equilibrium that eternally threatens to collapse” (1961, 349).

This book provides an unparalleled geographical assessment of the Maltese agricultural economy, in the years prior to independence, and still serves as a compendium of knowledge and terminology nearly sixty years later. The authors’ opening gambit recognises the swell in national identity and the resulting desire to exert more control over the nation’s socio-economic direction. However, their opening tonality also expresses an awareness of the influence of development and its potential threat moving into the future, thus directing the authors to the formation of a study that facilitated a greater understanding of the interplay between socio-economics and the landscapes of the Maltese Islands.

Reflecting upon their edict, a modern reader could be forgiven for agreeing with this assertion. A cursory overview of the islands reveals a marginal, alkaline environment with thin and heavily worked soils, overlain by rampant development and inhabited by 1505 people per km² (National Statistics Office 2019). However, at a deeper level, the environmentally deterministic and modernist view of Bowen-Jones et al. (1961) should be eschewed. Writing in the 1950s, these authors continued by stating “the collapse foreseen is an increasing reality, the unstable equilibrium no longer being maintained.” Yet, in 2020, the collapse has not arrived. What the authors couldn’t predict was that the future of the islands lay in connectivity: tourism, financial services, light skilled industry and casinos. A deeper historical perspective would have noted the crucial threshold of the beginning of the 1st millennium BC when external investment first became crucial, adding external input to the island system, and reducing direct dependence on the land. At a more theoretical level, what the authors failed to consider was the delicate equilibrium of fragility and sustainability – the core themes of the FRAGSUS project. Where Bowen-Jones et al. (1961) lacked a chronological framework, this project has re-asserted the importance of understanding human, rather than simply physical environments,
through the full length of time. This leads to a greater comprehension of how humans live in, adapt and manage their environments – forging dynamic landscapes that have deep-seated histories.

A landscape represents an idea greater than the sum of its constituent parts. Indeed, a concept such as the Maltese (or Gozitan) landscape contains within itself a nested hierarchy of landscape units, which are responses to lower and higher order processes. Although the spatial elements of landscapes are usually in flux, it is the palimpsest-like nature of landscapes through time that should be recognised as the key to understanding the inter-connected relationships between humans and their environments. This can be viewed as the central philosophical difference between Bowen-Jones et al. (1961) and the present project.

The FRAGSUS project has focussed on the successful reinvestigation and development of the complexities of the prehistoric Maltese Archipelago. However, in recognition of how landscapes develop through time, elements of the project stretched beyond the prehistoric world to include the classical, medieval and early modern periods. Building on the temporal nature of landscapes, an Annales school framework could be adopted to aid the observation of how people have managed the agrarian environment through time, especially in association with the establishment of the Anthropocene epoch. FRAGSUS offers detail on three major agricultural phases available for study – prehistory (encompassing the early Neolithic through to the end of the Temple Period), the 1800s (via Alberti et al.’s quantitative analyses (Alberti et al. 2018; In press.)) and the contemporary Maltese landscape. This chapter will therefore provide a union between these strands of the FRAGSUS project by providing a synthesis of the population change and the linked agricultural intensification within the region. This will link together a synthesis of the longue durée of the Maltese landscapes, applying a quellenkritik to various phases of evidence. In doing so, the central lines of inquiry will focus on what the available agricultural resource is on the islands and how people have successfully intensified the use of the landscape to balance environmental fragility with population sustainability.

5.2 The Annales School and the Anthropocene

Braudel (1966), the historian, introduced the concept of structuring the understanding of human activity through time, through the medium of three scales of history and change: événements, conjonctures and longue durée. Bintliff (1991) provides a valuable archaeological application of these concepts, describing this paradigm as a series of interdependent wavelengths– which is a useful analogy especially when considering the nature of how waves combine. The shortest of these wavelengths is the history of events or événements, which can be described as the staccato record of
activities on the shortest timescale. This is framed by the more structuralist account of medium- and
long-term markers of time – *conjonctures* and *longue durée* respectively, each of increasing duration
and of apparently lower frequency to the observer. Knapp describes the *Annales* direction as having a
“fundamental ambivalence” and the propensity to “adapt and grow with the demands of an always-
shifting method and theory” (Knapp 1992, 16). In sum, it enables the understanding of how long-term
processes relate to shorter term events. The increasing acceptance of the Anthropocene as a distinct
geological epoch (Waters et al., 2016) raises the implication that intensely applied *événements* can
impinge on *longue durée* geological scales.

Goudie and Viles (2016) adopt an approach which blends the often-conflicting accounts of various
scholars, demonstrating the entwined nature of human activities and geomorphology; avoiding the
application of the term ‘golden spike’, which is common the Anthropocene literature. Their synthesis
negates the marking of the Anthropocene as *événement* and accounts for the ebb and flow of human
activities through time, beginning with the *Palaeoanthropocene* (c. 5050 BC – AD 1750), followed by
the *Industrial Era* (AD 1750-1945), the *Great Acceleration* (AD 1945-2000) and culminating in the
proposed era of *Earth Systems Stewardship* (AD 2000 onwards). Although the authors openly concur
with the escalating pulse of change from the Industrial Era onwards, their timeline is designed to
account for the “many examples of the potent impact of humans in previous millennia” (Goudie and
Viles, 2016, 13). The rationale accords with the *time-transgressive* synthesis, called for by Brown et al.
(2013) and Butzer (2015), which promotes a less alarmist response to the changing world. In particular,
Butzer stresses the need for a non-anthropocentric view as “the dynamic menu of ongoing changes…
are by no means ready to be synthesised” (2015, 1540). This agrees with the commonly held view that
geological epochs can only be viewed at a distance, from a suitable perspective. Caution must
therefore be taken, as the study of the Anthropocene is a complex affair which must account for the
‘natural’ process of the Holocene and the subsequent layering of human activity (Butzer 2015, 1541).

Bauer and Bhan (2018) recognise the tendency for earth systems scientists to observe the
Anthropocene in terms of broad geophysical effects, therefore masking the nuanced impact of regional
human activities. Human impacts with such locational specificity could necessitate the use of different
terminologies, such as *Anthropoeurocene*, that reflect the prominence of particular regions in
particular periods (Edgeworth et al. 2016); the net effect of human activity is generated from “place-
based actors through a number of differentiated activities that have long been documented by both
archaeologists and cultural anthropologists alike” (Bauer & Bhan 2016, 13). However, it should also be
noted that significant disparities exist when considering the variation in anthropic effects worldwide
(Malm & Hornborg 2014); influenced by long term social, political and economic factors.
Understandably, many islands lie at the least impactful end of this scale, as they are attenuated by
their geomorphological size. Despite this, an island such as Malta is by no means devoid of the evidence of the Anthropocene. Where the earth systems approach to the Anthropocene may overlook the specificity of human activities, it serves to remind us of a core commonality shared by humanity. Gibson and Venkateswar (2015) dwell on this unifying nature of Anthropos and build upon the idea that the concept of Anthropocene is not yet fact, instead existing as a product of thought. To take this a step further, I would propose that thought – human cognition – is central to the Anthropocene’s physical origin (as opposed to its conceptual origin); the epoch’s genesis is rooted in the net effect of human cognitive traits which value species needs over environmental stability. The Goudie and Viles (2016) approach, perhaps inadvertently, encapsulates the interplay between the *longue durée* and *conjonctures* by emphasising the role of long- and medium-term factors with the onset of the Anthropocene. Laparidou et al. (2015, 1537), emphasise that humans have always had a role in modifying their environments, “as we employ flexible and novel solutions for the survival and well-being of our societies.” Captured within this is the sense of *événements* – the history of events – since niche construction (Smith, 2011) can be viewed as a short-term series of events, as well as a longer-term paradigm of human activity. In short, the three temporal categories of the Annales School of thought bleed together, as time progresses. Niche construction can be an event and a cultural pattern; cultural patterns can be viewed geographically and demographically; geography and demography are influenced by the permanence of societies and other natural factors – all of which can influence the creation of one’s niche. This cyclicity is a potential antithesis for Butzer’s (2015) need for analysis of the Anthropocene at a distance. In summary, the *longue durée* of the Anthropocene involves the creation of a complex feedback loop, where early human activities remain layered in the environment – and act as an influence for subsequent people.

5.3 The Maltese Archipelago and the *longue durée* of the Anthropocene

While keeping these thoughts in mind, we can turn to the islands of Malta. At present, visitors to the islands are met with a rich palimpsest of overlapping cultural history which has been carved into, and layered above, the natural limestone. Explicitly, much of the islands’ history is visible as built heritage, yet an almost intangible time-depth can be seen within the implicit traditions of the rural world. Neolithic monuments, flanked by terraced slopes, are surrounded by buildings of the 19th and 20th centuries. Each of these features is representative of short-term traditions yet intertwined through
time as people act relatively in respect to elements of the past present in their contemporary landscapes.

The central resource is, in essence, the islands themselves – with the limestone being the primary building material since the arrival of people. It is rare to encounter a structure that is not comprised of limestone blocks, especially those which are quarried from the Globigerina Limestone strata. This encapsulates the longue durée of the Anthropocene, at least locally, as the layers of human development are constructed using materials which were initially deposited during the Miocene Epoch (c. 5.3Mya – 23 Mya). Perhaps ironically, the voids left from this resource extraction have become refilled with the less dense waste of human activity. This has continued to such an extent that new landforms have been generated by the deposition of this anthropic layer, as can be seen at the Magħtab landfill. Fittingly, this site is now undergoing environmental management, including a landscaping programme which has constructed a striking set of terraces on this anthropic landform (See Figure 5.1). In many ways, Magħtab is a microcosm for the Anthropocene within the Maltese Archipelago, with its anachronistic terraces being carved to disguise the artificial nature of the location, appearing to mimic the local landscape. Yet, this approach is likely to be ignorant of the ancient and essentially human origin of terracing practices. This is indicative of an engrained mentalité where current landscape traits are perceived as the norm, irrespective of what the true natural state may have been.
Focusing on the issue of terracing, there are many similar longue durée traits worth considering. Primarily, the archipelago’s topography is dominated by the construction of terraces across all geological zones, through time. Thompson (2006) conveys how the shifting practices in wall construction evidence the gradual change in the cultural makeup of the islands, yet the walls still display a commonality that is millennia old. While the scientific analyses of the terraces may alter the understanding of some terracing practices, particularly where the geological variability is concerned, Thompson’s anthropological study still provides value in the form of the engagement with lived experiences. “The contrasting modes of wall, ancient and modern, are reflections of the values supported by the people of the times... No wall is created strictly favouring one ideal set of values over another. Rather, each wall is a complex of these contrasting values and their designs” (Thompson 2006, 34). Thus, the terraces are as much a cultural palimpsest as the wider landscape is. On a superficial level, they are the anthropic reshaping of the environment – with the creation of each terrace wall as an événement which involves a juxtaposed set of longue durée processes (quarried geology and subsequent soil erosion). Equally so, on a deeper level, these walls also represent their own palimpsest of fluctuating mentalités.

The blurring of mentalité and conjoncture can be seen within the system of land tenure in the islands, as demonstrated by Bugeja (2018) who outlines the division between established landlords/church land and peasant landowners. The entrenched stagnation of ownership made it difficult for less
economically viable farmers to acquire the land in which they worked. However, the availability of long-term perpetual leasing, *emphyteusis*, “elevated the tenant into a position of quasi-ownership” (*ibid.*, 26). While this form of lease represented balance between the landlord and the tenant, the short-term leasing that was available represented greater gains for the landlord – especially considering the fluctuating value of the land based on its perceived quality. More developed private land would usually be subject to higher taxation, which would be reflected in the leasing costs. In contrast, long-term leasing was commonly found with Government and Church land, which came with lower taxation and “very often characterised by feudal practices” (*ibid.*). Although the annual rent, *Qbiela*, relieved the farmer from tithe, they were obliged to repair field walls and not to sub-let land. Where extensive repairs were required, it was not uncommon for the landowner to intervene – assumedly as a matter of responsibility along maintaining an element of control. Where farmers invested in improving the land, at their own expense, it was common for landlords to increase the rent after the end of tenancies. Accordingly, tenant farmers were disinclined to move on from land they had heavily invested in – especially since no system of compensation existed to account for their improvements. Where landowners “were largely characterised by a strong sense of elitism” (*ibid.*, 27), it is understandable that tenant farmers would opt for long-term leasing in order to regain a sense of control over their destinies.

From the 1850s, there was a considerable effort to encourage the expansion of agricultural practices to the barren, xagħra lands. This served to increase governmental revenue and thus offset the cost of repairs elsewhere. Although this land was rarely productive, competitions were held to reward the most successful farmers, where the prizes were a valuable income source. In the period surrounding WW2, when the need for agricultural productivity was heightened, farmers enjoyed legislative changes that promoted their positive input – protecting them from excessive rent increase and harsh changes in lease conditions. Equally so, the landowner retained the right to reassess tenancy if the farmer was not operating the land adequately. Finally, in the post-war period, the accumulation of wealth and the rise of pensions resulted in the redevelopment of the land tenure system. With farmers retiring earlier and sub-letting their land, the overall amount of cultivated land increased while freeholding was in decline.

In essence, the rise of the tenant-farmer class, as described by Bugeja, is an artefact of long-standing tenancy practices. Although aspects of these practices have transformed through time, the process still maintained the architecture of the medieval traditions. This reflects the process of ‘Agricultural Involution’ (Geertz 1963), as increasing complexity is can be found within a seemingly static system. Tied to these practices, the personal experience of the farmer, as presented by Thompson, is
effectively encoded in the walls they build and repair; they are indicative the *conjonctures* that exist. Ultimately, these *conjonctures*, such as the expansion of land in the post-war era, are physically embedded in the *longue durée* as altered and abandoned land, now subject to unimpeded ecological processes. These ‘Anthroscapes’ ultimately reflect how short- and medium-term histories can directly influence the flow of the *longue durée*, therefore reinforcing how, at least in Malta, the Anthropocene has been present for a considerable period.

During the later 20th early 21st centuries, continual population growth and rampant development have placed renewed pressure on the landscapes of the archipelago. The traditional and historical rural locations are increasingly threatened by the advance of urban areas. A variety of public interest groups, utilising social media, have formed to raise awareness of the risk to the local heritage. When observing much of this development, it is noticeable that many sites remain abandoned. Not wishing to comment further on the specific causes of this, all that remains to be said is that modern development and expansionism is mimicking the drive to incorporate new land, as described above. Ultimately, both cases involve the inscribing of the Anthropocene; with the cyclical nature of the expansion beyond need perhaps being part of a medium-term *mentalité*.

5.4 Intensification

The concept of intensification is fundamental to the understanding of several longue durée environments. In this instance, the term specifically refers to the aspects of human activity which drive increased productivity from managed landscapes. Although this discussion refers to agricultural intensification, it is prudent to remain cognizant of the subsequent forms of intensification that are facilitated by increased agricultural output. Boserup’s (1965) model is a fitting point of departure. A basic interpretation suggests that population increase is supported by an advancing technological framework available to that population – in essence, that the carrying capacity of the land is constantly improved by greater investment of labour and/or the investment in infrastructure. Boserup (1975) pursued this further by emphasising the importance of the ratio between people and land as the central factor in determining productivity, within the context of a rural socio-economic system. Morrison (1994) stresses that archaeologists should exercise caution when using Boserup’s model as a means of understanding intensification, since the approach acts more like a typology of societies rather than a mode of analysis. Morrison notes that Boserup’s model cannot account for the myriad of strategies employed by societies through time and space. The restriction of Boserup’s model is its linearity and lack of clarity on the specific nature of what intensification involves; instead, research should focus on “delineating the actual paths of intensification” (Morrison 1994, 145). A more cautious approach should be adopted, especially considering the risk of dichotomous interpretations of
intensification/disintensification, with emergent complexity serving as a broad concept that encompasses the intersection between population and production – specifically, the genesis of a complex and self-organising system comprised a variety of actors (Marcus & Stanish 2006). Further to this, Miller (2006) stresses the nuances of intensification, noting the concepts of extensification and Fuller’s (2001) diversification as alternative routes to producing a result similar to Boserupian intensification.

In effect, there is an element of Annales school thinking that needs to be considered here – that production and intensification strategies are part of the cyclical process discussed earlier. Boserup could be interpreted as observing the concept of production as a string of événements, framed by the conjunctures of investment methods. The central caveats to draw from Boserup are that investment in pre-mechanised societies is often seen with an increase of labour using pre-existing tools and methods; productivity can be achieved through greater use of status quo techniques. Interestingly, it is worth drawing comparison with Geertz (1963), where the process of ‘Agricultural Involution’ was defined. In this instance, agriculture develops into a system of increasing complexity, with ever increasing land divisions dominating the outward appearance of the agricultural system. Comparison between both models suggests that each population continues to a point of maximal indigenous carrying capacity, from which new management strategies must be employed. Boserup (1975) posits the greater investment of labour/technology, followed by economic migrations, while Geertz observes increasingly complex social management. Crucially, only Geertz (1963) is referring to an island context. Boserup’s consideration of economic migration is attenuated by an island setting. Despite this, a fitting proxy would be the factors surrounding the socio-political setting of an island and how these influence the agrarian world. Boserup (1975) suggests that a population has little incentive to produce surplus beyond subsistence, unless external factors provide enough influence to generate a need. This is a vital idea to consider in the framework of the complex history of the Maltese archipelago.

5.5 Population

Dwelling on population as the motivator behind increased production, we must observe the complex demography of Malta through time. Undoubtedly, the complexity of demography is deeply interrelated to the growth of population and social networks. During the Neolithic and Temple Periods, these networks were primarily local-regional/Malta-Sicily, as evidenced by ceramic styles, with occasional outliers (Bonanno, 1986). Moving through the Bronze and Phoenician periods, the islands enter a wider maritime network (Stoddart, 1999), where the archipelago’s natural harbours served to
increase the external perception of the archipelago’s value. These periods represent the islands on the cusp of broad connectivity with the wider Mediterranean; something which would be achieved from the Phoenician period onwards. Later historical records provide insight to the islands’ relationship to the political powers of Sicily and the interplay between the needs of the inhabitants and the structure of wider regional politics. Thus, the phasing of population can be divided into two categories, sub-carrying capacity and post-carrying capacity. Since the islands have finite resources, it is logical to observe the periods that are drawing on insular means of production as distinct from those which rely on the outside world. Not surprisingly, the latter periods involve a marked shift in Malta’s inclusion within the extra-regional political world.

5.5.1 Sub-carrying capacity periods

Understandably, this category carries the most uncertainty, regardless of chronology and technology. There have been attempts by Renfrew (Renfrew, 1973; Renfrew and Level, 1979) to estimate the Temple Period population. From the perspective of this discussion, a prehistoric population estimate could act as an initial representation of the carrying capacity – assuming limited trade and population mobility. Renfrew’s estimates for the archipelago reached c. 11,000 individuals, based on territories defined by the positions of pairs of megalithic sites and the population required to build such structures. Perhaps more reasonably, Clark (2004) estimated a population of 1407 for the Late Neolithic of Gozo – based on 60% land utilisation and 2 ha of land per person. If we extrapolate this to include Malta, the total number becomes 8787. Grima (2008) presents a systematic analyses of estimated carrying capacity - based on areas of low slope (<5% gradient) and a minimum of 1.5 ha per person – which reveals pockets of low lying land totalling 7071 ha and supporting 4713 individuals. Usefully, the Clark and Grima estimations do not exceed records of the medieval population which was not reliant on imports as a means of sustenance. During the 14th Century, Malta exported grain to Sicily, although this is likely to have been an uncommon practice (Aloisio, 2007). During the 15th Century, the islands suffered due to grain shortages every 2-3 years (Wettinger 1982) which drove increased demand of Sicilian grain imports (Aloisio 2007). Referring to Table 5.1, below, the population is likely to have been between 8000 and 10000 individuals during this century. In contrast, Sagona (Sagona, 2015) presents a brief analysis of the potential carrying capacity of land with recorded archaeological field scars, although this is an unconvincing interpretation which is reliant on poorly applied, northern latitude, ethnography. In brief, the suggested land utilisation, based on Gregg (1988), is 0.62 ha to 0.73 ha per person and therefore would suggest a considerable difference in carrying capacity in comparison with the Clark extrapolation. Although this may initially conjure the idea of populations ranging towards the Renfrew computation, it is worth considering the highly undefined
nature of the prehistoric agricultural environment. FRAGSUS has highlighted the potential role of the hilltop plateaux for early agriculture, and emphasised the relative inaccessibility of the clay slopes (French & Taylor, in press). Finally, while observing the physical remains of the Temple Period, Malone et al. (2009) caution that the current record only offers a limited synthesis of prehistoric populations, with isolated sites providing an uncertain cross section of ancient communities.

<table>
<thead>
<tr>
<th></th>
<th>RUSLE 0-10 (t/ha/yr)</th>
<th>RUSLE 10-25 (t/ha/yr)</th>
<th>Grima (2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>3843.81</td>
<td>13997.61</td>
<td>7071</td>
</tr>
<tr>
<td>Population (1.5ha/person)</td>
<td>2562.54</td>
<td>9931.74</td>
<td>4713</td>
</tr>
</tbody>
</table>

Table 5.1: Carrying capacity estimates for the Neolithic/Temple Period of the Maltese Archipelago. Figures are based on areas of low slope and calculations of low soil loss, Figures from Grima (2008) provided for comparison.
The use of the Revised Universal Soil Loss Equation (RUSLE) provides a direct measure of soil stability, whereas the Grima (2008) model was based on the presumption of higher soil stability from low lying areas. These new estimations help extrapolate some of the recent environmental findings discussed in this volume and enrich the understanding of the lived experience of these islands during prehistory. Importantly, Grima’s (ibid.) approach should be recognised as meritorious as it sets the agenda for quantifying the past landscapes of the archipelago. Undoubtedly, future data and refinement of this GIS investigation will further delineate the parameters of early population in these islands.
Moving forward in time, the Bronze Age has had comparatively less research on population structure. Recchia and Fiorentino (2015) suggest that the Maltese Archipelago was still within carrying capacity at the end of the Temple period, with the Early Bronze Age population co-habiting with the indigenous in a manner that suggests the islands could support a subsistence based economy. The evidence from the Gozo survey (Boyle 2013; Stoddart et al. In press) suggests an expansion of domestic territory, with site clustering similar to what was seen during the Early Neolithic, and an intensity of activity at reused sites from earlier periods which is interpreted as a “recommencement of a cycle of domestic activity that was played out of the earlier Neolithic and Temple Period phases” (Boyle 2013, 287). Boyle also indicates the value of focal locations as loci of trade and communication, given their position on the
best routes to natural harbours. However, this perhaps contradicts the assertion that the Bronze Age was marked by a socio-ideological change, rather than a significant demographic change. Adding to this, a marked hiatus in cereal agriculture occurs in tandem with an increase in livestock grazing indicated by the palynological data (Farrell et al., 2020). This could be indicative of a net reduction in human activity on the islands or at the very least it demonstrates changes in land-use activity.

