Introduction

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0.1. Introduction

The *FRAGSUS Project* (*Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory*) was devised to explore issues of prehistoric island sustainability set against the background of environmental change and instability. Particular foci were the fragility and sustainability of society and environment in the Maltese Islands (Fig. 0.1), primarily during the Neolithic period of the sixth to third millennia BC. Specifically, the research team aimed to understand and explain the nature of the impact of expanding human populations on a restricted, resource-limited and fragile environment such as the Maltese Islands. Our goal was to advance knowledge of the mechanisms and innovations (cultural, technological and political) that traditional (prehistoric) farming societies developed in order to cope with changing resource availability and environmental unpredictability. We sought to understand how some societies managed population impact and sustained their socio-economic system and culture over long periods of time through examining the evidence preserved in the archaeological and palaeoenvironmental records.

Island studies have long interested archaeologists and ecologists. An island represents a conveniently circumscribed landscape of known size, surrounded by water, and thus remote from larger landmasses and their biological and cultural stimuli. They are sometimes taken as a microcosm of the situation of the human species in a severely circumscribed and overcrowded planet. From the seminal ecological studies of Charles Darwin (Jones 2009) and Alfred Wallace (1892) in the nineteenth century, to the rich theoretical literature on biogeography and equilibrium theory in islands first initiated by MacArthur and Wilson (1963, 1967), an entire sub-discipline of island studies has developed. The studies range from Simberloff's equilibrium theory (1974), the ecology models of Gorman (1979), ecological anthropology (Vayda & Rappaport 1968) to current ideas of evolution and equilibrium (Lomolino *et al*. 2010) and colonization (Cox *et al.* 2016). Generally, the bulk of research has been focused on non-human subjects, with issues of extinctions and conservation foremost, but nevertheless, a number of important theories and models from these island studies are relevant to archaeology.

FRAGSUS has sought to examine the particular impact made by humans on the natural environment and resources available in a prehistoric island context. There have been a number of useful studies on island colonization patterns and case studies of the Mediterranean and the Caribbean in particular, that extract some key ideas from the ecological models and apply them to the anthropic context. Evans (1973a) was amongst the first to present the 'island' as the laboratory case study of an ancient society in the Mediterranean context. Cherry (1981, 1990) further demonstrated the more mathematical outcome of these ideas, and that work has generated a succession of useful, relevant studies some of which specifically focus on Malta (Broodbank 2013; Dawson 2014; Kirch 1986; Kolb 2005; Malone 1997–8; Patton 1996; Rainbird 2007; Renfrew 1973; Stoddart 1997–8, 1999) that have worked to develop both the theory and to show the archaeological relevance of the application of the island ecology models to ancient island issues.

As time has progressed, increasingly detailed complementary information has been added, especially a more detailed and exact chronology. Now with fifty years or so of increasing numbers and resolution of radiocarbon dating estimations, the tempo of island colonization, consolidation and desertion can be more effectively presented and the archaeological record better understood. We can now present an understanding of chronology rather than speculate about when humans arrived on particular islands, and