Progressing through the Late Bronze Age/Borg-in-Nadur phase, the accumulated data suggest a return to greater levels of productivity along with the establishment of defended hilltop settlements. The climatic fluctuations between arid and humid periods is reflected in the variation between adapted cereal taxa – which is indicative of local strategies to support population. The crucial difference that Recchia and Fiorentino (2015) highlight is the advantage of wider cultural contacts, which perhaps enable the used of climate adapted crops more readily than would be found with a less connected island community. This reflects that the Maltese Islands were beginning to enter the increasingly complex Mediterranean classical world. Phoenician activity in the archipelago is well documented, however the generation of a population estimate remains difficult due to the nature of contact and colonisation. The account from Herodotus (Book IV) tells of a building of trust through indirect trade at new locations. The Maltese Islands, with poor natural resources other than rock and crops, would appear to have little to offer Phoenician colonisers (Bowen-Jones et al., 1961; Blouet, 1963). However, such an assertion ignores the value of the archipelago’s sheltered harbours and strategic position between the North African littoral and the Near Eastern heartland of Phoenicia (Recchia & Fiorentino 2015). Considering this, there is an accepted model (Bondi, 2014; Sagona, 2015) of overlap between the Phoenician traders and the indigenous population, which ultimately gave way to a more permanent form of Phoenician settlement – highly evident from the rock-cut burial tombs. At this stage, the issue of carrying capacity becomes a little more tenuous as the presence of a trade network would suggest that the sense of supply and demand may have existed within the Phoenician period. The subsequent population development, and the transition of Phoenician (trading outposts) to Punic (hinterland management) (Vella, 2014), brought the Maltese Archipelago into the period of post-carrying capacity populations, or post-insular reliance – where the islands were reliant on external contact as a means of supporting local production capabilities.

5.5.2 Post-carrying capacity periods

Said-Zammit (1997) has produced a population estimate for the Punic period of the archipelago, with the estimate representing the population just prior to entry into the Roman world. Based on 100% utilisation of cultivable land (equalling 18,960 people on 60% of the total land area), Said-Zammit proposes that the total population was in the region of 17,555 individuals – with population
incrementally rising to this level. However, caution must be taken with the concept of complete land utilisation as geological factors render areas inaccessible to agricultural practices. Although technological innovation would improve accessibility, a significant area of land will always remain unavailable e.g. littoral and steep gradient locations. This is echoed by Alberti et al. (Alberti et al., 2018) in a logistical regression analysis of 19th century land quality assessment. Although this is discussed in detail in Alberti et al. (2018; In press), the central theme to consider is that the later historic landscape contained locations which spanned the gamut of agricultural viability. Notably, this includes areas of exceptionally poor agricultural viability, despite near-contemporary technology. By applying this new understanding to the landscapes from the classical period onwards, it is obvious that 100% utilisation of the environment is simply not possible. Returning to Said-Zammit’s (1997) work, it is straightforward to re-scale this estimate according to a reduction in available land. For example, at 60% utilisation of cultivable land (including the additional support of trade) the population would have been around 10,200. Although this is only speculation, it serves as a reminder that a more detailed analysis of the environment must take place – one which incorporates the pedological and spatial investigations of the FRAGSUS project.

In her study of the Roman Imperial and the Byzantine periods, Bruno (2009) states that there is no concrete way to determine the population size. She suggests that the recorded military garrison of 2000 (all male and of military age) is consistent with what would be expected for a significant population size. However, this overlooks the role of the garrison, perhaps suggesting that it served to defend/exert control over the local population, when in fact a frontier garrison may have had other strategic purposes and whose numbers should not be used as an indicator of local demography.

With the appearance of historical records, there is a more reliable basis for understanding the output and requirements of the Maltese Islands. Bowen-Jones et al. (1961, 133) provide a useful summary of the population record during the historic period which is adapted below (see Table 5.2), incorporating their comments and those of Cassar (2002). The first official census on the islands took place c. AD 1241, under the jurisdiction of the Norman King Frederick II. Across both islands the local governor, Gilberto Abbate, recorded 1891 families – which equates to c. 7267 individuals (Bruno 2009). However, comparing this figure with the table below reveals discrepancies. This emphasises the need for caution when scrutinising these early population records, using them as a guide to the general trajectory rather than as absolute fact, at least until the later Medieval period.
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Source</th>
<th>Comments by Bowen-Jones et al.</th>
<th>Comments by Cassar</th>
</tr>
</thead>
<tbody>
<tr>
<td>991</td>
<td>21000</td>
<td>Emir Yusef al Futah</td>
<td>Excessive in comparison with Giliberto’s report</td>
<td></td>
</tr>
<tr>
<td>1240</td>
<td>5600</td>
<td>Giliberto Abbate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1241</td>
<td>2199</td>
<td></td>
<td></td>
<td>Potentially the number of hearths as opposed to total population.</td>
</tr>
<tr>
<td>1400</td>
<td>10000</td>
<td>Bosio</td>
<td>Population did not exceed this number.</td>
<td></td>
</tr>
<tr>
<td>1419</td>
<td>8335</td>
<td></td>
<td></td>
<td>Established figure for Malta</td>
</tr>
<tr>
<td>1480s</td>
<td>9829</td>
<td></td>
<td></td>
<td>Established figure for Malta</td>
</tr>
<tr>
<td>1528</td>
<td>17000</td>
<td>Commissioners of the Order of the Knights of St. John</td>
<td>Number includes 5000 Knights.</td>
<td></td>
</tr>
<tr>
<td>1530</td>
<td>25000</td>
<td>Chev. L. de Boisgelin, Bosio and Fra Joannus Quintinus</td>
<td>Multiple suggestions of local population at 20,000 (plus 5000 Knights).</td>
<td></td>
</tr>
<tr>
<td>1535</td>
<td>22000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1565</td>
<td>31000</td>
<td>Order of the Knights of St. John</td>
<td>22,000 (plus 9000 Knights) pre-Great Siege.</td>
<td></td>
</tr>
<tr>
<td>1565</td>
<td>23000</td>
<td>Following casualties according to Zabarella and Bosio</td>
<td>20,000 (plus 3000 Knights)</td>
<td></td>
</tr>
<tr>
<td>1582</td>
<td>20000*</td>
<td>Grand Inquisitor Visconti (Malta only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1590</td>
<td>32290</td>
<td>Knight de Quadra, for the Viceroy of Sicily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1632</td>
<td>52900* (51750)</td>
<td>Enumeration under Grand Master de Pawla</td>
<td>48,450 (plus 4450 Knights)</td>
<td>Cassar presents 51750 excluding 5000 Knights</td>
</tr>
<tr>
<td>1736/40</td>
<td>66364</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1741</td>
<td>111000</td>
<td>Enumeration under Grand Master de Despuz</td>
<td>Conflicts with Ciantar’s assessment</td>
<td></td>
</tr>
<tr>
<td>1760</td>
<td>66800*</td>
<td>G. A. Ciantar. 1772. <em>Malta Illustrata.</em> (Malta only, excluding members of the Order of Knights).</td>
<td>Excluding members of the Order of Knights</td>
<td></td>
</tr>
<tr>
<td>1798</td>
<td>114000 (98000)</td>
<td>Boisgelin</td>
<td>Unreliable as Gozo estimate is 24,000. This conflicts with 1842 population of 14,000 as there is no known population migration to Gozo.</td>
<td>Cassar presents 98000</td>
</tr>
<tr>
<td>1807</td>
<td>115154</td>
<td><em>Almanaco di Malta</em> 1807</td>
<td>Based on Parish registers. 93,000 ‘native Catholic’ and 22,100 ‘other inhabitants and domesticated strangers.’</td>
<td></td>
</tr>
<tr>
<td>1828</td>
<td>115945</td>
<td><em>Historie de Malte</em> 1840</td>
<td>Little difference in comparison with the 1807 account. The plague may have limited population growth, however the enumeration process must be questioned.</td>
<td></td>
</tr>
<tr>
<td>1837</td>
<td>119878</td>
<td>Watson, S. B. 1838. <em>The Cholera at Malta in 1837.</em></td>
<td>Over-estimation is also a likely to be at fault here.</td>
<td></td>
</tr>
<tr>
<td>1842</td>
<td>113864</td>
<td>The First Census of the Maltese Islands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1871</td>
<td>200000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1931</td>
<td>245640</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>304991</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>355910</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although Bowen-Jones et al. (1961) scrutinised the validity of each of these estimates, the overview presents a much clearer idea of how the population has accumulated within the archipelago. At this juncture, the concept of Boserup and intensified production meets a complex socio-political structure where the nature of external events and external investment influenced activities taking place within the Maltese Islands. To chart this, the following section will consider the environment within which agriculture takes place – and which frames the adaptations driven by either internal or external influences.

5.6 The Agrarian Archipelago

To develop a synthesis of the development of intensification within the Maltese archipelago, it is essential to comment on the nature of the agricultural environment through time. This section will observe the geological and pedological constraints which provide the context within which technological and population changes occur.

5.6.1 The Agricultural Substrate

Lang’s (1960) study has acted as the foundation for the understanding of Maltese soils and their development. This study identified three main types of soil – Carbonate Raw, Xerorendzinas and Terra soils. Of the four Carbonate Raw series soils, two are formed from Blue Clay parent material (Fiddien and San Lawrenz series), one from weathered Upper Coralline Limestone (Nadur) and one from dune sand (Ramla). These highly calcitic soils conform to an A/C profile, where the upper horizon directly overlies the parent material, and contain a very low level of organic content. The Xerorendizinas, which were divided into three series (San Biagio, Alcol and Tal-Barrani), are largely formed from Globigerina Limestone parent material and also present an A/C profile. Normally grey, loose and powdery when dry, these soils have a high chalk and gypsum content with limited organic content (yet distinguishably more than the carbonate soils). Lastly, the Terra soils are found as terra fusca and terra rossa. Both are derived from Upper and Lower Coralline Limestone parent material and present an A/B/C profile. Terra soils are well developed with little organic content (although more than the previous soils) and the notable presence of ferric hydroxide.

In more recent years, an EU supported project, MALSIS - A MALtese Soil Information System (TCY00/MT/036), has developed an inventory of soil for the Maltese Archipelago (Vella, 2000; 2001; 2003). This has progressed from Lang’s considerable work to a quantitative survey which is aligned with the FAO World Reference Base (Food and Agriculture Organization of the United Nations, 2014) of soil. Specifically, this has reclassified the soils identified by Lang (1960) and added some more nicher
soils that were not previously acknowledged. Calcisols are noted as the most dominant and likely correlate with Lang’s carbonate raw soils. Linked by the Blue Clay parent material, Vertisols are another reclassification of the carbonate raw soils – defined by the deep clayey fissures resent during the dry summer months. Luvisols correspond to the terra soils, which are essentially relict soils with subsequent CaCO$_3$ concentrations which are indicative of the present climatic conditions. Utilising the WRB and working with archaeological considerations, French and Taylor (in press) have presented an extensive re-analysis of the soils across the Maltese Archipelago which emphasises a shift away from developed argillic brown earth soils (or Luvisols) as the result of anthropic factors – leaving an environment characterised by thin xeric soils and vertisol slopes. Thus, to manage this delicate situation, soils must be constrained by agricultural terraces and improved through the use of natural and artificial fertilisers.

5.6.2 The development of agricultural technology

Sustaining the agricultural environment requires the careful management of a variety of different factors. In the case of the Maltese Archipelago, soil conservation is the key to maintaining any level of agricultural viability. Given the restricted limestone environment, as described by Chatzimpaloglou et al. (Chatzimpaloglou et al., 2020b), the variety of soils available is relatively limited. This is exacerbated by the difficulties of geology, with the predominance of Blue Clay slopes, especially in Gozo. Sagona (2015) reports ethnographic accounts of 1830s soil production which tell of thin and friable soils, which have good agricultural return. However, where the landscape is denuded of soil, these accounts include the practices involved with the regeneration of a viable substrate. Generally, this relies on the breakdown of the soft limestone (usually the Globigerina), sometimes aided by manual interaction. Through weathering, and improvements such as manuring and crop rotation, the land can be ‘amended’ to something more viable and productive. Bugeja (2011) describes the practices of surface preparation, such as depicted in Jean Houel’s late 18th century drawing of Borg-in-Nadur. Typically, these involved the clearance of barren rocky areas, with the levelling of protruding stone and the infilling of negative space in the bedrock. Such preparation echoes the medieval ‘Red Soil Law,’ latterly incorporated within the Fertile Soils (Preservation) Act of 1973, which required anyone who is erecting a building to gather and preserve the red soil present at the building site. Thus, the legislative structure of the archipelago preserves an entrenched practice of bedrock preparation and redistribution of soil – to encourage better agricultural productivity.

Folk practices and accounts of pre-mechanised farming (Halstead, 2014) are invaluable to the interpretation of agrarian practices through time. Observed practices provide a reference tool for how ancient landscapes may have been utilised, with varying states of technological development. The folk
accounts reported by Sagona (2015) are the first ‘technological’ step in managing the landscape. Awareness of soil performance and the methods required for improvement were advances made during the prehistoric phases. French and Taylor (in press) describe pockets of developed Pleistocene soils which would have been readily available to prehistoric agriculturalists. Despite this likelihood, evidence from a number of ‘Temple’ sites suggests that much work was already taking place to improve the productivity of the soil prior to the construction of the ‘Temple’ buildings. Notably, soils at Ġgantija show significant levels of enrichment with settlement-derived organic waste, contained within what could only be described as a rudimentary terrace – based on the spatial setting of the soils (French & Taylor, in press). The related strata appear to underlie elements of the megalithic structure and represent an intentional accumulation of soil to form a viable agricultural topsoil. It could be postulated that this may be one of the earliest forms of agricultural terrace in the Mediterranean and beyond – however, further investigation would be required to confirm the veracity of this interpretation.

As the FRAGSUS project has revealed, the continual degradation of soils within the archipelago has led to the adoption of agricultural terracing in the traditional sense. This technology acts as an effective control mechanism for eroding soils. By physically altering the gradient of the hillslope, and creating additional surface roughness, soil can be captured and built into flat surfaces. Terracing is also advantageous as it maximises water retention within fields – which is vital in semi-arid locations. Labour investment therefore surrounds the construction and maintenance of terraces. On limestone bedrock, Pace (2004) has demonstrated the intentional ‘cutting’ of the bedrock surface, prior to the creation of a terrace structure, dating to c. 800 BC. (see Section 3.6 also). Although relating to a much later landscape, that practice can be seen at the site of Tal-Istabal, Qormi, in Malta where the FRAGSUS project used Optically Stimulated Luminescence dating in relation to the exposed archaeological landscape (Cresswell et al., 2020; French and Taylor, 2020; McLaughlin et al., 2020). Fundamentally, this practice is not dissimilar to the soil preparation techniques described by Sagona (2015) as the limestone cut during the formation process could be crushed and used as for soil formation, if not used in wall construction. Borg (1915) reflects that fields had reached a peak of development because of the division of land into terraces – ploughing was meticulous and reliant on the use of non-mechanised techniques, including the ‘Maltese plough.’ This device balanced the need for a strong steel ploughshare with the practicalities of maintaining a shallow depth of furrow which avoided exposing the bedrock. Borg also describes the use of the hoe, especially as a spade is not effective in the stony and stiff soils. The challenges, overcome by traditional practices and steel tools, were likely an even greater problem for ancient agriculturalists. The creation and development of soil is one achievement while the seasonal process of working the soil is another. Accounts such as Borg (1915) and Halstead
(2014) suggest that scratch agriculture, using simple tools, may have been very long established, perhaps since the prehistoric period.

Establishing a date for the onset of agricultural terracing is difficult in practice, as soil stratigraphy and chronology pose a significant challenge to overcome. A combination of thin soils and regular ploughing ensures that cultural material would lose its stratigraphic security. As material slowly erodes into terraces, there is a small chance of dateable material entering the fill. However, to utilise this, the material would need to be found in an intact deposit, or perhaps in the lower parts to the wall. Any secure dateable material relating to the formation of the terrace may provide a *terminus post quem*, while subsequent additions during the use of the terrace would represent a *terminus ante quem*. However, finding distinction between these would be exceptionally challenging when considering the stratigraphic nature of terraces. One potential way to overcome this problem is by using Optically Stimulated Luminescence (OSL) dating, which allows the acquisition of absolute dates from the soil itself. Although the uncertainties of soil accumulation would still apply to this technique, the use of relative accumulation profiling (Sanderson and Murphy, 2010) would enable a controlled observation of this effect alongside the use of direct OSL dating. This could be achieved in two ways. Firstly, an attempt could be made to date individual terraces (Davidovich et al., 2012), which could be an arduous and expensive process that provides dates with very specific spatial dates. A second, novel method, is to consider terracing’s effect on erosion into the valley basins. By searching for deep valley deposits, the use of OSL profiling could be used to relatively date terracing through the proxy of valley stratigraphy. Logically, the onset of terraces would constrain the amount of soil eroding into the valleys. By profiling a deep valley section, it is possible that the pre- and post-terrace erosion deposits could be identified and dated. In 2016, the *FRAGSUS* project tested this method at several sites. Dates obtained from the Ramla Valley, Gozo and the site of Tal-Istabal, Malta, show much promise for the technique. In the lower Ramla Valley, AD 1880 ± 16 is the date after which the degradation of the upper slope was constrained. At the latter site, AD 1620 ± 23 has been noted as the start of soil accumulation. Further samples were taken in the Marsalforn Valley and suggest colluvial accumulation from at least 1560±240 BC and throughout later prehistoric times, but do not directly constrain the period of terrace construction (French and Taylor, in press).

The two sites dated above represent the use of Globigerina Limestone and Blue Clay geological zones for terracing. Tal-Istabal, represents a continuation of the hard geology terrace construction methods – utilising the easily worked limestone to prepare a flat bedrock surface upon which a terrace can be constructed. Interestingly, this site also contained a deep channel for water flow from a cistern and an interconnected wheel well. As such, this weight of archaeological evidence is indicative of the Knights
period production intensification – and this is further corroborated by the OSL date. Similarly, in the Ramla Valley, colonisation and field demarcation in the mid-16th century AD associated with the Knights of St John suggests that the Blue Clay slopes were not intensified through terracing until at least this period and well into the late 19th century. This is likely because of the difficulty encountered when working with the soils on these slopes, as the plough horizon is no more than a restructuring of the parent material – a stiff, retentive argillic layer. The intensification of these slopes is therefore an artefact of a drive to increase productivity during the Knights of St John and the British Colonial periods, when a significant level of investment could be made to alter this landscape.

5.7 Balancing fragility and sustainability

The Maltese archipelago could be viewed as an allegory for the Anthropocene world. The analyses of the changing environment have shown that the influence of human actions can have consequences that remain for the longue durée. The flourish of agricultural activity in the later Neolithic caused resounding effects to the stability of soils on the islands. Through clearance of scrub and heavily worked soils, the processes of erosion and soil loss began. Quickly, people adapted by working to improve soils using uncomplicated enriching techniques in an attempt to sustain the viability of soil. However, the need to expand agricultural zones also arose, and is possibly visibly indicated by cart ruts (Pace, 2004) which have become inscribed into the bedrock. Although much uncertainty exists regarding the function(s) of the cart-ruts (Hughes, 1999; Magro Conti & Saliba 2012), a common interpretation is one of short-range commodity and communication routes, likely utilising wheels vehicles as indicated through geomorphological investigations (Mottershead et al. 2017). While the haulage may well have varied in composition, its perceived existence is indicative of more intensified landscape from the Bronze Age onwards, especially considering the ruts as markers of vectorised movement relative to upland areas. Equally so, the process of terracing has been occurring throughout the historic period, and probably stretches back in some form to the Late Bronze Age.

In summary, these threads of intensification would suggest a trajectory of growth throughout the prehistoric period that would have necessitated a greater output from the land. This is evidenced by the relationship between erosion and the establishment of terracing – at least as a proxy where the archaeological record is yet to fully support this conclusion. Although soil exhaustion may only be a marker of the most commonly used land, it is likely that a continually increasing population – associated with the rise of the Temple Period culture – were the true driving force behind the need to intensify the prehistoric landscape. It could therefore be postulated that the notable cultural change
between the Temple Period and the Bronze Age was partly influenced by the degrading agricultural landscape. Through time, population may have dropped through lower birth rates and out-migration – although FRAGSUS has confirmed that a complete abandonment did not occur. As such, sustainability gives way to fragility. From the later Bronze Age onwards, the influx of new technologies and external interests in the archipelago allowed the population to adapt the agricultural environment once more. The adoption of agricultural terracing helped to preserve the fragile status quo and is still extant in the modern era. Terraced ‘anthroscapes’ are an almost indelible mark on the landscape – one which states the general discontent with the natural processes of erosion. As such, they mark human intentionality to change the environment; rather than change occurring as a by-product. Crucially, in the Maltese archipelago, terracing is indicative of the longue durée effects of early farming practices. However, in the 21st century, the Maltese islands have managed to preserve a modest level of sustainability. Nonetheless the reliance on the land for subsistence rapidly diminished through the late 20th century – allowing the expansion of local produce and market gardening enabled by the permanence of knowledge within folk agrarian practices. This could be considered as ‘counter’ Geertzian; with the landscape having been intensified through terracing, and made sustainably productive – yet the pressure to work the land is driven by factors not necessarily related to sufficiency. In addition to development pressures growing hand-in-hand with an increasing population, the possible abandonment of marginal coastal zone agricultural land, particularly since the mid-20th century (Grima 2008), may have also had an important role to play. Together these factors could lead to a catastrophe not unlike that predicted by Bowen Jones et al. (1961). However continuing rampant development could lead to a much greater anthropic erasure of the agrarian landscape – well before any widespread environmental collapse takes place.
6 DISCUSSION

*Mingħajr art u hamrija, m’hemmx sinjorija*
(without land and soil, there is no wealth)
Traditional Maltese Proverb

6.1 Introduction

The central chapters of this thesis can be divided into two groups; Chapters 3 and 4 focussed on archaeological methodologies and scientific investigation, while Chapters 5 and Appendix 3 explore more generalised, yet deeply related, theoretical themes. Initially, this thesis was conceived to provide new insights regarding the agricultural terracing of the Maltese Archipelago and following preliminary investigations, it was decided that the direction this project should be an exploration of methodology and theory, rather than a chronological investigation of the phenomena. Primarily, this was the result of funding limitations at this academic level, coupled with a high-cost ideal dating methodology (discussed in Section 3.6.2). Fortunately, the varied investigative styles related to terracing enabled a wide choice of directions for this project. The critique and adaption of geoarchaeological approaches enabled this thesis to make use of historical land use data, as well as recent statistical analyses relating to folk understanding of the Maltese agrarian landscape. By employing a detailed scientific survey of terraced soils, this thesis encourages a shift in how archaeology should investigate terracing in a holistic manner. Crucially, this thesis pairs geoarchaeological methodology with a critical exploration of population theory and social cognition - facilitating a synthesis which layers valuable social meaning onto environmental facts.

This thesis has an appropriate scalar fluctuation, evident with the purpose of each exploratory chapter. Chapter 3 considers the macro-scale realities of agricultural terracing, while Chapter 4 employs micro-scale scientific techniques to compliment the former investigation. If Chapter 4 is to represent the narrowest point in an hourglass structure, then Chapter 5 is symbolic of an expanding scale – which considers the interaction between human populations and the Maltese Archipelago which they inhabit. Appendix 3 expands the scale of view further, considering aspects of landscape with are common to all human minds. Therefore, reflecting the varied nature of the preceding chapters, and following the scalar shift, this chapter will serve as the *ties that bind*, connecting each set of chapters with a broader discourse on archaeology, agriculture and the Anthropocene.

Furthermore, this discussion will be made in reference to the core aims of this thesis, as established in Chapter 1, which ranged between physical and social directions. Although Section 1.5. established the objectives in a logical order, this chapter will begin in the centre of these objectives - beginning with
concepts discussed in Appendix 3 and the connection of social and cognitive theory with the theoretical
direction adopted by this thesis (Objective IIIa). Following this, the results of fieldwork will be
incorporated into the narrative (Objectives I and II). Finally, this chapter will close with the
consideration of how this study relates to the Anthropocene of the Maltese Islands. The approach to
this chapter will therefore address all the aims of this thesis (Objective III).

6.2 Intensification, Extensification and Involution

The opening salvo of this thesis (see Section 1.4) briefly expounded the relevance of the anthropologist
Clifford Geertz and his work on Javanese agriculture. In particular, *Agricultural Involution* – “the
progressive complication, a variety within uniformity, virtuosity within monotony” (Geertz, 1963, 81)
– is a lens through which the agrarian environment of Malta can be observed. Geertz’s essential
proposition is that a given agricultural regime will develop to a point of boundedness, following which
progressive obfuscation occurs within the bounded spaces. In the case of terraces, fields become
delineated – increasingly so – to the point that all available agricultural space is incorporated, at least
as far as “inventive originality” permits (ibid.). From this point, successive ownership and tenure rights
are physically realised through the division and redivision of bounded plots.

Returning to the discussion of intensification (see Section 5.4), this concept deserves deeper scrutiny
in reference to involution. Millar (2006) draws attention to the overlap between intensification and
extensification – suggesting that both can arise from the use of novel crops, technologies and increased
labour. Following Boserup, intensification refers to the increase of yield within a given unit of land
(Fuller, 2001; Miller, 2006). Therefore, extensification refers to the increase of total land under
cultivation. In comparison, the FAO define agricultural intensification as “an increase in agricultural
production per unit of inputs (which may be labour, land, time, fertilizer, seed, feed or cash)” (Kenmore
et al., 2004, 3). This conflicts with the earlier definition as it encompasses both intensification and
extensification. Crucially, the use of either term would appear to be a matter of perspective regarding
space and place (see Section A3.3.1.), especially when considering the scale and boundedness of a
location. The dichotomy appears to reside within the sterility of space – intensification occurs within a
given space and extensification increases said space. However, if space is swapped for place (a location
constructed through knowability and perception) then the dichotomy is turned on its head. The
incorporation of new land within a given place is both extensification and intensification – as the
boundaries shift so too does the productivity contained within. This is reinforced by Boivin’s (2008)
assertion that the investment in soil is an investment in place. Shifting scales, the size of the landscape
(the collection of places) also influences the dichotomy. For island landscapes, a natural boundary
exists for intensification and extensification to comingle. Within the confines of an island, any extensification is also an example of Boserupian intensification, barring the unlikely engineering feat of land reclamation.

Geertz’s Agricultural Involution encapsulates both intensification and extensification as they each offer a route to a definitive or final form which, rather than evolving, becomes increasingly more ornate. In the example of the Maltese Archipelago, in/ex-tensification gave rise to the dominance of agricultural terraces within the islands. This landform represents the definitive form which supports agricultural activities in the region and climate. However, with steady increases in population (see Chapter 5), the terraces have been the subject of multiple divisions, thus reducing the size of individual plots. To combat this, poly-cropping offered a means of intensifying productivity from reduced plot sizes. In many ways, the combination of a restricted island environment and involution creates a near-fractal system – with the restricted places and their management strategies being a small-scale image of the wider landscapes and the islands as a whole.

Further comparison exists between Geertz’s involved Javanese agriculture and the Maltese case when the socio-economic systems are considered. In both cases, the influence of colonial powers has been felt, and effectively encasing the indigenous communities. The local communities were subject to the issues of increasing population, market dependence and contact with a governance which served as an interface to the wider world. This served to reinforce local practices which provided a source of social stability for communities. Land-tenure also shares some commonality, within Javanese sawah (rice terraces) being subject to communal ownership and labour, managed by the village as a “corporate body” (Geertz, 1973, 90). In many respects, the influence of the Church in Malta, through the Order of St. John, echoes the Javanese system, with its ownership and taxation of tranches of the landscape (see Chapter 3) – the Cabrei exemplifying this process.

Chapter 5 considers the ebb and flow of population in the Maltese archipelago, through time. Of particular relevance here is the Mediaeval period (1200AD onwards), during which the islands experienced successive changes in political control. At the time, agriculture was the primary driver of economy, supported by a free peasantry, with main crops of wheat, cotton and cumin. During the 15th Century, the islands became more reliant on the import of grain in exchange for the valuable cumin and cotton crops. Sicilian grain, which was a resource exploited by Norman, Angevin and Aragonese rulers, was regarded as higher quality than that produced in Malta and therefore a valuable return for the local produce (Aloisio, 2007). At this time, the Maltese Islands fell into the outer reaches of a core/periphery system as part of the Sicilian demesne – a system which was predicated on urban centres/elites acting to ensure “fiscal and commercial privileges” (Aloisio, 2007, 308). This perhaps serves to reinforce the role of the established local governance – the Universita/Jurati – which sought
to obtain exemption from grain taxation or *tratte*. When the Islands fell the rule of the Order of St. John, the semi-autonomous role of the *Universita* was agreed under the proviso that the ancient customs and privileges were to be maintained by the Order. This a proviso was later mimicked by the British who agreed to uphold the Declaration of Rights of the Maltese, thus acting as *protectors* rather than colonial rulers. Accordingly, the Order acted cautiously in respect to the islands - playing a careful game of power management with Malta (Abela, 2018).

The production of high value crops, especially cotton, continued until the mid-1800s (Bowen-Jones et al., 1961), following at least 600 years of production and export. The importation of cotton from Malta is recorded in Genoa during the latter half of the 12th century. During the 14th century there is reference to it being imported to a variety of places including Syracuse, Tripoli, Venice, Ancona, Bari and Barcelona. In the same period Pegolotti listed Malta as one of the six main cotton producing countries. During the 16th century, Rabelais used the phrase *blanc comme cotton de Malthe*, indicating the high regard which Maltese cotton enjoyed on the international market (Wettinger, 1982). Abela states that “the preference for cash crops as against staples not only brought in much-needed foreign currency which balanced against trade payments in respect of grain imports, but placed the island as a prime producer of specialised crops” (2018, 73). Furthermore, Abela posits that Malta’s “economic backwardness” (ibid.) should be viewed as part of a wider socio-political landscape – that a dearth of grain was the result of selective production of cash crops – and that the Maltese Archipelago was effectively part of a commercial agricultural system.

Returning to involution, the notion of a *hemmed-in* system is not directly applicable to Malta. As noted above, there can be initial comparison to the colonial histories shared by the archipelago and Geertz’s study of Java. However, Malta’s subsistence was reliant on the import of grain from abroad and from this was born the infrastructure attached to external political powers. While the role of the *Universita* may echo the rigidity of local/non-colonial socio-political structure in Java, one must question how this structure would have existed without external political relations. Geertz regularly suggests that the *crystallisation* of involution was visible within the preservation of the precolonial communal land tenure. Gordon (1992) suggests that Geertz’s approach indicates that colonialism either preserved or destroyed the colonised systems while failing to actually establish what the pre/peri-colonialism socio-economic systems were comprised of. Gordon’s critique also indicates an inherent dualism at the core of agricultural involution – the distinction between swidden and sawah agricultural modes and perhaps even the dichotomy of pre-colonial and colonial. The rise of involution is therefore to depart from evolution – “‘Involution’ is a deviation from the norm” (Gordon, 1992, 495). This critique suggests that Geertz, in some way, views the pre-colonial agricultural system as deviant and somewhat retrograde. However, it could be argued that Gordon is viewing Geertz through the lens of a bimodal dogma – that
agricultural involution is only capable of following a binary path. Considering that adaptation and change are fundaments of evolution, it may be better to consider involution as the gradual reshaping or, at least, a flux of the norm. The Maltese Archipelago offers no parallel for the slash and burn type swidden agriculture, with terraced agriculture being the predominant form. The lengthy history of agricultural trade, including the production of cash crops from the Classical period onwards, places the archipelago in a different frame of view to the system explored by Geertz.

The Maltese islands have existed, for at least two millennia, as a strategic holdfast in the central Mediterranean. This engendered a gradual population increase which has demanded subsistence support through the proxy agriculture of cash crops. Can the islands be considered as truly involved? There are superficial similarities, especially when considering agricultural morphology and local political structures. However, uncertainty lies with whether the Maltese islands failed to evolve. While the agricultural terraces exhibit a pseudo-fractal morphology reminiscent of involution, it must be noted that they are the product of a canny economy which was predicated on a restricted environment that supported valuable crops. In summary, it could be offered that Agricultural Involution is not an empirical theory, as observed by its critics (White, 1973; 1983; Kahn, 1985; Gordon, 1992), but merely a lens through which agricultural societies can be considered. It seems that fine detail problems found with involution, especially economically, limit the beauty of the model. Therefore, aligning with the theoretical direction of this thesis, Agricultural Involution could reside within a systems approach – especially one at the scale of Braudel’s longue durée. Here involution aptly describes the broad geomorphological patterns and the reflexivity between the land and culture without the need to be detailed on a quantitative level.

6.3 Landscape, Social Entanglement and Geertz

Braudel posits that “the longue durée is but one possibility of a common language arising among the social sciences” (1980, 51), which is a theme that is central to this thesis. It is an assertion which places any particular study within the wider remit of human experience through time, built from the acknowledgement of unconscious history and models. In essence, Braudel signifies that humans, more often than not, create history through a state of heedlessness which becomes apparent to scholars through the construction of models. However, Braudel stretches this Marxian tenet further by applying the power of individual perception – that “each one of us can sense, over and above his [their] own life, a mass history” (ibid.). Reflecting on Appendix 3, the very concept of landscape is rooted in the individual, and subsequently shared, perspective of the environment. In a similar manner to Braudel’s unconscious history, landscape is not necessarily formed through full conscious acts – habituation and
familiarity (Rochat, 2014) serve to aid their formation just as much as intentional acts of production and exchange (Tilley, 2006). These converging ideas reinforce a sense of entanglement as an allegorical medium – not the type portrayed by Hodder (2012) but rather something which instead aligns with Braudel’s use of models.

Agricultural Involution offers a model which inconspicuously contains the entangled nature of agrarian world yet lacks the historiographic element central to the Annales school of thought. This is not a critique per se, rather an observation of the difficulties of social science and the trappings of discipline. It is perhaps more eloquently stated, as follows:

“...the problem for anyone tackling the world scene is to define a hierarchy of forces, of currents, of particular movements, and then tackle them as an entire constellation... one has to distinguish between long-lasting movements and short bursts, the latter detected from the moment the originate, the former over the course of a distant time” (Braudel, 1980, 34).

Geertz presents a good example of landscape and its entangled properties, in an albeit indirect manner, with the discussion of sawah agriculture. Here the landscape of production – terraced and irrigated rice fields – essentially created a positive feedback loop for the associated social sphere. The loop/state of involution was described as being resistant to change, with innovation serving to “dampen structural change in the rural economy [rather] than to strengthen it” (Geertz, 1963, 91). The addition of new crops simply fitted into the pre-existing pattern of production, allowing terraces to be worked more intensively to meet the demands of rising population. It could therefore be said that the creation and habituation associated with terracing underpins their social biography. Population, supported by the habitual production of food by the landscape, intensifies through escalated habituation and the spread of land under cultivation. This reinforces the lifeways of the cultural system – individuals intensify the alignment of their sense of self through increased activity in the landscape and the growth of landscapes. Therefore, the resistance to innovation is not merely a cultural trait, but rather one which is shaped into and by the landscape. Were innovation to take hold in a terraced culture, it would have to be so radical as to change the morphology of the landscape as it would the routines of the population.

Agricultural Involution could be described as an expression of essential components of human cooperative endeavours – a method of understanding the self-fortifying nature of activities which align with how people acquire identities and form landscapes. Accordingly, this fits into Braudel’s category of conjonctures; the medium-term measure of structural histories. However, when considering terracing, the integral role of people in their creation defines them as anthropomorphic. Thus, human agency manifests as a geophysical force, which is a trait of the
longue durée. Furthermore, the stability associated with involution lends itself to the label of mentalité – a slow moving or persistent cultural trait which can be both long or mid-term. Considering these factors, the nature of terracing and agricultural involution can be seen as an amorphous form within the historical model of the Annales school, relevant at multiple – if not all – levels.

Observing social change from a different perspective, Rosa (2016) divides the process of social acceleration into three core components - technical acceleration, acceleration of social change and the acceleration of the pace of life. The first aspect, relates to the “intentional acceleration of goal-direct processes” (Rosa, 2016, 301) – the gradual advancement of production, communication and transport processes. Rosa’s second element refers to the development and change in cultural matters – “the escalation of the rate of social change with respect to associational structures, knowledge (theoretical, practical, and moral), social practices, and action orientations… primarily the accelerated change of fashions, lifestyles, work, family structures, political and religious ties, etc” (ibid.). The final element respects the apparent reduction of free-time which occurs with accelerated modernity. This critical theory provides an excellent addition to the congruence of Agricultural Involution and the longue durée. The technical acceleration encountered with terracing is directly related to the social change encountered as the method of production plays such a deep role in structuring the population’s lifeway – ultimately influencing the pace of life. Furthermore, the development of multi-cropping reflects a paradox indicated by Rosa whereby technical acceleration should serve to alleviate time resources, thus decrease the pace of life. In the case of multi-cropping, this technical acceleration encouraged further productivity from the terraces through an increased input of labour. Rosa notes that the loss of time resources only occurs when the rate of acceleration is greater than the rate of production/growth. In constrained island environments, where the issue of growth is so closely tied to the land, Rosa’s model gives further indication of a sense of stagnation that can occur in agrarian societies. Though there are manageable levels of production, the socially reinforcing nature of a terraced system eludes modernity. Rosa describes this as “territorial, cultural, and structural “islands of deceleration…” places where “time stands still”” (2016, 302). Such areas are not necessarily unable to modernise, instead they have either avoided it or simply remained static.

Social acceleration, when considered alongside Braudel, could apply at all levels of the Annaliste model of history. Technical acceleration could be viewed as both an aspect of the longue durée and as a conjoncture, considering the variation between broad advancements (e.g. agriculture) and more specific advancements (e.g. mouldboard plough). Equally so, the acceleration of social change could also fit both aspects too, considering broad patterns of activity (hunter-
gatherer/agrarian/industrial) versus specific shifts (generational – Wartime/Baby Boom/Generation X/Millennials/Generation Z) as examples of longue durée versus conjonctures. Furthermore, acceleration of social change could possibly be ascribed as an événement, where specific moments have a such an influence as to create a social fluctuation which has no shared dependencies with broader societal trajectories (e.g. Beetlemania). Finally, Rosa’s pace of life fits best with conjonctures and événements. While issues of individual freedoms do affect this (slavery, poverty), chronological and physical constraints determine available time resources – therefore abiding cultural norms at the time (conjonctures) or the necessity of current affairs (événements) define the concept of pace of life. Finally, it is worth noting that Rosa observes how social acceleration can be counteracted through five modes:

i. Natural checks – geophysical, biological and anthropic influences on speed.
ii. Islands of deceleration (as described above).
iii. Dysfunction as a by-product of accelerative change (e.g. traffic jams or economic recession).
iv. Intentional Deceleration – either functional to encourage future acceleration, or ideological to move away from modernity.
v. Rigidity

Barring ideological deceleration, all these decelerative modes could fit well with the case of agricultural involution and terracing by extension. The natural constraints of environment, when subject to technological change, become dysfunctional – either becoming an island of deceleration or facing cultural rigidity. Furthermore, crop rotation and fallow periods can be classed as function deceleration. Reflecting on the resistance to change noted by Geertz and the concepts of deceleration, Surowiecki’s (2004) assessment of crowd wisdom offers informative parallels which help explain these cultural processes. Group wisdom relies on a collective understanding of the world, or at least the group’s world. Polling this wisdom with a specific query usually results in an answer which is mostly, if not completely, correct. In the case of insular groups, Surowiecki suggests that imitative behaviour is higher, and the available pool of decision makers is relatively sparse, leading to conservative decisions and a general mitigation of risk. Fostering this, conservative/risk-averse strategies are preferable within groups as “sticking with the crowd and failing small, rather than trying to innovate and run the risk of failing big, makes not just emotional but also professional sense” (2004, 49). This phenomenon is described as herding and had been documented in situations where there has been great opportunity for independent thought. Considering the adoption of new strategies, Suroweicki describes the role of information cascade, where piecemeal information transfer and sequential decision making serves to accelerate the legitimacy of a new strategy within a group – “people fall in line because they believe they are learning something important through
the example of others” (2004, 53-4). Regardless of direction, the quality of a collective decision can be predicted by the role of a minority of influencers whose decisions are legitimised by the cascade effect. Ultimately, this process of “imitation is a kind of rational response to our own cognitive limits. Each person can’t know everything. Within imitation people can specialize and the benefits of their investment in uncovering information can be spread widely when others mimic them” (2004, 58).

The association of Rosa and Suroweicki, with Geertz and Braudel provides a tentative concept of how the multi-faceted fluctuations of time, technology, people and ideologies intersect – with the intersection being a sense of entanglement as described in Appendix 3. In the case of terraced environments, the landscape is an integral part of the feedback loop – having been created by humans it can then act to reinforce the cultural patterns that exist within related groups. This can ultimately promote a cultural deceleration, or rigidity, which is fostered by a herd mentality that arises from insularity. In the case of terraces and Agricultural Involution, widespread insularity effectively resisted the genesis of innovative thinking – resulting in a system which displayed increasing complexity as opposed to dynamic change.

6.3.1 Considering Posthumanism

The concepts introduced above, and within Appendix 3, prompt the need to consider their place within posthumanist discourse. In particular, the prospect of landscape being integral to the extension of human cognition is reinforced by the discussion in section 6.3. – encouraging the need to understand the nature of defining human.

“Posthumanism rejects human exceptionalism and seeks to de-centre humans in archaeological discourse and practice. Linked to this is the so-called ‘ontological turn’ (aka the ‘material turn’), a shift away from framing archaeological research within a Western ontology and a movement beyond representationalism (i.e. focusing on things themselves rather than assuming that objects represent something else)” (Díaz-Guardamino and Morgan, 2019, 321).

Braidotti (2013) describes posthumanism and in the flux of materialism and vitalism – both embedded and embodied. It could be therefore be described as a synthetic framework within which human-environment/landscape interactions can be better understood. Posthumanism represents the combined ideas of what comprises the idea of human – the nature of human as a porous term which can be described in many unique ways. At the core of our sense of humanity traits such as gender, sexuality, identity, race and class indicate the plurality of human. This creates a sense of openness to the concept of human; there is no one set way of defining what a human is. Within this mode of thought, the idea of transhumanism is used to describe the acts of moving beyond a typical sense of
humanity, through augmentation. The ultimate concept of transhumanism would be cyborg, which is the blend of human biology and biotechnology. However, transhumanism can also include contemporary, ‘mundane’, augmentations such as prostheses and pacemakers. Such additions bear enough significance to become incorporated into one’s sense of human – yet that same sense would not accurately describe another individual. Roden describes transhumanism as the “itinerary for the perfection of human nature and the cultivation of human personal autonomy by technological means” (2015, 9). Central to transhumanism is the idea of morphological freedom which relates to both physical and mental freedom. Roden posits that a prime tenet of this philosophy is the use of technology to “amplify and enhance human cognitive powers” (2015, 14). Clark, as discussed in section 6.3.4., postulates that humans are Natural Born Cyborgs (2003) who have always integrated cognitively with cultural constructs – a process of externalism known as extended mind thesis (Clark and Chalmers, 1998; Clark, 2008) which reconciles a similarity between mental processes and their functional equivalents in the external world. However, the transhumanist philosophy is aspirant in nature, focussing on the potential for posthumanity in the future, with present humanity exerting some form of intermediate state.