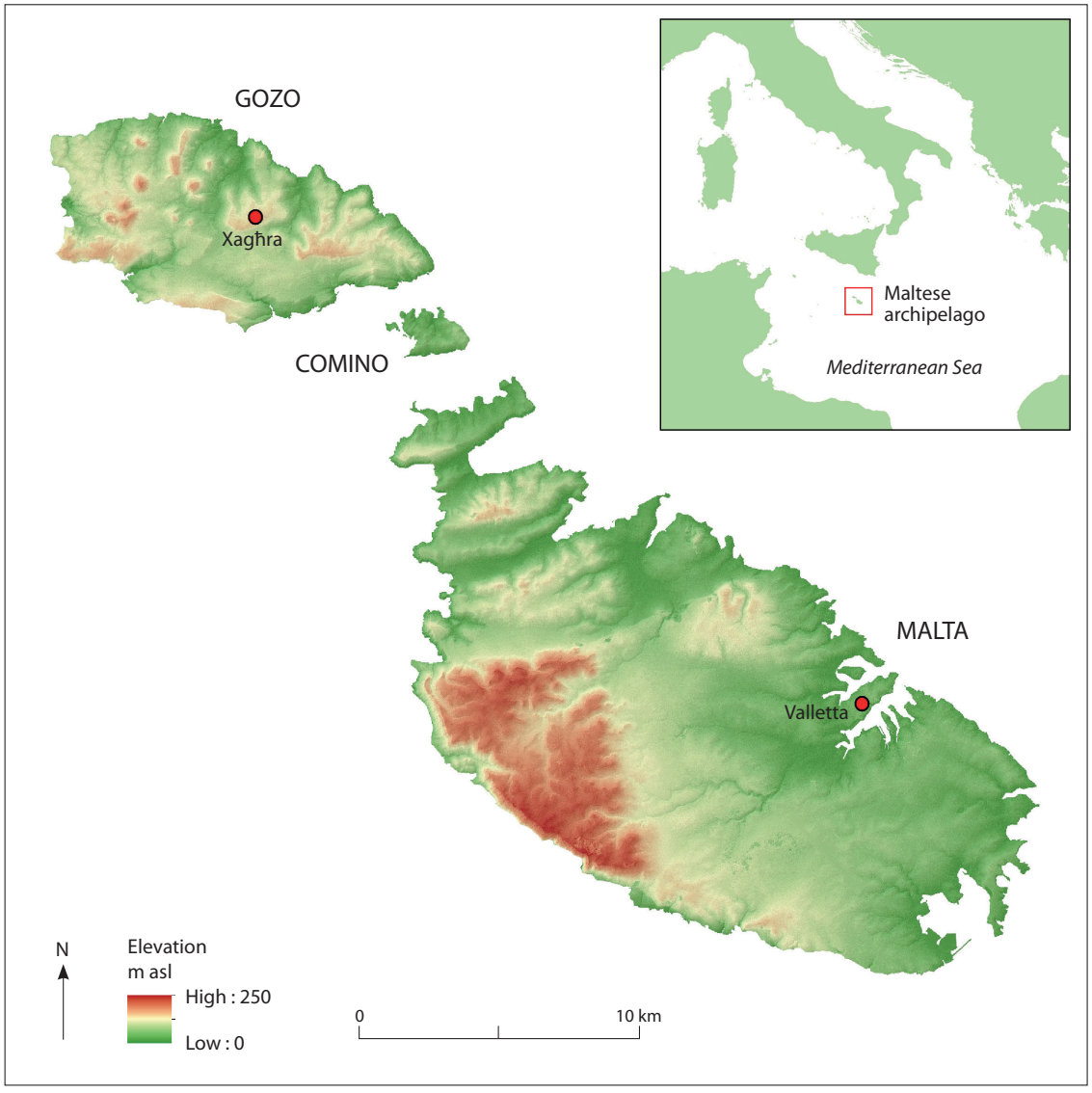

Figure 0.1. *Location map of the Maltese Islands in the southern Mediterranean Sea (J. Bennett).*

when distinctive socio-cultural evidence appeared and disappeared in the sequence of social and environmental evolution. When Cherry (1981, 1990, 2004) was estimating island colonization patterns in the Mediterranean, far fewer uncalibrated radiocarbon dates were available. Whilst he and Patton (1996) identified that the sixth millennium BC witnessed the first major episodes of colonization associated with the spread of farming, there was little chance then to break the key sixth millennium BC into detailed episodes that might trace the dynamics of what was probably an extended and punctuated process. Dawson (2004–6, 2008, 2010, 2014) identified Malta and Gozo as an archipelago likely to have been colonized just once, on the basis of data available, and this was a notion largely supported by Trump (1995–6), although he did speculate about possible breaks in the cultural sequence. Without detailed chronology, the often momentary episodes of cultural activity are impossible to pin down in a time sequence that may cover millennia with little apparent cultural change. Accurate time measurement is fundamental too in controlling and comprehending the relationships between human activity and environmental change and climate fluctuation.

The growing field of palaeoecology, combined with increased knowledge of past climates and catastrophic events, has also added to the need for chronological precision that can correspond with human timescales. Current studies using precise proxies, such as tree-ring dating, demonstrate distinct

events in the past which are clearly signalled by a number of data that demonstrate downturns, climaxes, catastrophes (Baillie 1999) and also, the impact of humans on the natural environment (Butzer 1982; Goudie 1993).

Islands make excellent subjects against which to test these many ideas and technical approaches, especially when a combination of factors are clearly identified, such as:

- a reasonably isolated island of small size (i.e. less than 500 sq. km).
- a distinctive and dated archaeological sequence of human activity and material culture that changes over time.
- potential for extracting suitable environmental data such as pollen, molluscs-invertebrates, soil history, human and faunal remains with the potential to demonstrate dietary and climatic isotopic information.

Such data provide a solid base upon which to explore past human impact on the natural environment, and to identify how humans managed to cope when the resources of the natural world began to fail their needs. *FRAGSUS* was designed to explore and record a long human sequence that could challenge established theories and interpretations, and the outcome is recorded in the three *FRAGSUS* volumes, of which this is the first.