Dwelling on vital materialism, see Section A3.3.4., and the vibrancy of things (Bennett, 2010), Braidotti presents the concept of a new scientific theory described as matter-realism which “combine[s] the legacy of post-structuralist anti-humanism with the rejection of the classical opposition ‘materialism/idealism’ to move towards ‘Life’ as a non-essentialist brand of contemporary vitalism and as a complex system” (2013, 158). Therefore, given the time-depth of human interaction with vibrant objects human beings can be described as being posthuman. A central facet of this posthumanity can be found with the entangled relationship between people and their landscapes. Appendix 3 established the how human thought extends beyond the body (sensu Clark), to incorporate the landscape within cognition. This is further developed by section 6.3. with the embedded role of landscapes as a reinforcing agent of cultural processes. In summary, the interconnection between people and landscapes demonstrates that the concept of humanity has a permeable boundary. While crossing this boundary may constitute a state of transhumanity, e.g. the cognitive role of landscape, the long-term effects of such interactions, those that become culturally interdependent, e.g. Agricultural Involution, exemplify the need to observe people through the lens of posthumanism.
6.4 Malta, Terraces and their Theoretical Setting

Centring the focus of this discussion on the terraces of Malta, this section will incorporate methodology-based findings of Chapters 2 and 3 with the theory encountered above and in Chapter 5 and Appendix 3. Section 6.2. has already situated the discussion of Agricultural Involution within the framework of the Annale School, using the Maltese Islands as a case study. This fostered a need to understand how involution relates to the extension of cognition and the reinforcement of cultural traits – ultimately being a post humanist trait. To draw all themes together, this section must address how the terraces of the Maltese Archipelago fit within this discourse and consider if they are demonstrative of the theory that has been constructed. Accordingly, this section will consider Objective 1c, as presented Chapter 1 – consider the relationship between social practices and the physical and chemical character of the terraces. To accomplish this, information originally presented in Chapters 3 and 4 will be interconnected and then reviewed with the reference to the theory developed earlier in this chapter.

6.4.1 A Hypothetical Model of the Terracing of the Archipelago

Previously, Section 3.5.1 presented a tentative timeline for the development of agricultural terracing within the Maltese Archipelago. This section will elaborate upon that model by incorporating elements discussed regarding geochemistry, from Chapter 5, as well as socially relevant factors from this chapter and the preceding. Table 6.1, below, presents the chronological model first proposed in Chapter 3 along with interpretive considerations arising from subsequent chapters.
<table>
<thead>
<tr>
<th>Stages</th>
<th>Period</th>
<th>Description</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Early – Mid-Holocene</td>
<td>Formation of Blue Clay ‘shelf’</td>
<td>Erosion of Upper Coralline stratum produces a shelf-like feature on the underlying Blue Clay. This is a natural terrace-like feature.</td>
</tr>
<tr>
<td>II</td>
<td>Late Neolithic – Iron Age</td>
<td>Early terraced features</td>
<td>Terrace-type soils present at Ġgantija (French et al., 2018) and terraced (non-agricultural) features at Mġarr ix-Xini (Azzopardi, 2014).</td>
</tr>
<tr>
<td>III</td>
<td>Classical</td>
<td>Viticulture Landscape</td>
<td>Adoption of natural locations (Stage I) and use of outcrop edges (Azzopardi, 2014). Ubiquitous cultural manipulation of Coralline and Globigerina is well established. Establishment of olive growing and oil press sites from before the 1st Century BC (Anastasi and Vella, 2018).</td>
</tr>
<tr>
<td>IV</td>
<td>Classical – Medieval</td>
<td>Expansion of agricultural terraces on ‘hard’ geology</td>
<td>Expansion of landscape to support pressures of increasing population through time (Bennett, 2020b)</td>
</tr>
<tr>
<td>V</td>
<td>Early Modern</td>
<td>Appropriation of marginal land</td>
<td>Constraints on erosion in Blue Clay valleys (French and Taylor, 2020) and historical incentivisation for cultivation of barren garrigue land (Maltese: xagħri) (Bugeja, 2018).</td>
</tr>
<tr>
<td>VI</td>
<td>19th/20th Centuries</td>
<td>Abandonment of unsuccessful terraces</td>
<td>Social stratification (Bugeja, 2018) and restrictions placed on peasant farmers (see Chapter 5) encouraged a decline in the use of terraces on marginal land. 43% reduction of utilised agricultural land in late 20th Century (Role et al., 2005).</td>
</tr>
</tbody>
</table>

Table 6.1: A chronological model for the establishment and proliferation of agricultural terraces across the Maltese Archipelago. Interpretations following investigations presented in Chapters 3-6.
6.4.1.1 Stage I

Considering a *longue durée* history and the geological composition of the islands, this stage refers to the gradual erosion of the Upper Coralline strata as a primary contributing factor to the eventual terracing of the islands. As detailed in Chapter 2, the Upper Coralline limestone overlies the Blue Clay – sandwiching a thin stratum of Greensand. The friatic nature of the upper layer contrasts with the homogenous mass of the clay; and the erosion of the former usually results in the separation and collapse of boulders, while the latter erodes in a more subtle manner. Consequently, the Upper Coralline erodes rapidly at its limits and material collapses downslope. In effect, this crumbling leaves the upper surface of the Blue Clay with the morphology of a shouldered hillslope, with a level bench as the upper surface. This creates a rudimentary terrace which, from an agricultural viewpoint, has the added benefit of water outflow from the Greensand, following percolation through the Upper Coralline. This erosion of these Miocene deposits primarily occurs within the Holocene and contributed to an environment characterised by steppe landscapes with cyclical spreads of *Pistacia* (lentisk) which were tied to periods of increased humidity (Farrell et al., 2020). This environment eventually gave way to one of grassy steppe, maquis/garrigue, with some minor woodland. Importantly, from 6067-5821 cal. BC the first agricultural colonization is indicated by the presence of cereals (*Avena/Triticum* – oats/wheat, *Hordeum* – barley) in pollen assemblages (ibid.).

6.4.1.2 Stage II

If the previous stage relates to natural terrace morphology that pre-existed, then this stage represents the formation of non-agricultural terraces. As discussed in Chapter 3, the concept of building a terrace existed within the islands from at least c.500 BC, as found with the construction of upland ritual sanctuaries. Moving further back in time, the presence of terrace soils have been noted at Ġgantija, Gozo (French et al., 2018). The megalithic structure itself is set into the natural terraced form of the eroded Upper Coralline limestone – which forms a set of three steps in the topography. Evidence exists for a terrace soil which buried a palaeosol from after the later 2nd millennium BC. Therefore, it can be surmised that this location had a worked agricultural surface at the edge of a natural terrace feature. Furthermore, the underlying palaeosol reveals a similar micromorphological character, with less humic material – suggesting that this surface was also an agricultural layer which existed at the edge of a natural terrace, dating to the mid-2nd millennium BC with the potential for an earlier occurrence dating to mid-3rd millennium BC. Crucially, all examples within this stage indicate either the construction of a terrace for non-agricultural purposes, or the existence of agricultural processes on a naturally terraced landform. It seems prudent to distinguish these from the concept of intentional agricultural terracing proper. The wider environment was open, with a growing component of cereal cultivation and grazing.
The intensification of agriculture and expansion into more liminal areas has been indicated by soil fungal spores and corrosion-resistant pollen taxa. Furthermore, there is a noted increase in proportion and variety of weed taxa which may suggest that agriculturalists were fighting a battle between productivity, erosion and weed growth (Farrell et al., 2020).

6.4.1.3 Stage III and IV

Regarding the Bronze Age and Classical periods there is uncertainty surrounding any precise measure of the population and agricultural need. Following a reduction in cereal pollen coinciding with the end of the Temple Period (2350 cal. BC) there are pollen and spore taxa which suggest wider arable and pastoral practices taking place away from coastal areas (Farrell et al., 2020) and potentially verifying the reorganisation of the landscape associated with the Early Bronze Age (Grima, 2007) need for more protected settlements. Between 1000 cal. BC and AD 1000 (Late Bronze Age, Punic and Classical periods), there is growing evidence for a degraded landscape and significant soil erosion with cereal pollen rising through the Punic period and peaking during the Roman period (Farrell et al., 2020). Historical sources (Bruno, 2009) attest to established populations of pine, juniper and olive (Pinus, Juniperus and Olea) by the 11th Century AD and this as largely been confirmed by the FRAGSUS project (Farrell et al., 2020) although there are noted taphonomic issues with the pollen record.

As time progressed from the Temple Period (sans agricultural terracing) to present day, agricultural terracing has increased to become the dominant landform. Stage III indicates the earliest intentional terracing for agricultural purposes. Referring to Stage I, it can be hypothesised that the Blue Clay shelf morphology could have been adapted into a terrace at this point, particularly on Gozo. Where a relatively level bench pre-exists, it is possible that agriculture, utilising natural water outflow from the Greensand, could be carried out here and bounded by walls on the slope side of the bench. However, this hypothesis remains to be ground-truthed. Figures 7.1 and 7.2, below, illustrate examples.

Requiring a more considerable input of labour, sites at the limits of a Lower Coralline outcrop in Gozo have been shown (Azzopardi, 2014) to be agriculturally linked from the 6th-5th Century, through evidence of vine presses, quarrying and field construction. As suggested in Section 3.6.1., the concept of a terrace (in the non-agricultural sense) existed in the architectural morphology of the post-Temple Period inhabitants of the archipelago and it is during this stage (loosely attributed to the Phoenician-Classical and Byzantine Periods) that the proliferation of agricultural terracing occurred at these suggested vantage points in the landscape. This is corroborated by the sedimentation evidence arising from the FRAGSUS project (French and Taylor, 2020) – indicating a significant erosive period which extended from the mid-2nd millennium BC, culminating during the 1st millennium BC. While further research is required to ascertain the nature of this period and the subsequent constraints on erosion,
it is plausible that the establishment of terracing at valley bottoms, along the edges of outcrops and weil systems, may have acted to stem the loss of soil.
Figure 6.1: Orthographic projection of Ta' Kuljat, Gozo - looking South West. This image illustrates the natural shelving effect that occurs beneath Upper Coralline outcrops (Google Earth 2019).

Figure 6.2: Orthographic projection near Il-Bahrija, Malta, showing the edge of a Coralline outcrop with terracing directly beneath the outcrop edge (Google Earth 2019).
The subsequent development of landscape, Stage IV, is characterised by the eventual proliferation of terracing across the archipelago. This stage relies on the proxy of population change, alongside archaeological evidence from the Medieval period. Wettinger (2011), discusses population growth, after AD 1000, following a phase of decline during the Arab period. Part of this growth, poorly indicated by toponyms, includes the improvement of arable agriculture. Rahal, meaning village, indicates settlements which were likely base around both arable and pastoral agriculture, with over 100 identified in archival records. Tied to this, Wettinger notes the appearance of galcae, rubble walled fields, which were constructed to protect crops from sheep and goats. In the first instance, Wettinger emphasises that there is no record of rahal in Gozo. This perhaps reflects this island’s limiting geomorphology in so far as it may not have supported arable farming at this point – perhaps with the Blue Clay slopes as yet uncultivated. Secondly, the appearance of ‘rubble walls’ – which is usually a catch-all term for field walls whether terraced or not – indicates a sense of boundedness and appropriation that evokes concepts discussed in Appendix 3. These walls would have been labour intensive, and visible as significant landscape capital. While galcae may or may not include terrace walls, the investment of labour for either instance is on a similar scale. Conflicting opinions on this matter can be found, with Horden and Purcell asserting “that the proprietor is able to transcend the limitations of individual micro-environments, and to override their divisions” (2000, 237), while Foxhall (2013) suggests that laborious installations such as terraces can be accomplished by small-scale farmers during spare time. In either case, the benefits of the investment serve to alleviate future labour costs within that plot. Galcae are indicative of a trend towards landscape investment that had not occurred since the Punic and Roman periods. While no specific evidence of Arab period terraces can be presented, Grove and Rackham (2001) note that terracing was introduced in Spain during this period, as part of agricultural improvements in occupied territories.

Historical records, discussed in Chapter 5, indicate a general growth in population through time, aided by the archipelago’s fluctuating socio-political status. It can be hypothesised that the land would encounter greater use with increasing population, and an increase in terracing accordingly. However, the timing and nature of this remain unavailable at present. Notionally, the latter part of this stage, the Medieval period, provides a greater record for the use of the landscape and the significant use of terracing e.g. Tal-Istabal (Section 3.4.2) where soil accumulation begins AD 1620 ± 23 (Cresswell et al., 2020; French and Taylor, 2020). Increasing proportions of Poaceae, Plantago (Carroll et al., 2012), and grassland molluscan species Truncatellia callicratis (Hunt and Schembri, 2018) are most likely related to the drive to adopt terracing during this period (Farrell et al., 2020). Chapter 5 discusses the variability in subsistence patterns during this period, noting fluctuations between the agrarian economy operating in states of need and plenty. Considering that cumin and cotton, being non-subsistence
linked, were primary cultivars along with wheat (Aloisio, 2007). The search for sufficient grain was "a constant preoccupation" (Abela, 2018, 110) for Malta's rulers both before and after the Knights. The islands' agriculture was focussed on niche products because of their requirement for less land, and the "relative infertility of the land" (ibid.). These crops were of a high-quality and in demand in foreign markets, thus acting as a source of income for the local population. "This cultivation strategy was beneficial in offsetting the substantial payments which the island had to pay out to import almost all of its vital necessities" (ibid.). The arrival of the Order caused a c.25% population growth, not including the additional foreign presence attracted to the islands as a result of the Order's position there. This influx of people created a higher demand for food, and the Order understood the value of negotiating duty-free imports in relation to maintaining adequate governance of the islands. Abela intimates that the observed lack of grain production should be tempered by a preference for cash crops – a commercialisation of agriculture – which elevated the archipelago’s status to that of a main producer of niche crops.

Reflecting on the galcae and the growth in political influence of the Order of the Knights of St. John, it should be noted that the cabrei, discussed in Chapter 2, are an indicator of the development of agricultural morphology – serving to record locations that have been terraced by the time of compilation (Alberti et al., 2014; 2018). In essence, these laborious investments perhaps arose as quasi-projects within the local culture, neither explicitly commanded nor only reliant on an individual’s more – an exercise in best interests and a Braudelian mentalité of sorts.

6.4.1.4 Stage V and VI

The latter stages continue this theme of wider socio-political encouragement, with Stage V representing the 19th Century AD attempts to cultivate the barren, xaghri, areas of the landscape (Bugeja, 2018). Bugeja indicates that 19th century agriculture was attenuated by a relative lack of investment – the result of higher-status landowners, many absentee, who were preoccupied with rent collection above all else. As detailed in Chapter 5, the peasant farmer was effectively discouraged from developing improvements to the land. By the mid-20th Century, in the wake of two World Wars, the archipelago was particularly well linked internationally – partly a result of its strategic location and partly because it was a British colony. By this period, the peasantry had waned and was replaced by more prosperous tenant-farmers. However, between 1956 and 2001, the total utilised agricultural land has reduced by 43% (Role et al., 2005). During this period, Malta claimed its independence from Britain and operated as an unaffiliated state until accession to the EU, in 2004. Although total agri-land use was in decline, a 3.6% increase in utilised agricultural area was noted between 1990 and 2001 (ibid.). This included the reuse of abandoned agricultural land and some reclamation of natural garrigue.
habitats, reminiscent of 19th century activities. It is possible that this small increase arose through a growth in economic stability that would ultimately be required for successful accession to the EU.

6.4.2 Methodological Results and the Speculative Timeline

The methodological endeavours presented in Chapters 3 and 4 have contributed new insights to the nature of terracing in the archipelago. Primarily, Chapter 3 has facilitated the creation of the speculative timeline, expounded in the previous section. This has been constructed from limited test excavations in conjunction with an exploration of available archaeological and analogous information. Focusing on the visible morphology of the land, the tested location showed elements of both continuity and change when compared with 19th Century cadastral mapping. While there was only a slight shift in terrace boundaries, attributed to downslope erosion, it was noted that new terrace features appeared, resulting from the ploughing and reshaping of the more established fields. In both cases, evidence for the construction methods was surmised. Given the difficulty of working the soil, it has been established that the Blue Clay terraces were unlikely to have been constructed until the advent of iron or steel tools. Considering the need for socio-economic impetus, discussed above, it is therefore unlikely that these terraces were constructed until the later medieval period – likely coinciding with the Order of St. John. Furthermore, the time-depth of the cabrei could be used to suggest that the terraces depicted are at least 150 years old – given the relative stabilisation seen between the mapping and present analyses – which would place them within the Knight’s Period. Anecdotally, the site of Tal-Istabal (Section 3.6.2), dated by the FRAGSUS project to AD 1620 ± 23, helps corroborate the notion of Knight’s period terrace construction. Further to this, the excavation results showed no evidence of soil reworking, which suggests that their creation was a large-scale exercise that has persisted without subsequent manipulations. This has been confirmed through the augering carried out as part of Chapter 4 – although future work may yet prove this assumption to be incorrect. Placing this within the model, Chapter 3 represents activities which took place during Stage IV, when terraces proliferated across the islands following socio-political encouragement.

Chapter 4 presented a more detailed study of the geochemical function of the terraces as a method of understanding their ecological function, particularly in relation to the cabrei. The resulting data were found to be somewhat converse to the expected outcomes. In essence, the detected fertility of soils, as derived from geochemical methods, indicated the opposite of what was expected from fields which were classified by the cabrei. Curiously, while there is a notable negative correlation between soil nutrients and cabreo classification, there is a positive correlation between soil clay fraction and reported land quality. These salient results may indicate some possible folk interpretations of land quality. Firstly, the positive correlation between clay and the reporting of good land could be tied to the properties of soil clay which aid the uptake of nutrients in plants. However, the relative lack of
nutrients observed, coupled with no correlation between organic matter (%LoI) and clays, would suggest a lack of enrichment befitting a good classification. On the other hand, the correlation of nutrients with the areas reported as poor may be indicative of a pattern of low usage, preserving the available nutrients or allowing sufficient replenishment. Therefore, it could be suggested that the *buona* fields are relatively exhausted, with the *cabrei* evidencing the knowledge of their relative value and engendering preferential use. Conversely the poorer fields, including those on *xaghri*, have been more readily avoided leading to the relative increase in recorded nutrients.

These ambiguities are also symptomatic of the reliance on the *cabrei* as a reliable source of information regarding the historic understanding of the ecology of agriculture. These maps were created at the behest of the state (Alberti et al., 2018) for reasons unknown. It should be speculated that they were used as a method of monitoring controlled land and associated revenue, as well as a means of drawing tithe from farmers working the land. By commissioning an overview of holdings that includes a classification of land quality, these locations are ascribed with an implicit value system. Anecdotally, the sale of land owned by the Knights of Malta, in Villamaura, Sicily, as part of an Italian legislated sale of ecclesiastical land (Schneider and Schneider, 1976) could exemplify how parcelled land could have utilised land use classification to realise value. Overall, while it remains unknown how this value may have been exercised, it does not require an imaginative leap to consider the nature of institutions and their taxation of individuals. Concerning the later middle ages, c. 50 years prior to the arrival of the Order of St. John, Bezzina (2001) has outlined that the élite were able to set taxes via their relationship with town councils, and also evade taxation as a result of this link. Schneider and Schneider (1976) note that the land sold in Sicily was largely bought by the *gabelotti* and *civili*. These groups were of higher status in society and the *gabelotti*, particularly, are mentioned by Bezzina (2001) as middle-class tax collectors appointed within villages. Given the entrenched nature of these institutions within Maltese history, as protected by the Knights (Section 6.2), a cultural awareness of corruption and tax evasion is likely to have permeated through time. Where any classification exists, the motivation behind this exercise should be queried, alongside the actors involved. What were the various purposes for the creation of the *cabrei*? Who was responsible for providing the input/yield figures that supported the classification? Furthermore, how do the *cabrei* reconcile any variability in farmer ability? Thus, the 1860s *Cabrei* may have carried the trappings of such social issues. For the purposes of this thesis it is prudent to recognise such an opportunity for an unreliability that may be inherent to early modern institutional surveying. While the *cabrei* are interesting and worthy of continued study, their reliability as a window unto past landscapes is questionable. Furthermore, extrapolations such as Alberti et al. (Alberti et al., 2018) may exacerbate the effects of this unknown social element.
6.4.3 Maltese Terraces and Agricultural Involution

The 20th and 21st Century Maltese agrarian landscape is one defined by fragmentation, with most plots of land being under 1ha. This can be attributed to the local laws of inheritance, particularly *Intestate* inheritance – where a will is not available – with which holdings are divided between surviving legitimate family (Role et al., 2005). Thompson (2006) comments on the diminishing maintenance of the agricultural walls in the archipelago, indicating that this growing fragmentation has led to a state of disrepair and the growing need to reparecel land to improve the viability of farmland – a difficult legal process. These traits bear the hallmarks of Agricultural Involution and indicate a need to push beyond the confines of *crystallised* system. However, Thompson adds that there is an increasing desire for landowners to lease to other farmers, rather than working the land themselves, therefore maintaining the fragmentation present. Furthermore, the governmental protection of traditional walls requires individuals to act to repair and preserve them. The combination of fragmentation and increased tenancies is a system which is difficult to enforce and leads to the eventual degradation of abandoned land. Further negative consequences of this *involved* fragmentation include a higher demand for access roads, a lack of modern farming techniques, poor economic performance from farms and ultimately increased abandonment (Role et al., 2005). The viability of farming is under wider constraints, as outlined by MEPA (2018): dearth of available land in proportion to geographical area and population density; low availability of natural resources, especially water; increasing urbanisation and land costs; reliance on imports of foreign fodder and an associated lack of bargaining power; division of human and physical resources; and the effect of individualism.

Thompson relates that Maltese independence encouraged a popular sense that people could break free from the confines of labour that historic populations were accustomed to. “The catharsis of the change in social hierarchy inflicted a disdain for the rural lifestyle and an embracing of the new tourist industry... The division between these industries, farming and tourism, manifested itself in a social geographic boundary whereby tourists are expected to remain near the coast and farmers are limited to the inlands” (2006, 34). In recent years, farming has become a largely (89%) part-time pursuit which is predominantly (55%) practised by individuals over 50 years old (Role et al., 2005). The National Agricultural Policy describes farming as:

“*primarily a lifestyle with skills and knowledge that are mostly acquired through practice. When farmers speak about the notion of inheritance, they do not only refer to passing over their farms or fields to their offspring but also the means to work in the sector including rural skills that are alien concepts to the non-farming population. Notwithstanding the fact that such skills can be improved through education, research and capacity building, the farming lifestyle does not*”
permit much free time in order for the farmer or livestock breeder to engage in formal education” (MEPA, 2018, 30).

Ultimately, it is recognised (ibid.) that farmers are actively discouraging their inheritors from becoming the next generation of agrarians – encouraging them to eschew tradition for the prospects of improved living standards through more stable income from the diverse industries present on the islands. The rigidity of indigenous agrarian practices and the increasing brain drain further constrain the ability of local agriculture to respond to economic and climate demands.

Therefore, it seems entirely likely that the archipelago is reaching a point of agricultural finality, at least on this trajectory. The stagnation of the physical agrarian world is symptomatic of socio-economic processes – a self-perpetuating cycle which will lead to the collapse of the local farming culture as a result of the longue durée of agricultural involution. Geertz (1963) draws comparison between Java and Japan, indicating that Japanese agriculture successfully advanced through the development of technological solutions – enabling each farmer to increase their productivity.

There are crucial differences between this Maltese case study, and examples present by Geertz. Firstly, as explored in Chapter 5, the Archipelago’s population has grown without a true reliance on local production – largely, subsistence has been supplied through trade and augmented through local agriculture. Linked to this, there is no ‘rival’ mode of practice – no equivalent of the slash-and-burn swidden agriculture which was an alternative to the terracing of sawah. Ultimately, these differences are a product of the archipelago’s restrictive environmental factors – particularly size and geology – and when considered alongside the role of imports, a low impetus for improvement can be understood.

However, there yet exists the potential for an evolution of the local practices. Just as technological advancement improved productivity in Japan, Malta’s inclusion the wider socio-economic diaspora of the EU has encouraged new thinking. Aligning with the Common Agricultural Policy (CAP), Malta has acted to remove import duty on agricultural commodities. Alongside this, a new status – Special Market Policy Programme for Maltese Agriculture (SMPPMA) – secured the production of certain staples including fresh fruit and vegetables, potatoes, processing tomatoes and viticulture (MEPA, 2018, 28). The National Agricultural Policy (ibid.) notes that this scheme was used by some sectors until 2014, but outlines that this may have led to a quantity-not-quality approach to compete with the foreign market. This trend reflected consumer habits that were sustained by a competitive open market – rather than helping shift habits through the promotion of local products. Farmers operate in a competitive gamut which is becoming increasingly more difficult to compete with imported goods (Spiteri Gingell et al., 2010).
In many ways, this reflects elements of a *mentalité* of familiarity with external sources which was likely to have been exacerbated during WW2, when the archipelago was a focal point for international activities in the region. From the Knights Period until WW2, the commercial agriculture (cotton and cumin) provided vital exchange goods for cereal imports. These would have been augmented with local vegetables to support subsistence. Historically, traditional meals were based on any ‘exotic’ goods – breads and soups made from cereals, pulses and potatoes. At some point in the late 20th Century, a shift towards a savvier level of consumerism has placed further pressure on the local agricultural market – intensified by EU related schemes following accession in 2004 and, “to some degree, is a result of past inward-oriented policy with which domestic supplies were secured to the maximum possible extent” (Spiteri Gingell et al., 2010, 74).

The National Agricultural Policy indicates that, despite the issues of an ageing and deteriorating agrarian population, there may not be a “labour force vacuum” (MEPA 2018, 29) as the fluctuation of market needs and capital investments is shifting the nature of local agribusiness. The protections provided by these larger economic schemes inhabited the sector from diversifying its approach to the market – with farmers acting more as individuals and constraining their ability to generate higher returns from the market through collective action and the recognition of new marketing areas. (Spiteri Gingell et al., 2010)

While SMPPMA may have inadvertently flooded the market with high quantities of products, and suffered as a result, a learning process occurred – one which is slowly encouraging an efficient, resourceful and profitable agricultural change. This could be seen as the seeds of adaptation and evolution for local agriculture. Between 2001 – 2005, the area of irrigated land increased by more than 100%, facilitating intensive cultivation (MEPA, 2010) – especially when compared with the trend for increased utilisation of agricultural area and decreased total agricultural area, discussed in Section 6.4.1. Attard (2009) comments that the limiting environmental and climatic factors may also be a source of positive directionality, with demands on crops having increased selection pressures through the need for maximised production – resulting in a distinctive agricultural genetics where Maltese species are valued for their resilience both locally and further afield.

Malta ranks low, among EU member states, with regard to innovation/knowledge transfer and there is an accordant national determination to remedy this, with the adoption of agritech innovations being regularly advocated for, especially to face climate challenges. Here, the real battle requires local research and innovation to occur in cooperation with rural actors, incorporating the complex cultural factors such as attitudes, risk perceptions, values and motivations. To accomplish this and to combat the ageing agrarian population, a considerable investment is required. Fortunately, a rural imitative mindset will facilitate the eventual uptake of new approaches (Spiteri Gingell et al., 2010).
Therefore, the Maltese Archipelago, through shifting *conjonctures* – from colony, to independence and accession to the EU – is poised for a new intensification of the agrarian landscape. Crucially, this may be built on the fields of the *involved* past and will expand using the implicit cognitive effects of involution – forging a new *mentalité* which is based on less agricultural individualism and a promotion of the value of locally produced crops. A more stable agricultural sector may attract a non-traditional and more highly educated agricultural population which is willing to utilise its educated statues to drive innovation – funded by regional/super-regional financial schemes.

6.5 Terraces, Posthuman Ecology and the Anthropocene

The primary goal of this chapter has been to braid the multi-threaded approach that this thesis has taken. Ultimately, these strands have fallen into three main chords: 1.) agricultural terrace ecology; 2.) socio-politics of the archipelago; and, 3.) social theory. Within the opening chapter, the concept of systems theory was introduced to facilitate a study which was not chronologically linked, nor culture-specific. Developing the concept of archaeology as a form of human ecology (Butzer, 1982), systems theory allows the understanding of archaeological phenomena, such as terracing, in a framework of nested scales of understanding. Each of the central themes of this thesis provide valid and interleaved contributions to the understanding of the system within which they are incorporated. Central to this systems approach is the role of *autopoiesis* – systems maintenance via the networked reactions of components. As discussed in Section 1.4.1, there are three significant concepts involved – *structural coupling, structural determinism and social autopoiesis* (Capra and Luisi, 2014) – which can now be fully related to this thesis.

Structural coupling denotes how a system is structurally related to its environment, through which interactions promote structural change within the system. Structural determinism denotes the nature of these interactions of living and non-living systems, the former involving adaptive change to inputs and the latter being subject to causality. Social autopoiesis outlines the nuances of systems theory, as applied to biological networks, are present within social networks –

“an organized ensemble with internal rules that generates both the network itself and its boundary... Each social system...is characterized by the need to sustain itself in a stable but dynamic mode, permitting new members, materials, or ideas to enter the structure and become part of the system” (Capra and Luisi, 2014, 137).

Observing agricultural terraces physically/superficially, coupling and determinism are essential to terracing as an anthropic creation – they are crafted into the natural environment and therefore
are part of the flow of natural and anthropic changes. However, structural determinism here is nuanced where human activity is concerned. Terracing, if abandoned, will ultimately be subject to reactionary determinism – with changes being natural in origin yet mediated by the environmental influence of terraces. For example, left unattended, terraces will stem the erosion of soil but will eventually begin to destabilise, collapse and eventually return to a natural slope and aspect.

Given the continued supply of human interaction, determinism becomes a matter of response – events happen, human managed terraces react and adapt. Using the previous example, the collapse of terraces would provoke maintenance exercises, which would extend the life of the system. Various levels can be added here, increasing the nuance of the system. For example, crops nest within the system – and crop growing techniques/regimes within that. Each of these levels can influence the surrounding levels e.g. people build terraces, influence the soil and plant crops – crops influence the soil, people respond by altering the planting regime accordingly. Furthermore, these levels are subject to wider systemic processes, such as climate and tectonics.

As agricultural terraces are anthropic in nature, humans are central to the understanding of this system. Here, social autopoiesis integrates with each level/nested system. Humans operate as a geophysical force, shaping their environments; and as a driver of climatic change, influencing the regional and global systems over time. Historically, the understanding of the local environment would have informed landscape management practices. Through time, as socio-cultural networks grew, and larger political entities formed, the autopoietic role of humans began to influence multiple levels at once. Broad cultural and political trends, e.g. the Green Revolution, have a reach that affects both wide scale human-linked systems and the lifeways of individuals. Therefore, when considering Agricultural Involution, the framework of a systems approach helps provide additional contextual enrichment. Involution is coupled with the environment, through the creation of terraced landscapes – which are themselves coupled with human action. Furthermore, involution is a route through which structural determinism occurs; existing an autopoietic manner which reinforces social patterns. In effect, Geertz was describing significant aspects of a landscape system which arise as a product of interaction of a variety of other systems of different scales. Additionally, the nebulous form of involution through the Annaliste lens, as described in Section 6.3, lends further credence to Geertz’s model as a system (sensu Capra and Luisi 2014) – having multiple applications within and across scales of observation.

In a similar manner, the Anthropocene can be used as a concept applicable to multiple levels. Superficially, the Anthropocene relates to the measurable shift from the Holocene epoch to a new, human-induced, epoch where the impact of human activities has a quantifiable effect on the environment and global stratigraphy (Crutzen and Stoermer, 2000; Crutzen, 2002). In this way, the
concept of the Anthropocene is firmly part of Braudel’s longue durée. Yet, as the Anthropocene is not yet a rigid term (Steffen et al., 2011), its place within in Annaliste history is also manifold. *Conjoncturally*, the concept increasingly creeps into popular discourse as a mode of communicating the mounting pressure to alleviate climate change, influential in political and cultural spheres as an evocative notion which is vague to the advantage of rhetoric and art.

Bauer and Bhan’s anthropological critique of the Anthropocene emphasises a variety of ideas that are central to the broad systems view adopted by this thesis. They posit that the popular concept of the Anthropocene is one predicated on the modernist binary of nature and culture; one which centralises the “Eurocentric notion of mastering Nature” (2018, 74). To the contrary, humans should be viewed as acting within an assemblage with climate and the environment alleviates the problematic nature of institutional socio-political narratives through the past three centuries. In other words, the Anthropocene is typically discussed in a reductive manner; relating to a narrative involving global political, economies and the post-industrial culture. Fundamental to their synthesis is the centrality of anthropology (and archaeology, by extension) to incorporating the alternative narratives of “earth’s many differentiated nonhuman inhabitants” via multidisciplinary studies which are “better positioned... to historicize and expand the ways through which people embedded in the materiality of a warming planet experience it, perceive it, constitute it, and attempt to reassemble it” (2018, 126). Ultimately, the reductive political mentalité of the Anthropocene – where the entirety of humanity is responsible for redressing the course of climate change; where Nature is external – serves to mask the nuances of human civilisation and the gamut of actions. Furthermore, the historicity of the role of humans in climate change is restrained by the attempted placement of the Anthropocene’s ‘golden spike’ – “the marker is not the epoch; it is just a marker” (Hamilton, 2015).

Thus, this thesis arrives at a crucial juncture of theory and ecology. The Anthropocene as a concept should be viewed as inherently posthumanist, relating to the assemblages of climate, people/cultures, environment/landscapes and time. Goudie and Viles (2016) argue for the phasing of epoch to represent the varied intensity of trajectories through time (see Section 5.2) in a manner which can be enhanced by Bauer and Bhan (2018). Furthermore, utilising the Anthropocene as a theoretical lens, its status as a mentalité can be projected through time as a way of contextualising human mindsets towards the environment. Hamilton (2015) reinforces that the golden spike is not the sole definition of the epoch and, in a similar manner, this thesis argues for a deeper appreciation of the posthuman relationships which involve humans and their environmental context. In this sense, the posthuman ecologies, integral to landscapes, are essentially built from the time depth of these human-environment interactions. A golden spike is ignorant of the long-term processes...
which are implicitly involved in Anthropocene concepts. The trajectories of change that are visible now have deep historic and cognitive origins and are entangled through time accordingly. Therefore, the Anthropocene is not reducible to a single point but instead must be examined as the reflection of posthuman and enmeshed cognitive predispositions towards the use of the environment.

6.6 Resilience

The variety of theoretical and methodological directions that have been brought together by this chapter are deeply related to the concept of resilience – “the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks and therefore identity” (Walker et al., 2006). Tied to this definition, which is rooted in systems theory and ecological studies, are concepts of significant thresholds which bring about systemic changes; adaptive, inter-scalar, cycles; and co-management strategies (Plieninger and Bieling, 2010). While these are centred on people and their environmental interactions, they also relate to the posthuman discourse explored throughout this thesis. The theories which contribute to this theory of landscape, enmeshed and posthuman, exhibit resilient characteristics. Agricultural Involution, as rationalised above, promotes social rigidity which is entwined with the physical adaptation of the landscape, in turn influencing processes observed as conjunctures and longue durée. Furthermore, the intersection between posthumanism and systems theory lend support to the role of mentalités as factors which influence resilience – as cultural ideas which promote, sustain or challenge the status quo of a system. Moving beyond this work on the Maltese Archipelago, there have been several studies which elucidate the nature of resilience in agrarian landscapes.

Archaeological investigations in the Iberian Peninsula have revealed the long-term impact of terracing by the Andalusi people. A rapid phase of pragmatic terrace building, during the 8th century AD, helped contribute to a landscape that is now among the most productive in semi-arid areas, yet is deeply reliant on its historic plan despite subsequent alteration (Puy and Balbo, 2013). Considering the thresholds described above, Puy, Muneepeerakul and Balbo (2017) have outlined the role of population sizes and socio-political factors in the maintenance of managed landscapes. One threshold pertains to the critical population required to support the system, below which systemic collapse occurs. The other major threshold is the population level that engenders diminished per capita returns from the agricultural system. In the case of irrigated terraced landscapes there is a trend towards such sub-optimal returns and these systems have been shown to suffer population decline where environment and social uncertainty occurs. More generally, Puy (2018) has demonstrated that
irrigated agricultural land increases at a rate that exceeds population growth – a trait which builds resilience within a system. However, it is noted dryland agriculture may only grow marginally or linearly with population since such systems usually involve larger proportions of land and relatively fewer people. Near Eastern research (Avni et al., 2019) has indicated that, although agricultural infrastructure promotes resilience, wider social pressure can negatively impact a group’s resilience.

In effect, these examples demonstrate the interplay between people and their environments and indicate the nature of the complex equilibria that is determined by these systems. With drylands, and semi-arid regions such as the Maltese Archipelago, there exists the opportunity to study the nature of resilience within the context of contemporary global climatic pressures (Balbo et al., 2016). The confluence of longue durée processes, conjunctural environmental management and the mentalité of climate awareness now places new pressures on resilient systems. Traditionally small-scale societies are now being thrust into a more global spotlight, with Malta being a prime example, where increased social complexity and technological innovation can alleviate many of the pressures traditionally encountered. However, the resilience of terraced landscapes – based on this chapter’s findings – is found with the long-term influence on people and environmental processes; an adaptable archetype which can support shifting mentalités as much as shifting soils.

6.7 Concluding Remarks

This chapter has brought together the broad range of themes explored by this thesis and placed them in context with the core aims set out in Chapter 1. Specifically, this discussion has outlined the relationship between social practices and the physical and chemical character of the terraces and in doing so, it has described the relationship between agricultural terraces their associated physical and social environments (Objective II). Building on this there has been consideration of how terracing connects with modern discourse on climate change, the Anthropocene and continued social development in light of increasing human pressure on the environment (Objective III). In summary, agricultural terracing forms part of a complex systems view, engaging posthumanist theory to contextualise the explicit and implicit relationships between climate, environment, people and culture. Through this framework, complementary theories – Annaliste History and Agricultural Involution – have been incorporated and have illustrated the complex and entangled nature of nested systemic processes. The background presence of posthumanism facilitates the connection between ecological geoarchaeological studies (Chapters 2 and 3) with varied theoretical discussions (Chapters 5 and Appendix 3).
In summary, this chapter has demonstrated that the concept of humanity has permeable boundaries (Section 6.2) and that the extension of cognition to the external world, e.g. the cognitive role of landscape, can have the long-term effects that become culturally interdependent, e.g. Agricultural Involution, exemplify the need to observe people through the lens of posthumanism. Terraced environments demonstrate that the landscape is an integral part of the feedback loop which reinforces the cultural patterns that exist within cultural groups entangled with that environment – potentially fostering a cultural rigidity. Specifically, the process of Agricultural Involution resulted in a system which became increasingly complex with no source of dynamic change. The Maltese Archipelago, subject to a variety of Annaliste processes (Section 5.3) which have reinforced the agricultural narrative over time. However, modern patterns have indicated that the archipelago may be poised to break the mould of involution, utilising the historic fields as a means of intensifying local and collaborative production encouraged through wider cultural support from the European Union. This potential flourish of a new mentalité is nurtured through the broad entanglements of environment, people and cultures operating at different scales – an enmeshed network of systems that contribute to each other in varying ways. Where landscape and culture are concerned, this is the function of the Anthropocene: the posthuman framework which describes the entangled systems of environment, people and things.
7 CONCLUSION

7.1 Thesis Origins

The concept of this thesis surfaced from the need to understand how the landscape of the Maltese Archipelago transitioned from a prehistoric (pre-terracing) state to the managed agrarian morphologies of the 19th Century, that were in turn the foundation of the contemporary Maltese agrarian landscape. From the perspective of the FRAGSUS project, the scientific methodology of this thesis elucidated new understandings of how the prehistoric landscape was utilised and how the archipelago’s restricted environment influenced human activity. The later landscape component of the FRAGSUS project presented the study of 1860s cadastral maps which included land quality classifications (cabrei). Ultimately, this work unconsciously promoted a new, quasi-phenomenological, perception of how the agrarian landscape was utilised prior to the rapid modernisation of the 20th century. The period between these temporally distinct sections of the FRAGSUS project required a more detailed investigation to bring them together, which this thesis has successfully accomplished.

In this respect, the issue of agricultural terracing was fundamental as it is one of the prime anthropogenic features of the islands, alongside quarrying. The ubiquity and plausible antiquity of terracing made the terraces central to the study of the agrarian narrative. Specifically, this thesis was conceived to establish whether agricultural terracing acted and continues to act as a fundamental part of the resilience of fragile landscapes in the Mediterranean, and beyond.

7.1.1 Thesis Aims

The thesis aims, as introduced in Section 1.4, were established to draw upon the author’s knowledge of archaeological science and cognitive studies; thus elucidating a programme of study that was meaningful to the advancement of methodological and interpretative investigations of agricultural terraces. To reiterate, these aims were as follows:

I. Establish a chronological model for the onset and proliferation of agricultural terracing in the Maltese Archipelago.

II. Investigate how agricultural terracing contributes to the delicate resilience of fragile landscapes in Mediterranean environments, such as the Maltese Archipelago?
   a. Characterise the salient physical features of Maltese agricultural terraces.
      i. Establish an optimal method for the investigation of terraces, which includes geoarchaeological and chronological factors?
   b. Characterise the geoarchaeological and geochemical properties of terraces.
   c. Outline the relationship between social practices and the physical and chemical character of the terraces.
d. Explore how this study is situated within wider studies of terracing in the Mediterranean and beyond.

III. How does terracing connect with modern discourse on climate change, the Anthropocene and continued social development in light of increasing human pressure on the environment?

a. Where possible, indicate the demonstrable links between human cognition and the appropriation of the environment – thereby demonstrating the posthuman theory at the core of this thesis.

In simple terms, this programme of study set out to establish a chronological framework for the development of agricultural terracing (I) which is entangled with the social and environmental narrative that ebbs and flows through time. This narrative could then be parsed to understand how terracing contributes to long-term environmental change (II) and how it is linked to wider themes of climate change and the human appropriation of the environment (III). The following sections will present how these objectives have been met by the relevant chapters within this thesis.

7.1.2 Theoretical Summary

This thesis has employed a broad set of theories which have embedded the project within a meaningful interpretative framework. Butzer’s (1982) *Archaeology as Human Ecology* established a strong basis of systems theory in relation to human landscapes. *The Systems View of Life* (Capra and Luisi, 2014) was utilised to refresh the work of Butzer and facilitated the exploration of terraced landscapes as part of a nested tier of systems – environmental, social, physical and conceptual. This offered a way to understand how differing scales of knowledge are deeply entangled, and ultimately inextricable. Therefore, this theoretical direction enabled the examination of both methodological and cognitive directions, guiding objectives designed to elucidate a holistic study of terracing. From an anthropological perspective, Geertz’s (1963) *Agricultural Involution*, provided comparative detailed observations of a social system at work in Java, and how this related to the agrarian landscape. Geertz’s work provided a model system related to terraced agriculture which could be compared with the Maltese Archipelago. The entanglement of systems was bolstered by the consideration of posthumanism, which decentralises the role of humans and places them within the complex network of actors and environments. In summary, this study was as much an attempt to describe the phenomenon of terracing within systems theory as it was an attempt to examine their function empirically. The latter cannot exist without the former.
7.2 Objectives and Conclusions

This section will outline the major conclusions of this thesis in relation to the central objectives, within the generalised theoretical themes described above. These objectives represent three particular ways of coalescing knowledge that has arisen from the congruence of systems theory and posthumanism within this PhD. For this reason, there is substantial convergence and overlap between these objectives.

7.2.1 Objective I – The Chronological Model

The formation of a chronological model for the onset and proliferation of terracing was paramount to the overall direction of this thesis. The successful completion of this objective produced a basis of understanding for the social and environmental contexts applicable to terracing. By establishing a timeline in Chapter 3, the socially and environmentally linked theme of intensification (Chapter 5) could be considered and applied to the interpretation of the model (Chapter 6). Ultimately, this model indicates that terrace-type landforms existed within prehistory. While not agricultural in purpose, these display a pre-existing technological basis for their subsequent agricultural counterparts. While this does not provide the satisfaction of a fixed point in time after which agricultural terracing proliferated, it has encouraged new thinking regarding how research may approach acquiring this.

7.2.2 Objective II – Terraces and Resilience

The overarching theme of this thesis was to investigate if agricultural terraces were fundamental to the resilience of semi-arid environments, using the Maltese Archipelago as a testbed. To unpack this, Objective II was established to understand how terraces could impact upon environments and their associated social landscapes. While this objective was expansive, all parts were entwined by the theoretical backdrop of this thesis; systems theory and posthumanism offer the tools to understand these various strands in harmony. Chapter 2 parsed a catalogue of pre-published material and identified a suitable gap in the research narrative for this thesis to follow and thus responding to the need to establish an optimal methodology (Objective II.b.i.) This methodological gap was examined within Chapters 3 and 4.