0.2. Background to *FRAGSUS* as an archaeological project

The richness of Maltese prehistoric archaeology has attracted a range of key figures who have explored its unusual qualities. Before the twentieth century, Maltese archaeology was a curiosity noted by travellers and administrators, but the study lacked much coherent scholarship. It was only from the first decade of the twentieth century that the outstanding partnership of Themistocles Zammit (an established scientist and archaeologist) and Thomas Ashby (a stratigraphic excavator whose skills were honed on the Roman monuments of Caerwent in Wales), projected the riches of prehistoric Malta onto the world stage. This followed the detailed published study of the German scholar Albert Mayr (Mayr 1908), who likewise had recognized the extraordinary prehistory of the Maltese Temple culture. The contributions of Ashby to knowledge of sites including Santa Verna, Kordin, Mnajdra and Ħaġar Qim (Ashby *et al*. 1913) and Zammit (1930), independently and more dramatically to the discovery of Tarxien, collectively demonstrated the creativity of the inhabitants of the Maltese Islands from an antiquity that had not previously been accepted. Zammit also developed a powerful understanding of the structure and diversity of the elaborate material culture within the impressive monuments he examined. Above all, he realized the importance of reconstructions *in situ* coupled with rapid publication and dissemination of information in written and museological form. A less well-known figure, until recently, is Luigi Maria Ugolini, who was one of the first scholars to appreciate the socio-cultural significance of these discoveries, stressing their importance over and above the classically inspired wisdom of the time. His work (Ugolini 1934) was amongst the first to interpret the discoveries in terms of the living people who created the monuments. As a synthesis, it is probably fair to state that these pioneers developed a broad understanding of the major monuments, most notably of the so-called temples, together with the underground burial chambers of Ħal Saflieni, but ignored other potential questions (principally those concerned with landscapes, environment and subsistence) that remained under-investigated.

After World War II, two archaeologists, John Evans and David Trump, built on the achievements of these pioneers. John Evans, like many significant figures of his generation, honed his forensic skills at Bletchley Park (the World War II code breaking centre for British Intelligence in Buckinghamshire, England) and applied them to the early Mediterranean through his training in Archaeology and Anthropology at Cambridge. In 1952, he was appointed by a committee led by the Royal University of Malta to systematize the unpublished and outstanding discoveries of the pioneers in a survey of the state of knowledge of the archaeology of the Maltese Islands. He combined this systematization with a series of surgical investigations of key monuments to attempt a chronological resolution to the rich material culture. Evans focused on sites where stratigraphy was clearly preserved by the sealed packed limestone plaster (*torba*) floors, and where uncontrovertible ceramic sequence could be extracted (see Volume 2, Chapter 10). In the tradition of Zammit, he also developed an early synthesis of these results (Evans 1953, 1956, 1959), even if publication of the full dataset took time (Evans 1971), a delay which allowed the inclusion of new and significant information. At the same time, he followed the footsteps of Ugolini by developing an interpretative framework, albeit in a rather different direction and tradition; he both posited the ideas of island archaeology (Evans 1973a, 1977) and considered the role of the priest in some of the monuments that he was synthesizing (Evans 1973b).

David Trump accompanied Evans on his exploratory fieldwork and, following his appointment as Curator of the Museum of Archaeology in Valletta in

1958, developed the subtleties in the prehistoric timetable much further. Most significantly, he excavated the site of Skorba Temple, uncovering new phases in the Maltese sequence and providing the radiocarbon dates to accompany this material (Trump 1961a, 1966). The chronology was no longer relative, but increasingly precise, even if based on remarkably few samples. Trump was also instrumental, with Charles Zammit, the museum director and the son of Themistocles, in displaying these achievements in the newly established National Museum of Archaeology in the centre of Valletta. In fact, David Trump developed a natural, albeit idiosyncratic, talent and strong following in the popularization of the importance of the Maltese Islands in prehistory (Trump 1972, 2002, 2010).

Two further figures (including one of the current authors) helped to steer us to developing the *FRAGSUS Project*. Colin Renfrew (1973) advanced the implications of the new radiocarbon dates largely produced by David Trump, but supplemented by himself, by highlighting the broader setting of calibration, and thus firmly establishing the claim that these monuments were the oldest free-standing stone monuments in the world. At the same time, he took their theoretical understanding further forward by putting forward theories of societies and their territories in an island setting, and how they might have developed over time (Renfrew 1973; Renfrew & Level 1979). Anthony Bonanno, the founding and long-standing head of the Department of Classics and Archaeology at the University of Malta, made his own very real contribution to the debate by synthesizing the available information (Bonanno 1986a) and by jointly proposing an Anglo-Maltese collaboration during a seminal conference that he organized in 1985 (Bonanno 1986b).