The physical features of the terraced landscape (Objective II.b) were investigated within Chapter 3, through limited archaeological intervention. This tested the validity and palimpsest of the historic cadastral mapping (Cabrei) utilised by the FRAGSUS project (Alberti et al., 2014; 2018). This thesis has shown that, in the c.150 years since these maps were commissioned, there have been notable changes to the terraces studied within the Blue Clay geological zone. This was visible in the form of terrace wall collapse and the formation of ‘floating’ terraces, a by-product of terrace management strategies. Furthermore, this investigation suggested a relatively straightforward stratigraphic sequence to
terraces located upon Blue Clay geologies. The strata were heavily derived from the geological parent material, with the topsoil being made distinct by its anthropically altered in structure. Objective II.c – the elucidation of the geoarchaeological and geochemical properties of the sediments – represented a natural bridging point for the methodological shift between Chapters 3 and 4.

While the excavation required for the Chapter 3 was successful, the methodology was necessarily adapted to explore the wider role of terraces and their social implications. In Chapter 4, 190 samples from 64 locations were analysed, creating an unparalleled geoarchaeological investigation of agricultural terracing. Through the implementation of broad-spectrum geochemical analyses (pH, magnetic susceptibility, loss-on-ignition, particle size, ion chromatography and x-ray diffraction), this investigation provided a new insight into the agrarian landscape of the archipelago. This was achieved by comparing these data to 19th Century cadastral land quality assessments (cabreí) and a statistical regression study derived from these historic maps (Alberti et al., 2018), undertaken as part of the FRAGSUS project. This chapter revealed a negative correlation between the perceived land quality recorded in the nineteenth century and the detected level of nutrients available today. Land classed as “good” contained a larger proportion of clay in the soils which can be interpreted as a vital component for the uptake and storage of nutrients and the retention of groundwater. Therefore, it is likely that these soils had been more widely recognised for their fertility in the past and have thus been preferably cultivated until a state of depletion in the present. Given the heaviness of clay soils, it may have been much more difficult to replenish the nutrients through ploughing/rotovating – practices which have been shown to replenish nutrients (via the negative correlation between %LoI and nutrients). This is confirmed by a positive correlation between %LoI and the proportion of clay – indicating a relationship between soil sorting and nutrient adhesive clay particles. Finally, the comparison between the logistical regression model, historic mapping and geochemical data has shown that statistical modelling requires engagement with field sampling and testing. Such exercises cannot be divorced from field examination. There were stochastic correlations between the logistic regression model (derived from the historic maps) and the geochemical data, and these were most likely the result of geological and pedogenic factors. Crucially, using the geochemical data as a means of comparing the model with its ‘parent’ dataset has shown no significant relationship between the archipelago-wide derived model of agricultural viability and the recorded culturally perceived value of the land.

The combination of efforts in Chapters 3 and 4 have helped identify an optimal set of methods for the understanding terrace chronology and function. Future investigations can pursue ecological and/or chronological knowledge by following the methods described in this thesis. As Chapter 4 has shown, the extraction of geoarchaeological data can provide a wealth of environmental data that can
contextualise agricultural terracing without the need for chronology. Chapter 3 exposed the difficult stratigraphic conditions that exist within the Maltese Archipelago and used this to formulate an idealised methodology that could be employed to extract an accurate timeline for terracing. Undoubtedly, an absolute chronology would provide an unparalleled depth of understanding.

The successful completion of Objective II emphasises that terraces provide an enhancement of resilience in the long-term management of the agrarian landscape. Furthermore, these investigations have indicated possible routes towards an expanded and more sophisticated methodology, as explained in Section 7.3. Crucially, these findings nest within wider studies (Objective II.c) – within the research gaps identified in Chapter 2 and in wider discussions of resilience (Section 6.2). However, the theoretical backdrop of this thesis demands consideration of how resilience entangles with social themes, and how terraces become fundamental to the equilibrium of semi-arid environments.

7.2.3 Objective III – Terracing and the Anthropocene

The connection of this thesis with the wider narratives of the Anthropocene was a logical progression to make. Superficially, the terrace themes confronted in this thesis - people, environmental practices and resilience - are synergistic with the ubiquitous discussions regarding the Anthropocene. However, reaching further into these concepts, the study of terracing offered the opportunity to consider the very origins of this epoch. Chapter 5 concludes with the remark that the Maltese archipelago can serve as an allegory for the contemporary Anthropocene world. The gradually increasing population through time has placed greater pressure on a fragile semi-arid landscape, yet irrevocable collapse has yet to occur. This is in part due to the resilience of the landscape, forged by the physical and cultural role of the terraces. However, these threads of intensification demonstrate a central human need to adapt the environment to suit popular requirements – where terracing is a primary example of an anthroscape (Bennett, 2015) in which the natural environment is changed intentionally, rather than as a by-product of other processes. This intentionality reflects the *longue durée* of the Anthropocene and the pervasive mentality of human populations who continue to exploit the environment for human centric purposes. Sadly, the posthuman relationship, described above, is not part of the Western and economically developed cultural diaspora – to which the Anthropocene is most related. Malta is at a crucial juncture point, where modern development and traditional farming fail to support each other. The agrarian landscape is likely to diminish further, erased by rampant construction and urbanisation. However, a shift in cultural approach, that involves support by international bodies, could engender change, enabling agriculture to adapt and improve local provision for the island. This change must come from the recognition of the effect humans are having on the world, the visible Anthropocene.
Terracing, while anthropic in nature, is indicative of the deeply posthuman resilience that can be found in a restricted landscape. Chapter 6 completes this connection with Objective III (Anthropocene discourse), by reinforcing the permeable boundaries of humanity and the erosion of the non-human world. If the Anthropocene trajectory is to continue, then humans are effectively damaging the deeper posthuman entity that they share. In this respect, the Anthropocene can be used as a *mentalité* — a lens to interpret culture — as much as it is a geological epoch. By viewing the Anthropocene through a Braudelian framework, the incorporation of time (the *longue durée*) helps reinforce the relationship between cultural fluctuations and their influence on the environment. In summary, Objective III is both the product of the study’s thinking and the driving force behind the development of this thesis.

The inclusion of this objective was originally intended to ensure that this thesis contained valuable social reasoning, rather than being solely restricted to a rigorous scientific commentary on human-environment relations. The concept of landscape is central to this thesis since the act of terrace creation requires a complex entanglement of things. *Thingness* can be found with objects, assemblages, environments and people. Landscapes are formed from the nebulous entanglement between humans and environments, at the interface of cognition and location. To reach this understanding, Appendix 3 was a vital exploration required to tease apart that very interface. Archaeology and cognate disciplines are adept at polysemous terminology. In this case, landscape and environment are often interchangeable. Appendix 3, which forms a matrix of understanding for inter-disciplinary knowledge regarding the formation of landscapes, emphasises the need for specificity in these discussions. Thus, this chapter presented a corpus of thinking which is essential for the effective contextualisation of the discussion of terraced landscapes in the Maltese Archipelago. This exploration presents how humans and environments become enmeshed, through a posthuman approach. By decentralising the role of humans, this chapter explains how externalised cognition enables the incorporation of outside agents (things) into a person’s sense of self — where landscapes *themselves* became agents and thus actively meaningful to individuals and groups. In essence, landscapes are not simply created by humans but are formed by an entanglement of the human and non-human, thereby creating a posthuman interactivity. People and landscapes cannot be mutually exclusive since landscape is formed from the cognitive internalisation of the external world. It is without doubt that this chapter satisfies Objective III.a and the need to understand how humans appropriate environments at a cognitive level.

This is brought into specific focus within Chapter 6, where Geertz’s (1963) *Agricultural Involution* is rationalised as a cultural system which demonstrates the reflexivity between land and culture. Utilising the work from Appendix 3, the terraced landscapes of the Maltese Archipelago are shown to be a component of a feedback loop within the posthuman entanglement of people and landscapes. Terraces were shaped by humans, but equally constrained environmental factors and reinforced the
social practices of the terrace users. Ultimately, this can engender a process of cultural deceleration (Rosa, 2016) fostered by herd mentality (Surowiecki, 2004). Through widespread insularity, terracing has resisted innovative thinking and perpetuated a system which has become increasingly complex over time (Geertz 1963). Effectively, this is a form of social resilience which also fosters environmental resilience in fragile landscapes. Chapter 6 progressed these considerations to a discussion of contemporary agriculture in the archipelago, indicating that these islands are poised to support a new shift in agricultural intensification which is reliant on technological innovation, and a shift in popular thinking which would support group productivity, rather than individualism. This refreshed agricultural sector would be constructed upon the longue durée of the terraces, utilising many of the systemic traits described above to provide a new form of resilience. However, this is deeply reliant on a shift in mentalité which must occur through the discourse surrounding the Anthropocene.

7.2.4 Conclusions
The primary motivation behind this study was to establish whether or not agricultural terracing acts as a fundamental part of the resilience of fragile landscapes in the Mediterranean and beyond. The focus on the Maltese Archipelago, capitalised on research synergies with the ERC funded FRAGSUS Project which explored issues of fragility and sustainability in small island environments during prehistory. Within the archipelago, the significantly terraced environment represented a dimension of anthropic management practices which arose at an unspecified point following the arrival of humans in the islands. Therefore, one of the first lines of inquiry surrounded defining this point in time. Adding a chronological context to the terraces provides a crucial backdrop to understanding their function within environmental and social histories – thereby providing greater insight regarding how they influence the resilience of their landscapes. With the resources available to this thesis, isolating a specific date for the onset of terracing was not viable. This did, however, encourage lateral thinking and novel approaches to help develop a timeline for the uptake of the phenomenon. Importantly, this flexibility also led to a deeper consideration of the nature of this resilience in social contexts. By engaging with systems and posthuman theories, the understanding of entanglement between people and environment helped isolate a new narrative which integrates archaeology and cognition, redefining the concept of landscape as the interface between mind and place. Considering this, the nature of resilience evolved to consider social and cognitive factors which result from the implementation of significant environmental alteration, such as terracing. In many ways, this echoes sentiments presented by Geetz’ Agricultural Involution and in other ways it is a modern amplification of this theory which emphasises the deeply complex relationships between people and the locations they inhabit. While Objective I fell short of identifying a specific date for the onset of terracing, this challenge ultimately inspired a new framework for the understanding the deeply complex relationship
between terraces, people and their associated environments. Through the use of geoarchaeological techniques, this thesis has investigated the geochemical properties of these relationships, testing terrace soils and comparing them with historical records. A methodologically unique programme of auger surveying identified where quantifiable data tells a story that runs counter to historical records. By establishing a replicable system of survey and analyses, this project has set a new standard of methodology which should be utilised to extract vital ecological information about agricultural terraces. While this thesis has a diverse range of outcomes, the aforementioned methodology is the primary area of success. This method proves that a dearth of resources, and shallow soils, can be used to produce a meaningful body of data that explores the social perception of terraces. Furthermore, this methodology has not been exhausted as there is great potential to expand the knowledge of terrace ecology and function through this route (see Section 7.3).

Contemplating the holistic value of this thesis, it is clear that the understanding of agricultural terraces and their resilience is a matter that must be explored and understood from both physical and theoretical perspectives. Though terraces themselves provide an almost self-evident element of environmental resilience, they also propagate a complex level of social resilience. It is therefore demonstrable that resilience is a concept that describes the effects of a variety of multi-scalar and enmeshed processes; incorporating systems both human and environmental. Thus, resilience can be further defined as a posthuman concept; moving beyond the definitions noted in Section 6.6 (i.e. systemic stability) to recognise the deeply complex layer of posthumanist theory that acts as a conceptual backdrop to life itself. The application of these theoretical considerations further separates this thesis from all other studies of agricultural terraces to date. Perhaps the attempt to encompass so many lines of inquiry detracts from the punchiness this study could have had. However, the unparalleled union of geoarchaeology, cognitive and posthuman discourses is exactly the agenda required for the archaeology of the Anthropocene. Although imperfect, it is hoped that this thesis contains some small portion of archaeology’s manifesto for the Anthropocene and beyond.

7.3 Reflections and Future Directions

Unsurprisingly, this thesis is not an exhaustive project and there have been a variety of ideas that have remained undeveloped as it has progressed. With abundant resources, the following research directions would be as considered:

1. A comprehensive OSL dating programme. In the first instance, this would require a dry-valley survey (selecting top, mid- and base of slope terraces), in tandem with a trench through valley fill deposits. Using OSL dating, and relative luminescence profiling (Kinnaird et al., 2017; Porat
et al., 2018), the valley deposit trench would provide a detailed chronology for the sedimentation rates within that locale and also indicate the periods where sedimentation may have become constrained by the construction of agricultural terracing. Dates from the terraces would provide a corroborative chronology for the valley trench. Ideally, after testing the validity of this method, further valleys could be dated to provide a general chronology for the uptake of terracing within the archipelago.

2. A GIS study of terracing. Initially this thesis was to include a spatial analysis component. However, the scale of such an endeavour would be sufficient for another complete thesis. Using the LiDAR dataset (1m resolution) made available to the FRAGSUS project, an automatic extraction of terraces could be formulated, either using QGIS and Python programming or software such as Trimble Ecognition. This extraction would immediately provide data regarding the geometry of terracing across the islands, and would facilitate acquisition of derived characteristics for each terrace (slope/aspect/solar radiation/hydrology etc.). Furthermore, complex modelling techniques could be applied e.g. MAXENT (Galletti et al., 2013) and SLACC (Sofia et al., 2014).

3. An ethno-geoarchaeological study of traditional farmers in the archipelago. This would collate folk agricultural knowledge and provide a quantitative overview of the geochemical factors related to traditional and dying practices.

4. The same methodologies could be applied to other terraced landscapes elsewhere in the world with potential impact on the generation of public policy. In Malta, the use of terraces is substantially restricted to market gardening. In other parts of the world, major cash crops, such as coffee, are generated in terraced environment. The longue durée study of terraces could have major economic implications.

7.4 Final Thoughts

This thesis has been an arduous and broad-spectrum approach to the study of agricultural terraces. Where the lack of a true chronological methodology could have been viewed as a hinderance it has perhaps encouraged alternative routes of investigation. In many respects, finding solutions to the question of terracing, without a dating programme, has led to the novelty of this thesis. In particular, connecting the ecological narrative of terraces with a discourse on landscapes as posthuman entities is a unique contribution to archaeological studies. Furthermore, it is hoped that the greater integration of cognitive studies can be embraced by archaeologists, especially those working in fields outside of evolutionary/Palaeolithic studies, where cognition is a more common point of discussion. Finally,
through this developed narrative regarding posthumanism, landscapes and the Anthropocene, it is hoped that this study may be used to convey a new understanding the links between people and the environment. Moreover, the use of posthumanism can help convey the integral and reflexive roles of people and place in an ever-changing world – expounding the delicate systems relating people and landscapes.


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APPENDICES
APPENDIX 1: SITE IMAGERY
BS: Buskett Gardens, Malta

A. 1: Buskett Gardens Sample Locations
A. 2: Buskett Gardens sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 3: BS1 Samples

A. 4: BS2 Samples

A. 5: BS3 Samples
IN: In-Nuffara, Gozo

A. 6: In-Nuffara Sample Locations
In-Nuffara Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 7: In-Nuffara sample locations in relation to the relevant Cabreo and Logistical Regression values
IS: Is-Sruġ, Gozo (nr. Xagħra)

A. 14: Is-Sruġ Sample Locations
Is-Sruġ Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 15: Is-Sruġ sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 16: IS1 Samples (split across two auger holes due to large stone disruption)
A. 21: ISSA Samples

A. 20: ISSB Samples
A. 22: IS6 Samples

A. 23: IS7 Samples
MG: Mġarr, Gozo (nr. Xatt l-Ahmar)
Mġarr Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 25: Mġarr sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 26: MG1 Samples

A. 27: MG2 Samples
A. 28: MG3 Samples

A. 29: MG4 Samples
**MIS: Il-Ġebel tal-Mistra, Gozo (nr. Dahlet Qorrot Bay)**

A. 31: Il-Ġebel tal-Mistra Sample Locations
Il-Ġebel tal-Mistra Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 32: Il-Ġebel tal-Mistra sample locations in relation to the relevant Cabreo and Logistical Regression values
ML: Mellieha, Malta (nr. Imbordin)

A. 37: Mellieha Sample Locations
Mellieha Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 38: Mellieha sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 39: ML1 Samples

A. 40: ML2 Samples
A. 41: ML3 Samples

A. 42: ML4 Samples
A. 44: ML5 Samples

A. 43: ML6 Samples

A. 45: ML7 Samples
A. 48: ML10 Samples

A. 49: ML11 Samples
**MR:** Tal-Merħla, Malta (nr. Il-Baħrija, Rabat)

![Map of Tal-Merħla Sample Locations](image)

_A. 50: Tal-Merħla Sample Locations_
Tal-Merħla Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 51: Tal-Merħla sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 54: MR1 Samples

A. 53: MR2 Samples

A. 52: MR3 Samples
A. 55: MR4 Samples
SL: Santa Lucija, Gozo (nr. Għajn Abdul)

A. 56: Santa Lucija Samples Locations
Santa Lucija Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 57: Santa Lucija sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 60: SL3 Samples

A. 61: SL4 Samples
A. 64: SL7 Samples

A. 65: SL8 Samples
A. 66: SL9 Samples

A. 67: SL10 Samples
A. 68: SL11 Samples

A. 69: SL12 Samples
TRA.C: Slopes of Xagħra, Gozo

A. 70: Transect C Sample Locations
A. 71: Transect C sample locations in relation to the relevant Cabreo and Logistical Regression values
ZB: Żebbuġ, Gozo (nr. Sagħtrija)

A. 72: Żebbuġ Sample Locations
Žebbuġ Sample Locations with Cabreo Classifications (left) and Logistical Regression Values (right)

A. 73: Žebbuġ sample locations in relation to the relevant Cabreo and Logistical Regression values
A. 74: ZB1 Samples

A. 75: ZB2 Samples
APPENDIX 2: RAW DATA
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APPENDIX 3:
ENVIRONMENT TO LANDSCAPE THROUGH COGNITION
A3.1 Introduction

For the most part, this thesis has focussed on the study of agricultural terracing through the analysis of environmental and ecological factors – assessing their form and function through an objective methodology which can be adapted for universal application. This research additionally seeks to set these factors within their social context and bridging the divide between archaeological investigation and knowledge from cognitive disciplines. In the pursuit of this aim, this appendix collates relevant inter-disciplinary knowledge to structure better how archaeology perceives human-environment interactions, specifically through the study of cognition.

Although the observation and understanding of the human appropriation of the environment – the formation of landscapes and cultural territory – are methodical in nature, the comprehension of the intra- and inter-cognitive processes is a more complex challenge. Observing the human appropriation of the environment involves the analyses of spatial, temporal and cultural factors which drive the awareness of how people operate within the visible world. Whereas, the understanding of environmental appropriation relates to the constant flux of mental conceptions – the permanent evaluation of multi-scalar (individual/in-group/out-group) risk and reward strategies. The link between these can be reduced to terms of human survivability and evolutionary psychology. In essence, the environment is appropriated in a manner which creates complex cultural landscapes which, on one level, mask and, on another level, exemplify the cognitive machinations taking place. Archaeology is exceptionally good at observing macro-scale signals and developing knowledge of broad cultural processes. However, it is prudent to examine these processes in greater depth, developing an understanding through posthumanist theory. By adopting a holistic view, this appendix will evaluate how landscapes are formed from the perspective of individuals and how this is incorporated into group dynamics. The appreciation of the cognitive processes involved with the appropriation of the natural environment provides an equal basis for understanding landscape phenomenology, regardless of cultural particularities.

This appendix will begin with an overview of the nature of possession and ownership: exploring how humans appropriate objects, and by extension the environment, at a cognitive level. Arising from this, the environment’s social role must also be examined to understand if/how it may be perceived to act as a social agent. The logical extension of this discussion will be to assess how the environment takes part in human social dynamics: how the environment exists as something objectified, with thingness. Finally, these concepts will be placed within the realms of social theory and therefore returned to levels of the complex terminology that is readily used in archaeology, such as territory, boundaries, space and place.
Overall, this chapter will draw multi-dimensional connections that range across a variety of scales, connecting human cognition with much broader themes at regional and environmental scales. In doing so, this will serve to construct a theoretical framework that contextualises the complexities entwined with agricultural terracing; complexities which are lost in the higher order theoretical terms so readily used by contemporary archaeology. Consequently, this appendix should be read as a working essay which builds the conceptual foundations for ideas expounded in Chapter 6. Accordingly, there will be minimal references to agricultural terracing as this appendix explores the cognition of landscapes in general. Therefore, this following exploration has value to the understanding of human-environment interactions universally – beyond the scope of this thesis.

A3.2 Possession and Ownership

A3.2.1 Possession and the Self

Deriving from the Latin verb *possidere*, meaning “to sit or put one’s weight or foot over,” *possession* is a concept central to understanding the appropriation of the environment. To understand it as a concept, it must be deconstructed and related to cognitive and neurological understandings, then reconstructed in a framework relative to the acquisition of the environment and the creation of landscapes. From a phenomenological stance, possession is an experience of feeling which arises from a myriad of mental dispositions that combine to create a psychological phenomenon (Rochat, 2014). This experience is intensely linked to an individual’s concept of *self* and the implied ownership of the self. Rochat (2014, 31) illustrates this as “my feeling and experience of the world are mine, and can only be mine and nobody else’s.”

It is valuable to consider this alongside the *Theory of Mind* (Baron-Cohen, 1995; 2012; Baron-Cohen et al., 2013) which governs how the mind relates to other individuals, ascertaining inferences of another’s mental states, beliefs and desires. Through this, neurotypical individuals are able to relate their thoughts and experiences to those encountered by other individuals, creating a hypothetical understanding of another’s thoughts (Breed and Moore, 2016). In effect, it regulates not just the concept of beliefs, but how people hold beliefs about other peoples’ mental states (Leslie, 2001). Importantly, Leslie argues that there are three core mental states which are at the basis of explanations: desires, beliefs and pretence. Essentially, these relate to how an agent formulates goals, an understanding of the state of the world and external agentic meaning.

Rochat (2014, 35) links the experience of possession to the “primordial process of incorporation to the embodied self: a literal process of projection and identification that leads to some assimilative re-embodiment of things to the self”. When considering the etymology of the word *incorporation* its link
to the body/corpus is evident, and thus can be related to the embodied experience of acquisition and union. Developing this further, Rochat (2014, 38) indicates that the underlying nature of appropriation is connected to “social power... the promotion of belongingness: the experience of social affiliation and ultimately the promotion of social harmony”.

The neurological basis for the self is narrowed by Damasio (2000, 154) to the proto-self – “a coherent set of neural patterns which map, moment by moment, the state of the physical structure of the organism in its many dimensions”. The central structures involved are several brain stem nuclei, the hypothalamus, and the insular cortex (S2 and medial parietal cortices). While the proto-self exists subconsciously, Damasio indicates the conscious role of the core self – the momentary character of consciousness which is provoked by encounters with objects; objects which are always available, leading to a near constant presence of the core self. The autobiographical self is derived from aspects of the proto and core selves, incorporating the nature of memory into the self, generated from the record of core self-experiences. Memories can be accessed: “activated as neural patterns and turned into explicit images... records are partially modifiable with further experience” (Damasio 2000, 175). Therefore, the internalised record of human experiences can be recalled, re-experienced and re-interpreted in a manner which is intrinsically linked to the sense of self.

A3.2.2 Sans possessions ‘self’ and the concept of ‘I’

Mittal (2006, 551) emphasises the existence of “a dichotomy between what one is sans possessions and what one becomes due to or with possessions”. In the possession-free sense, an individual is comprised of two views of self: the ‘personal identity’ view and the ‘trait-centred’ view. The former describes “a self-narrative conception of identity [which] offers a rich literary view against which products and brands may be appraised” (ibid.). The latter relates to “self-image...anchored and embedded entirely in personality-like dispositions and surface characteristics” (ibid.). On the concept of ‘I’ Mittal suggests this encompasses “everything we ever come to own and live with” (2006, 552), including:

1. Our body
2. Personal values and character
3. Success and Competence
4. Social role
5. Personal traits
6. Possessions.

Mittal (2006, 554) posits that possessions allow individuals “to bring out the inner ‘I’ for display so others may see us for who we are” theorising that the arrangement of these six factors combine to create a whole, with composition varying from individual to individual.
Interestingly, Mittal notes that an object can relate to an individual’s self-concept without needing to be specifically incorporated into their self-concept. Such objects may be used transitively in an attempt to improve another aspect of the self. In doing so, objects may become involved and/or attached, but not part of the ‘I’ unless the individual can possess them and define their concept of ‘I’ through them.

Elaborating upon the different forms of self, Mittal posits that the difference between ‘I’ and the concept of ‘me’ is a matter of perspective. An individual’s concept of ‘I’ is defined by how that person views themselves. Conversely, an individual’s concept of ‘me’ is based upon how that person believes others to perceive themselves. Mittal states that both these self-concepts are made of the same elements, as discussed above, since they are universal. Furthermore, “a person basically ‘projects’ on to the other person the template he or she uses to ‘read’ himself or herself as ‘I’” (Mittal 2006, 555). However, the projection of an individual’s concept of ‘I’ onto another individual causes three issues:

1. Each concept is built from universal elements although each concept differs in the centrality of constituent elements.
2. Each element can be defined differently by individuals.
3. Individual perception of an element’s form may differ.

Mittal suggests that such issues are resolved by individuals “(1) switching reference groups, (2) educating others; and (3) modifying consumption” (2006, 556).

Reflecting on the theory of mind, discussed in Section A3.2.1, Mittal’s synthesis touches upon the constant evaluation of agency that exists between neurotypical individuals. This is indicative of the entwined nature of the psychological self and psychological knowledge about others (Happé, 2003; Białecka-Pikul et al., 2020). Happé (2003) also posits that the ability to ascertain the mind of others may have preceded self-reflection, during human evolution, as comprehending the state of others influences the competitive elements of fitness, e.g. ‘Machiavellian Intelligence’ (anticipation of others’ thoughts). Nevertheless, this observation places the knowledge of other agency ahead of self-understanding, which would fit with a basic assumption that objects were functional before conceptual during human evolution. As the development of self-awareness arose, the formation and expression of self-identity grew – tied to which is the acquisition of objects and the recognition of their agentic properties. This conceptual discussion illuminates the differentiation between cognitive states of being, contrasting how individuals perceive themselves in isolation with the perception of being within an assemblage of other people and objects. These concepts will be discussed further in this appendix and in Chapter 7 – especially in relation to the concepts of Entanglement and Posthumanism.
A3.2.3 Incorporation

Belk (1998) defers to Sartre (1942) regarding the three ways through which an object can become part of the self. The first way in which an object be tied to the self is through its control or appropriation for personal use (Belk 1998, 150). Within this first process, there are several caveats. Belk (ibid.) states “Sartre also holds that we can appropriate intangible or non-ownable objects by overcoming, conquering, or mastering them... giving possessions to others as a means of extending self – a special form of control... the giver’s identity is extended to include the recipient”. This use of objects, whether giving or destroying, can be seen as an “affirmation of the self” (ibid.) as the act signifies the control over said possessions. The second way possessions can be incorporated into the self is via the creation of the object in the first instance. In effect, the creator maintains identity within the object as long as the object retains some level of association with its creator. In a similar manner, “Sartre feels that buying an object is merely another form of creating an object” (ibid.). The third manner by which objects are incorporated into the self is the act of knowing the object; such knowing will arise from habituation, whereby an object becomes “a part of our interior familiar landscapes” (Belk 1988, 151). Overall, all three manners of incorporation outlined here provide the means for objects to actively and intentionally become part of the extended self (ibid.).

Progressing from Belk, Mittal relates the various manners through which objects can enter the extended self. Firstly, incorporation can arise through “self-based choice” (Mittal 2006, 556) whereby an individual selects an object that appears to sufficiently fit his or her self-concept. Secondly, objects can merge with the extended self through the expenditure of resources in both the acquisition and the use of an object. Thirdly, the emotional connections related to “post-acquisition bonding” (Mittal 2006, 557) can elicit a feeling of attachment and consequently a sense of self extension. Finally, the processes of collection and memory association extend the object user’s self to objects which symbolise a special interest or a significant biographical factor for the user. Curiously, these various modes of incorporation can be categorised into chronological order. Self-based choice is clearly a decision that is made pre-acquisition of an object. Following this, the resource-based modes are tied to the act of acquisition and the use of an object, e.g. object creation and object deployment. The remaining modes of incorporation all occur post-acquisition, through repeated object use and/or the attribution of meaning to the object.

In summary, Belk asserts that an object can be incorporated into the concept of self through owning, creating or knowing the object. However, Mittal’s study streamlines the various methods of incorporation, focussing less on the intentionality of incorporation and instead addressing psychological aspects. In particular, Mittal addresses the mechanisms at work, pre- and post-acquisition, providing a more complex frame of reference with regards to how people observe and select objects in relation to their self-image.
A3.2.4 The Self and The Group

Humans are rarely solitary creatures, unless when exhibiting specific pathologies. Individuals perpetually exist in groups of varying size and functions, a trait examined by Boyer (2018) who deconstructs the nature of coalitional psychology. At its core, coalitions require the cognitive management of individual needs versus the establishment of mutually beneficial conditions. Although coalitions are noted in other species, “human alliances can include large numbers of agents, can persist for generations, and are in fact ubiquitous, extending to all domains of human behaviour” (Boyer 2018, 41). Boyer posits that these alliances arise from six core traits which all participants must hold in mental concordance:

I. A shared mental representation of a goal.
II. An expectation that each individual has a similar representation to other allies.
III. A cognitive transaction where the individual ‘discounts’ their working costs towards the common goal – where individual cost is offset by the expected future benefits.
IV. An expectation that other allies also discount their contribution to the goal.
V. The individual expects that allies also hold the same expectations regarding goal contributions.
VI. The shared understanding that any costs/benefits encountered by rival coalitions are benefits/costs to the group and thus the individual, thereby providing motivation for individuals to increase/decrease contributions accordingly.

These traits, although crudely formulaic, are supported through experimental analyses which expand (Baron, 2001). Furthermore, a central aspect of human coalitional behaviour involves an alliance detection system (Pietraszewski et al., 2014; 2015). Boyer (2018) emphasises that these detection systems create specific cognitive perceptions and incentives and thus activate hormonal and emotional systems. However, it is noted that these relationships are not always antagonistic. Instead, competition is based in the concept of rival good, where the drive to increase the size of coalition reduces the availability of support for others. This drives the formation of networks, with individuals forming coalitions to ensure support is required.

Linked to this, humans have an intuition for the proportional allocation of benefits from collective efforts. Generally, humans obtain a significant proportion of their welfare from action involving others – both from kin and from the collective. This relies on some central traits: the cognitive ability to track and monitor different individuals and past interactions, the ability to obtain transactive information about other relationships, and the ability to punish non-compliance with according severity (Boyer, 2018).

In sum, the needs of the self are assessed transactively when considering group activity, with the individual ceding personal costs to group goals. Considering theory of mind (see Section A3.2.1) as
contextual knowledge, humans hold a cognitive perception of co-monitoring of shared values, which provides a basis for intuitive cost-benefit analysis and alliance detection systems. This network of concepts places the self and the overall sociality of humans at the core of the processes of ownership and possession.

A3.2.5 Possession and Group Dynamics – *Claiming Ownership*

If, as posited above, sociality is an inextricable element of possession, an individual’s experience of possession can only take place in relation to the agency of others. Individuals fear dispossession, as without the presence of others there would be no competition for possession (Rochat 2014). Linked with this experience are the feelings of envy (when one is lacking something) and jealousy (when one fears losing possession of something). While these feelings are often viewed as negative traits, they serve to highlight the central concept of *proprius* – the feeling of exclusive possession.

Taking a plot of agricultural terraces as an example, it is clear that their construction and maintenance require a significant investment of labour; an investment which is both material and emotional (through the phenomenology of actions required). Those responsible for the land will tend to the various elements, installing a reflexive identity into the materiality of the fields. On a base level, care and attention should promote better productivity from the fields, reinforcing the sense of *proprius*. However, this productivity also increases the relative value of the fields beyond their ownership – encouraging relative comparisons/competition between landowners. So, with this, the individual sense of ownership must be considered within the dynamic realms of social affiliation and with the concepts of status, display and signalling.

Considering the phenomenology of ownership, Rochat (2014, 41) defines *proprius* as being reliant on three psychological factors:

\[
\text{Sense of Ownership} = \text{Differentiation} \times \text{Projection} \times \text{Identification}
\]

Differentiation is defined as the sense of self as distinct from others, while projection is the ability to externalise concepts of internal feelings including thoughts and desires. Finally, identification relates to the understanding that concepts beyond the self are differentiated and thus objectified.

The base need to declare ownership – enacting possession – arises from an awareness of the relative abundance of objects or resources available in a populated environment. Developing from the nature of possession within the context of group dynamics, the act of claiming ownership transforms the feeling of possession from something personal to an *object* of public knowledge. Ownership is therefore an “interpsychic, interpersonal phenomenon shared and co-experienced in reference to others” (Rochat 2014, 46). This transformative process remains a central focus for inquiry within cognitive and behavioural studies. At the core of this process, evolutionary traits associated with
emotion can be linked to possession and ownership. The James-Lange theory of emotion suggests that an emotion is the perception of contextual changes experienced by the body – emotions beget the state, as opposed to the state causing the emotion (ibid.). Rochat (2014) links this to cognitive structures, moulded through primate evolution, which govern the detection of safety and the assessment of risk – and which are intrinsically associated with defensive and pro-social behaviour.

Following the Polyvagal Theory (Porges, 2009), Rochat places the enactment of possession within three major stages of the development of the mammalian autonomic nervous system. Porges (2009, 3) posits that

“the polyvagal theory articulates how each of three phylogenetic stages in the development of the vertebrate autonomic nervous system is associated with a distinct autonomic subsystem that is retained and expressed in mammals. These autonomic subsystems are phylogenetically ordered and behaviorally linked to social communication (e.g., facial expression, vocalization, listening), mobilization (e.g. fight-flight behaviors), and immobilization (e.g. feigning death, vasovagal syncope, and behavioral shutdown)”.

Within the context of possession, Rochat (2014, 52) suggests immobilization is akin “clinging” to possession, mobilization is like contest or abandonment of possession, and social communication relates to the negotiation of disputed possession.

Damasio (2000) outlines the dual biological role that emotions play – the production of a state of reaction to an inductive situation, and the management of the internal biological preparedness for such reactions. Fundamentally, they form part of a homeostatic regulation which sustains life unless it is not managed. Considering the neurophysiology of emotions, Damasio notes that there are relatively few locations responsible for the production of emotions; these are mainly found in the subcortical regions of the brain-stem, beneath the cerebral cortex and include the hypothalamus, basal forebrain, periaqueductal gray (PAG) and the amygdala. The PAG acts as a significant co-ordinator of emotion responses, acting via several nuclei of nerve groups including the vagus nerve.

The wide variety of human emotions are the connective tissues between our experiences within the material world and the internal autobiography of the self. This is illustrated eloquently by Damasio (2000, 55) who states that “emotions are inseparable from the idea of reward or punishment, of pleasure or pain, of approach or withdrawal, of personal advantage and disadvantage. Inevitably, emotions are inseparable from the idea of good and evil”. Rochat (2014) also connects possession with morality, suggesting it is hard to consider the two as independently, especially considering the nature of possession with regards to resource scarcity.
An important trait involved with possession and found deep in human evolutionary history is the perception of territoriality, which involved “anticipatory prevention psychology” (Rochat 2014, 53). The nature of territory surrounds concepts of protection and loss prevention and is deeply instinctual, relying on evolved and automatic feelings of possession, as alluded to above. Nesting within the animal kingdom is a prime example of territorial behaviour and one which can be paralleled with the complexities of human territorial management behaviours.

Within Rousseau’s (1984) Second Discourse, the concept of inequality is considered as an emergent trait within humans that distinguishes them from the animal kingdom. With this, Rochat (2014, 57) states that “the invention of property generated and justified a new state of inequality in humans that did not exist originally”. Accordingly, the declaration of ownership requires legitimisation through recognition by trusted others. When considering ownership at a group level, historical events repeatedly show that ownership is reliant on the maintenance of a critical mass of ‘legitimising’ individuals. When this mass is broken, the power structure breaks down and dispossession ensues. Rochat’s (2014, 73) work therefore draws together not only the socially linked nature of claiming ownership, it also lays the foundations for the basis of social power, since social affiliation can be measured in terms of ownership recognition.

Boyer (2018) explores the nature of sharing and trade, with the latter arising from the former. Based on past and/or expected reciprocation, the act of sharing generates prestige and obligation at a relatively low cost. This is not necessarily based on some urge to support others but is instead reliant on intuitions related to monitoring resources, monitoring the identity and economic behaviour of resource producers, and identifying those who claim resources. In a similar manner to the process of co-operation described above, the basis of sharing relies upon intuitions of fair distribution of rewards with an economy which balances the nature of the resource and the relationship to the contributing people. Progressing from this, trade occurs where the sharing of substantially different resources is required, enabling the ‘unlike for unlike’ exchange to take place. Ultimately, this results in the existence of commodity chains, where resources are redistributed through a variety of social institutions (Earle, 2002).

A3.2.6 Summary

In summary, the nature of possession and ownership lies with complex cognitive functions involving overtly shared neurological pathways. It can be said that the concept of possession should be considered as an emotion, acting on a sub-conscious level, demonstrating how the self can be incorporative. Accordingly, the feelings of acquisition and dispossession – feeling being the sensory patterns which provoke emotions, e.g. pain and pleasure – guide the state of emotional possession. Ownership, however, should be classed as a higher order phenomenon, owing to the associated
cultural complexities. Possession can certainly be emotive in a base and public manner, but declaring ownership is suggestive of a philosophical and practical understanding of how objects should be distributed within a group. For example, one may own an object without having experienced acquisition, and thus possession. It is therefore worth considering, especially in relation to spatially fixed objects, how the concept of the self still maintains the emotion of possession regardless of proximity. Dwelling briefly on the nature of this thesis, these factors can be related to the variety of ways agricultural space can be acquired, owned, possessed and transferred – including the perception of more complex processes such as land tenure, tenant farming and inheritance (which are concepts that will be developed in the following chapter). Where this section has focussed on the human perception of ownership and possession of the landscape, the following section will unpack the role of landscape as something which can be acquired – exploring its object properties.

A3.3 Landscape and Thingness

In seeking to understand how humans appropriate the environment, we have explored the nature of possession from a cognitive and psychological perspective. In doing so, we can now consider how environments might be considered as something which can themselves be possessed, as objects available for acquisition by individuals and groups. Through this understanding, a direct link is found between the human mind and the external spaces that it engages with. Furthermore, this enables incorporation of the landscape as part of the extended self, a concept that can be related to themes of space/place, memory/memorialisation and identity within the landscape.

The concept of landscape represents an idea greater than typically synonymous terms such as environment, location or surroundings – it represents the way humans observe, account for and interact with the external world. Casey (1996, 27) suggests landscapes are “a given place [which] takes on the qualities of its occupants, reflecting those qualities in its own constitution and description and expressing them in its occurrence as event: places not only are, they happen”. Thus, in subjective human experience, the concept of landscape relates to the very nature of human interaction with the external world. The element of subjective human perception, involved in attributing qualities to the world around, therefore distinguishes landscape as unique among all other concepts of the external world. Universally, humans have always had a deep relationship with the landscapes they utilise and inhabit, involving and reflecting the world around them to suit a plethora of cultural needs. Historically and currently, landscapes are the subject of much consideration in terms of how they are used, how they are built upon and what such decisions say about those who inhabit a place.
A3.3.1 Landscape, Space and Place

Conceptually, landscape denotes a variation from environment – a duality between culture and nature. This is also embodied by the contrast of space and place explored in Casey’s (1996) metaphysical essay entitled *How to Get from Space to Place*. This meditation begins with the observation that concepts of *place* precede the concept of *space*, as the converse would suggest that an unspecified spatial realm lies in wait for “cultural configurations to render it placeful” (Casey 1996, 14). Through ethnographic accounts and from a phenomenological viewpoint, Casey (Casey, 1996, 18–19) posits that

“there is no knowing or sensing a place except by being in that place, and to be in a place is a position to perceive it... Given that we are never without perception... we are never without emplaced experiences. It signifies that we are not only in places but of them. Human beings – along with other entities on earth – are ineluctably place bound”.

Therefore, through the primacy of perception within place, Casey presents a spatial concept which lies between the acultural dimensions of space and the intensely cultural concept of landscape. Moreover, this idea of place is also distinct from the environment which is natural, rather than cultural, yet only knowable through the perceptions required for place. The body, acting as a conduit of knowability, also requires movement to establish place – through the contrasting perceptions of stillness, movement within and movement between places. Developing this, Casey (1996, 24) notes that “places gather” as a bounded arrangement of things which are reflexive of the local environment, retentive of its contents and a locus of immaterial thoughts and memories. Casey’s meditation aligns with the modes of incorporation, discussed above, all of which are based on embodied knowledge, participation and interaction. Casey’s *place*, however, is almost atemporal, being so heavily focussed on the moments of perception as the foundation of knowing a place, without considering the dimension of time.

Landscape, therefore, is the logical progression of such theorising when one adds the dimensionality of groups, culture and layered memory. As Casey suggests that *space* is conceptualised at some point after the perception of place, it is apt to recognise space as a concept that has arisen from within culture as a means of ascribing an element of sterility to locations which are otherwise place or places. So, just as place is natural, perceptible, yet unequal to environment, space is cultural and collective, yet unequal to landscape.

Contemplating the broad spectrum of cultural/environmental relationships that have been alluded to in this section, it is apt to consider the distinction and transition between space and place. Geertz (1996) addresses this through the notion of human dwelling:
"For it is still the case that one lives in the world in general. Everybody, even the exiled, the drifting, the diasporic, or the perpetually moving, lives in some confined and limited stretch of it – “the world around here...” The sense of interconnectedness is imposed on us by... the featurelessness and interchangeability of so many of our public spaces... and the routinization of so much of our daily existence. The banalities and distractions of the way we live now lead us, often enough, to lose sight of how much it matters just where we are and what it is like to be there” (1996, 262).

Geertz’s eloquent, if somewhat nihilistic, observation reflects the concepts of entanglement discussed in Section A3.3.4. Humans are subject to a myriad of involvements between themselves and things, including their landscapes. Casey (2010, 112-3) echoes this sentiment, eschewing the concept of embodiment for the more inclusive notion that humans are "an array of bodies, many different kinds of them, in a nested set of microbiomes". Accordingly, landscapes are one such type of body which exist through the extended human sense of self that incorporates the variety of environments and assemblages experienced.

A3.3.2 Framing the properties of Landscape

A typical understanding of how ‘landscapes’ perform, within archaeology, is that they are something to be owned and managed – evoking notions of memory, identity and territoriality. Students of landscape archaeology are regularly presented with processualist approaches, such as the division of the landscape by XTENT modelling (sensu Renfrew & Level 1979), or post-processual attempts at deriving meaning (e.g. Bradley 2013) or through ethnographic analogy (e.g. Parker Pearson & Ramilisonina 1998). The posthumanist approach, however, is less concerned with the interpreted meaning, and more with the routes and processes through which is meaning that are encountered. Tilley (2004, 25) provides a broad description to be explored:

“...landscapes can be most parsimoniously defined as perceived and embodied sets of relationships between places, a structure of human feeling, emotion, dwelling, movement and practical activity within a geographical region”.

Earlier in this appendix, the nature of human feeling and emotion was explored with relevance to how the environment can become possessed. Through developing an understanding of the concept of landscape, as the cultural layers upon any spatial location, the cognitive links between space/place and self can be identified.

Ingold (1995; 2000) develops a dichotomous relationship between building and dwelling, with the former relating to the mentally and physically constructed world, one with inferred purpose. Conversely, the latter refers to the non-meaningful description of a lifeway within the natural world.
An individual ‘builds’ by conceptualising and constructing in relation to the environment they exist in; following Heidegger (1971), an individual builds because they dwell rather than building to dwell. Carsten & Hugh-Jones (1995), while focussed on the connectivity of the body and the house, relate the house as an instrument of thought. Returning to Heidegger’s approach, landscape could be considered as a logical forebearer to the house – or, at least, an equivalent (as spaces on and within which we dwell) – thus equally as important as an instrument of thought. In a similar manner, Whatmore & Hinchcliffe (2010) relate Ingold’s work to Thrift’s (1999) ‘ecologies of place’ – whereby the landscape provides the ecological framework in which a myriad of inextricable human and non-human processes take place. Through these concepts, Whatmore & Hinchcliffe (2010, 457) posit that humans connect to place through a “bodily register of ecological conduct” which arises from the nature of their engagement with the constructed and natural elements of that environment.

Integrating these concepts inspires the idea that the environment acts as a cognitive space which allows people to explore and develop complex ideas within social and natural realms. Therefore, the environment is intangibly linked to the concept of landscape through such cognitive activity and, paradoxically, by facilitating the extension of human thought (a concept developed further in Section A3.3.4). “If the house is an extension of the person, it is also an extension of the self” (Carsten & Hugh-Jones 1995, 3); thus, following Ingold’s homology and by applying Heidegger’s logic, the landscape is also an extension of the self. This approach develops the basis for understanding how the environment, and landscapes, can become possessed by individuals. Overall, the notion of engagement with the landscape should be linked to how individuals engage with material culture. In essence, the landscape can be objectified, acquiring a sense of thingness. In this respect, the alignment and incorporation of these properties with the self is facilitated through the experience of possession.

Boivin (2008) notes a critical relationship between soil and the investment in place. This thesis naturally places soil as a central component of the agrarian landscape. Although Boivin’s work relates to the Neolithisation of the eastern Mediterranean, there are allegorical similarities between the adoption of agriculture and the later intensification of the landscape. Boivin asserts that the “investment in soil means investment in place” (2008, 137), reflecting Heidegger and Ingold with the consideration that the concept of settlement encouraged soil usage is interchangeable with the concept of soil usage encouraging settlement. On this basis, Boivin (2008, 138) expresses the agentic properties of soil and, by extension, the landscape:

“The unique material properties of soil helped create a new world, and once people began to experiment more systematically and frequently with it, these properties helped channel and distribute human energy along particular lines and according to particular patterns”.

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Boivin continues by suggesting that this agency, although non-conscious and without will, was nonetheless active in shaping the cultural processes that surrounded the adoption of the Neolithic in the eastern Mediterranean. Boivin charts the theoretical background to the agency of matter, noting the perils of determinism that arose with the application of biological models to society. Crucially, it is noted that the reduction of object agency to the status of *derived agency* – i.e. human agency via things – would lend credence to anthropocentrism, suggesting that humans were the main determinants in the natural world. Boivin’s work emphasises the problems with the current understanding of how materiality relates to society, and the need for new thinking to reconcile these varied ontologies.

The relative uncertainty regarding the nature of agency, especially related to material culture, arises from an associated polysemy of meaning. Dobres & Robb (2000) assemble a collection of differing interpretations in an effort to emphasise the difficulty of studying and utilising a nebulous concept. Observing this collection, one might offer the assessment of agency as the *conjunction of individuals, actions and the physical world*, enabling the *manifestation of intent*. Through this definition, the polysemy of agency may still flow, yet the major components are identified.

Considering the cognitive roots of agency, Haggard (2017), while noting a relative lack of understanding surrounding agency within neuroscience, summarises the neurological correlates. Current analysis associates the frontal and prefrontal areas of the brain with the selection and initiation of actions, while parietal areas – associated with monitoring intent, actions and outcomes – receive these signals. Haggard notes that this circuitry acts both prospectively and retrospectively, with such flexibility being the likely source for the developed sense of agency. Furthermore, Haggard emphasises that, under neurotypical conditions, the experience of voluntary motor actions is a fundamental aspect to the formation of a sense of agency. Referring to the earlier discussion of the self, this experience of voluntary actions likely engages elements of the proto, core and autobiographical selves. Actions and, by association, the perception of actions, therefore, relate directly to the neurological self – thus forming a central part of memory building.

Observing the natural world through these lenses exposes the routes through which humans have adopted and personified phenomena. In one sense, agency is realised in the practical responses to events such as flooding and erosion and, in another, through the complex linguistic examples of how nature is personified. The use of metaphor can be considered as the main way for individuals and groups to understand the world, through “a corporeal and sensuous animistic and anthropomorphic way of relating the self an culture to the world” (Tilley, 2004, 22). Tilley further asserts that the expression of metaphor is the manner in which human thought is materially objectified. Crucially, Casey (1997) presents the human experience of place and landscape as one of kinaesthesia – being sensed through bodily experience. Therefore, it can be said that the human experience of the
environment is not just one of existence but an entanglement of the senses and incorporation of the self, colliding to produce landscapes which are relevant to those who identify with them and relatable to others.

A3.3.3 Landscape and Possession

Taking a step closer to possession, the embodied experience of landscape relies on how people objectify materials. Developing this further, Tilley (2006) outlines a variety of other modes including: Socialisation, Production, Biography and Exchange. Central to these is the embodied experience of materials which takes place in a way that aligns the individual’s self with the material and enables a transfer of properties between the two (Socialisation, Biography and Production) – or the acceptance of pre-transferred properties (Exchange and Biography).

Returning to Rochat (2014), a series of routes to possession are discussed which hold a notable similarity to how Tilley describes objectification. Firstly, Rochat – following Weiner (1992) – separates alienable, easily transferable, and inalienable, non/poorly transferable, possessions. Associated with these is the perception of personal, intrinsic to the self, and interpersonal, extrinsic and contextualised, values. Conceptually, landscape is property that flexes between these categories as people can equally freely possess and exchange portions of their landscape, yet also be intrinsically bound to place through nuanced personal and social attachments. Rochat’s routes to possession can be grouped into modes of acquisition and transfer.

**Acquisition:**

- **Strongest and First** - the concept that the physically fittest/first to get the object acquire possession.
- **Labour** – following John Locke, possession is acquired as a result of the input of labour related to the object.
- **Creation/Invention** – the creator/inventor/generator possesses the object.
- **Familiarity** – a distinct feeling of possession arising from frequency of contact with an object.

**Transfer:**

- **Violent** – seizure of possession without any prior explicit declaration of possession or ownership.
- **Generosity** – possession resulting from the acts of gift giving.
- **Exchange** – negotiation and agreement on possession and ownership which is contextualised by comparative value of exchanged possessions.

Considering this from a cognitive perspective, Boyer (2018) observes the developmental discrepancy between ownership and possession intuitions, with young children being capable of differentiating between possessor and owner – intuitions which are based on the knowledge of an individual’s depth of connection with the thing. Tilley’s assertions parallel cognitive research (Friedman and Neary, 2008;
which explore the concept of object transformation as a means of ownership identification.

Linking back to Tilley (2006), there is an easy comparison between the object properties of landscape and the routes through which possession of objects take place. The landscape is possessed through initial claims, physical manipulation, innovation, change and habituality; aligning with the socialisation, biography and production properties described above. Not surprisingly, the modes of transfer described by Rochat (2014) are in parallel to Tilley’s exchange (2006). However, there are examples of ownership intuition being a secondary factor, after the primary expression of explicit conceptions (Noles and Keil, 2011). An incoherency exists whereby individuals dismiss the ability to own people or ideas and require a prompt to consider the nature of music or slavery. It could be argued that these are cultural phenomena which are layered upon human cognition through millennia of social development, thus existing beyond the reach of core intuition. It is within this incoherent realm that one may find the space for exploring the ownership of landscape, especially considering the broad cultural terms in which humans are documented to engage with the environment. A notional contrast can be drawn between the relationships Indigenous cultures hold with their environments and those relationships found between industrialised cultures of infrastructural development and their environments; both forge landscapes with abiding and often intangible links to their inhabitants.

A3.3.4 Entanglement

Seeking to overcome the divide between materialism and social construction, Hodder (2012) presents a theory of ‘entanglement’ as a means of exploring the relatedness between people and objects. Entanglement attempts to overstep the particular challenges of ecological focus or environmental determinism. This concept represents the interplay between the dependence and dependency found between humans and non-human things – entwined with the temporality of nature – which is reinforced by “conceptual abstractions and bodily resonance, a reverberation between mind, body and the world of things” (Hodder 2012, 206). To further complicate matters, the nature of entanglement suggests that it occurs at multiple scales simultaneously. Hodder devised a formulaic reduction which states that the increase in dependence equates to an increase in dependency, where entanglement (E) is encapsulated by:

$$E = (HT) + (TT) + (TH) + (HH)$$

Where: H = Human and T = Thing.
This theory struggles with scale overlap – losing robusticity in the fact that nature plays out on every scale and interrelatedness occurs like a flexible glue between scales. Hodder’s attempt to provide a summative philosophy is valiant, but also seems to overstep the physical reality of nature. Entanglement and the posthumanist/systems approach, discussed in Chapter 1, do not mesh effectively. Although entanglement does not inhibit the inclusion of multi-scale interactions, it does struggle with multiple temporalities. Hodder (2012, 217) states “in the end there is no linear sequence. There is simply entanglement with all its conjunctures and temporalities.” Perhaps entanglement, when faced with the challenge of time, is overstretched.

When considering the realities of physics, there are some comforting parallels that can be drawn. Newton’s Third Law – for every action there is an equal and opposite reaction – could provide a metaphysical backdrop for entanglement. It serves to remind us that we exist in a mesh of interactivity and causality that exists at the grandest and finest scales. Nature can be reduced to the quantum scale, with interaction between fundamental particles defining the inter- and intra-scalar events. Equally so, at the Universal scale, ‘grand’ events – supernovae, quasars, fast radio bursts etc. – serve to influence activities at much smaller scales. For example, the practice of radio astronomy demands a zone of terrestrial radio silence, to ensure the validity of extra-terrestrial observations; this zone undoubtedly affects how individuals act, with a knock-on influence occurring beyond this zone. Most importantly, this relationship exists to enable the observation of astronomical signals which were emitted deep in the past, thus aged temporalities are able to influence contemporary time. Conversely, at the smallest scale and with the consideration of quantum superposition, the concept of time begins to erode – with observation being critically linked to the presence/absence of particles. Fundamentally, quantum superposition defines how particles or entangled groups of particles can exist in a variety of states until observation, upon which, the probabilistic nature of these particles collapses and certainty can be defined.

While this may seem abstract, there is allegorical beauty to be found when comparing with the interaction between humans and things. Hodder’s struggle with time is, perhaps, understandable. However, taking a systems approach and accepting the scalar nature of the universe, entanglement serves to describe the imperceptible edges of interaction between these scales/systems. – “ironically its main neatness, is its messiness... [and] We can never mop up all this mess” (Hodder 2012, 222). This sentiment is developed through Vital Materialism (Bennett, 2010) which observes the challenges of scale and relevance. Bennett (2010, 30) states “humanity and nonhumanity have always performed an intricate dance with each other. There was never a time when human agency was anything other than an interfolding network of humanity and nonhumanity”. Furthermore, the enmeshing of human culture with dynamic nonhuman entities, and the state of human agency conferred by the association
with these nonhumans, demands a frame of reference that is neither individual nor specifically collective but rather a malleable collective which surrounds a problem.

So, how does this relate back to landscape and possession? The diversions into entanglement and quantum thought serve as a consideration of human existence within the universe. Human experiences are immersed in the dimension of Space-Time. Action, reaction and the passage of time are normal course in this reality. Bennett (2010, 97) describes how "...vegetation, forest trees, soil, soil microorganisms, and humans.... are all responding, in real time and without predetermined outcome, to each other and to the collective force of the shifting configurations that form". Perhaps Hodder’s (2012) stumbling block is that our scales of reason are centred upon the human scale, with less consideration for the meaning of entanglement within other scales.

Crucially, human consciousness provides another line of entanglement between the scales, limited only by our scale of experience. Carl Sagan (1980) described human consciousness as the route for the Universe to know itself. While this notion is inherently anthropocentric, it is founded on the knowability of science and the implicit agency of the physical world. Consciousness is the conduit of understanding for the physical world; science provides access to scales formerly inaccessible, yet still deeply linked to human action. One might offer that our landscapes are a composite of scales, with human consciousness binding the experienced past and the anticipated future (Damasio, 2000), and cognition providing implicit links and observations which define reality.

A3.3.5 Scalar Increase

With consciousness forming a part of the matrix of entanglement, it is worth returning along the path of agency – as the means of building the relative concept of self in the world – to the idea that individuals ‘think through landscapes’ (sensu Ingold 1993; Carsten & Hugh-Jones 2010). This discourse can be related to explorations (e.g. Clark 2008; Clark & Chalmers 1998) of embodied and extended cognition. The Extended Mind Thesis (EMT) suggests that components of the human mind extend beyond the skin/skull boundary to utilise elements of an individual’s physical environment and sociocultural landscapes. Typically, cognition is extended when “internal and external resources become fluently tuned and deeply integrated in such a way as to enable a cognitive agent to solve problems and accomplish their projects, goals, and interests” (Kiverstein et al., 2013). A more individualist example of extended cognition is provided by Clark (2008, xxv) who recounts a discussion between Richard Feynman and Charles Weiner, within which Feynman emphasises that his paper notes and sketches were integral to his mental working, and not merely a record as Weiner suggested. Clark uses this to suggest that Feynman was “thinking on the paper” and that “the loop through pen and paper is part of the physical machinery responsible for the shape and flow of thoughts and ideas that we take, nonetheless, to be distinctively those of Richard Feynman.” Here, technological resources
have become deeply entangled with human cognition, to the extent that they are considered part of human mental machinery itself. Contemporary examples of this process include the widespread reliance on mobile computing, and the functionality provided by Google services. This example ranges from mundane user-specific tasks – information recall, planning, organising etc. – to aggregate and socially attenuated functions, such as traffic, routing, informed recommendations. The latter represents a complex entanglement between individuals, their environments and their technologies.

Landscapes are bound to extended cognition through the process of active externalism (Clark and Chalmers, 1998) through which humans form a coupled system between themselves and external things – a two-way interaction which can be defined as a cognitive system in its own right. The function of such systems is to govern behaviours through the active causal role played by each component part. For example, any card game which relies on a player’s hand of cards as a component of play usually involves the player preparing game actions through the rearrangement of cards in hand – a function of actively externalised cognition. The aggregate cultural traits, observed by archaeology and anthropology, may serve to act as an appropriate analogue for a deck of cards. In particular, memory is a multi-facetted trait of human cognition and social dynamics that is manifest in a variety of forms across humanity. Jones (2007) develops the embodied link between landscape and memory, describing the physical world as an index which enables the deeper consideration of inter-related components. He posits that “the act of inhabiting the landscape is therefore an embodied activity, in which the form of the landscape is generated through a process of incorporation whereby forms are not so much inscribed upon the landscape but are rather generated out of interaction” (2007, 194).

Drawing upon work by Ingold (1993), Jones (2007) describes taskscapes as a reminder of the temporality of activity within landscapes, linked to Bender’s (2002) assertion that landscapes are the product of time materialising. Perhaps dissatisfied with this processual approach, Jones relays Ingold’s (2000) dichotomy of cognitive maps and wayfinding as a means of parsing memory as a structure and as a process. Cognitive mapping suggests that movement through a landscape actuates previously memorised cognitive maps, thus “bodily movement is harnessed to the complex structure of the cognitive map” (Jones 2007, 195). Therefore, the individual departs on a journey with a total understanding of the journey ahead, with movement facilitating the completion of the journey. Conversely, wayfinding utilises the active memory of previous journeys and experiences – relying on the physical embodiment of the current journey and relating this to the encoded activities of the past; thus, movement is no longer predetermined but instead reflexive of the mnemonic features encountered presently and through time. Ingold eloquently summarises the time-rich entanglement of landscapes, memory and cognition by stating that:

“...places enfold the passage of time: they are neither of the past, present or future but all three rolled into one. Endlessly generated through the comings and goings of their inhabitants, they
While Jones uses this argument to preface the inscription of rock art on the landscape, the observations are transferable as a general commentary on how landscape and memory interact. Fittingly, these descriptions align with the cognitive basis of memory, namely semantic and episodic memory formation. Tulving (1972) posits that the combination of these two types of memory – the overall purpose of memory – serves as information processing systems which receive, select and retain information from perceptual systems and relay, on cue, specific information to other systems. Semantic refers to the categorisation of those memories associated with the “stable, declarative, and accessible knowledge of the environment, [which] allows us to extract relevant information about current situations from past state[s] of affairs” (Boyer, 2009, 4). The semantic system registers cognitive correlates of input signals, rather than the perceived properties of the input. As such, it enables the retrieval of information that is stored beyond the semantic system, while leaving stored memories unchanged. Furthermore, use of semantic memories affects the formation of episodic memories. Episodic memories encode temporally located events, and their complex spatio-temporal relationships (Tulving, 1972) – “what we most commonly refer to as “memories” – information about unique, specific situations... encountered in the past” (Boyer 2009, 4). Episodic memories are autobiographical in nature and their retrieval also acts as a memory input which alters the episodic memory store (Tulving, 1972).

Therefore, it can be said that semantic memory, along with procedural memory (skill and expectation based), provides rapid and situation specific responses to activities, affected by past experiences; whereas episodic memories are the specific record of personal experiences which are autobiographic and relatable to other memories in terms of perceptual details. Examination of the neurophysiology of memory has revealed a general pattern of “bilateral activations of posterior regions of the temporal lobes, cerebellum, and left lateralized activations in frontal regions” (Wiggs et al., 1998, 103). However, differentiated testing revealed that semantic memory utilises the left temporal and left frontal regions of the brain, whereas episodic memory activates the medial parietal cortex, retrosplenial cortex and the thalamus.

Returning to the discussion of cognitive maps and wayfinding, it is easy to see how the universal concepts of semantic and episodic memory can be translated respectively. Human cognitive maps are shaped by past experience, but part of the rapid recall of semantic memory that maintains our situational preparedness, while our wayfinding relies on meaningful experiences of spatio-temporal relationships which are encoded by episodic memory. Fundamentally, the interaction between semantic and episodic memories is highly relevant to the concept of the self – especially when memories are considered in relation to autobiographical recall. This recall serves three main purposes:
Self-reflection, the sense of Personal Agency and Ownership, and Representing the continuous self (the self through time) (Boyer 2009). This emphasises the importance of landscape in constructing our individual sense of self and is suggestive of a feedback loop where an individual’s self, agency and memory are continually boosted through the experience of the landscape. Yet, landscape being a cultural manifestation serves to reinforce the deeply entangled nature of people in their environments.

A3.4 Synthesis

This appendix set out to draw together a matrix of understanding that helps to situate complex theoretical terms within their neurophysiological and cognitive correlates. Treating human cognition as a unifying factor across the species, neurotypically speaking, this matrix of understanding enables archaeologists to observe vital connections between physical remains and the people they relate to. Cognitive studies can serve archaeology as an aggregate of knowledge which is otherwise chronologically intangible. While it is prudent to eschew absolutism, it is valuable to utilise our multi-disciplinary knowledge of the human condition to fill the gaps that exist in the archaeological record and are eroded through the taphonomy of time.

Landscape, as a loaded cultural term, is ubiquitous within archaeology and anthropology. For the purposes of this thesis, it acted as a trajectory to explore the deeper comprehension that cognitive studies can provide archaeological theory and interpretation. Departing from the broad concepts of possession and ownership, this appendix has observed how these phenomena related to an individual’s concept of self – with objects being incorporated into the self, utilising neurophysiological components which relate to perception and emotion. Building on this, the concepts of self and possession do not exist in isolation as they are intrinsically related to inter-personal and group dynamics. The cognitive processes involved are linked to an individual’s perception and management of others, with possession being an emotion and ownership being a higher order concept, both of which are central to group dynamics.

With the pathway to possession outlined, this appendix shifted focus to the concept of landscape as an ownable thing. At its core, landscape is a higher order term which is rooted in the collective perceptions of place – and an overlapping of commonalities, rather than identical values being placed on locations. In a similar manner to how possession is experienced, the knowability and manipulability of environments engenders how humans appropriate locations. However, at the centre of this is the cognitive utilisation of environments as an extension of mind. This aligns with the incorporation of objects (or in this case, landscapes) into the self and supports the concept of possession through conscious embodied familiarity.
At a broader level, this appendix has explored the near-imperceptible links between human minds and the wider universe. What Hodder (2012) offers with *entanglement* is essentially an alternative description of phenomena which exist in nature; an attempt to link complexities of human relationships with the matter that composes the world around. Karen Barad, a physicist and philosopher, presents (2007) the concept of *intra-action* – which describes out defined bodies participate in action together. In this theory agency is the *dynamism of forces* related to how bodies/things are in a constant state of action, exchange and. Furthermore, intra-action posits that objectivity – or absolute separation of bodies – is impossible, as the intra-acting bodies form an intrinsic part of a process that results in detectable outcomes (observations/measurements etc.) However, Hodder’s approach should not be discredited as, instead, it serves as a vital allegorical model which can support archaeological interpretation. Bolstering entanglement with the current understanding of natural sciences (particularly physical and cognition), as well as the offerings of vital materialism, builds a matrix of understanding which can illuminate human engagement with environments and non-human entities (of all scales). These varied connections, only truly observable through polymathy, fit the posthumanist discourse that this thesis has adopted through accepting the multi-scalar interactivity that is central to how humanity is joined to a wide assemblage of things, many of which being cognitively internalised while remaining physical external.

Bennett (2010, 166) declares that "it is futile to seek a pure nature unpolluted by humanity, as it is foolish to define the self as something purely human". This appendix has enriched these concepts further by drawing landscape into a Posthumanist discourse and relating how landscapes only exist through the extension of human cognition to incorporate external *things* within the internalised sense of self. Thus, (post-)humans exist as an entanglement - or intra-action - of physical bodies and cognitive processes, with landscapes being established through the enmeshing of environmental bodies and the people who experience them. This advances the vital materialist and post humanist discussion by recognising the universality of landscape as the incorporated and reflexive context of human life. To reiterate the introductory disclaimer, this appendix exists as a working essay which can be applied to landscape generally. However, this thesis will draw upon the body of knowledge presented above to provide a deeper interpretation of the role of agricultural terracing within this reflexive theory of landscape. Chapter 6, the culmination of this thesis, will consider the relationships between archaeological methodology, population theory and cognitive discourse, themes previously detailed extensively, ultimately forming a commentary on agriculture, the Anthropocene and the Maltese Archipelago.