The collaboration that followed (1987–95) between the Universities of Malta and Cambridge and the then Museums Department took stock of the current state of knowledge based on Anthony Bonanno's 1986 synthesis. It was clear that study of the Neolithic 'temples', mainly on the island of Malta, had dominated previous research. Questions of death, domestic life, economy, the human and physical landscape had been under-researched. The Cambridge Gozo project under the direction of Anthony Bonanno, Tancred Gouder, David Trump, Caroline Malone and Simon Stoddart sought to investigate these remaining gaps. A single phase Temple Period settlement structure at Għajnsielem on Gozo was investigated in the first 1987 season (Malone *et al.* 1988, 2009a), the Xagħra Brochtorff Circle (sometimes referred to as a hypogeum) over seven field seasons (1987–94), and a field survey was started at the same time in those moments when the great investment of work on the Xagħra Brochtorff Circle permitted (1987–95). The most successful feature of the project was a deeper understanding of death ritual (Malone *et al.* 2009a). Some major strides were made in the survey towards appreciating the principal changes in settlement distribution between the ceramic phases of Għar Dalam to Baħrija in the central part of Gozo through a systematic landscape survey (Malone *et al*. 2009a; Boyle 2013; see Chapters 2 & 7). Some new information was gleaned on domestic life, and several likely settlement sites located, although the excavated Għajnsielem Road structure was largely devoid of informative refuse (Malone *et al*. 1988, 2009a). Very few advances were made in understanding the changes in the physical and natural landscape although several specialist scholars sought to identify means to extract knowledge and data (notably Hunt, Keeley, Canti and Schembri). The most successful work came indirectly from the study of land snails from the Xagħra Brochtorff Circle (Schembri 1995; Schembri *et al*. 2009). The scientific goals of the Cambridge Gozo Project (1987–94) were significant on a number of fronts. In particular, it achieved knowledge of prehistoric funerary ritual and an initial study of the prehistoric population. Inadequate funding meant that the osteological study was preliminary. Nevertheless, that work revolutionized approaches to the bioanthropology of the prehistoric population. It represented only the second discovery of a Temple Period funerary complex (rather than individual tombs) in Malta and the only example of a fully recorded burial assemblage. Chronological progress included a suite of accelerator mass spectrometer (or AMS) radiocarbon dates on human bone, fixing the episodes of burial for the first time, the study of molluscan evidence for environmental reconstruction, the identification of hard stone sources from outside Malta, and preliminary work on diet and the prehistoric exploitation of domestic animals (Malone *et al*. 2009a & b).

This archaeological work between 1986 and 2009 identified a number of directions for future research. There was a specific need for more scientific analysis of the human remains, for better understanding of diet, disease and changing life patterns, more precise AMS radiocarbon dating, and for application of (the then) new and promising aDNA methods on the enormous assemblage of human bones (*c*. 220,000 individual parts). In conjunction with excavated materials, we also suggested that sediment and environmental research might interrogate the question of climatic downturns that might address an overriding question, 'why did the Temple Culture collapse and disappear'? Central to this question is a current concern – the resilience and sustainability of human and natural systems, even though, with the luxury of historical hindsight, it is

evident that almost all cultural system fail eventually, or evolve into new formations. Malta provided an ideal test case to examine how a prehistoric community over time dealt with many constraints of space, resource depletion, and climate change. We hoped that climate and environmental changes in the local environment of Malta might be detectable, with the potential to inform on the archaeological social changes we identify in the human sequence. Rarely is this type of combined approach taken with small-scale prehistoric cultures, but surely an interdisciplinary approach has the potential to tells us far more about our human story and the manner by which humans cope that simply studying cultural materials?

0.3. Environmental research in Malta and the Mediterranean

Research on Quaternary environmental change has its roots amongst the earliest manifestations of the scientific investigations of the world by Classical and Enlightenment authors, many working in the countries around the Mediterranean. In the nineteenth and early twentieth centuries, however, advances were most rapid in the countries of Northern and Alpine Europe, where the very abundant glacial features and deposits had clear analogues in contemporary glaciated landscapes, attesting to the former extent of great ice-sheets. Further, technically straightforward investigations could be, and were, conducted on post-glacial materials such as bog peats and lake muds which contained easily recognisable sub-fossil plant and animal remains. During the earlier twentieth century, Quaternary sciences advanced rapidly in Northern Europe through investigation of previously glaciated landscapes and post-glacial sediments. Consequently, understanding of climate change and the role of humans in landscape change advanced considerably with the development of pollen analysis and a suite of other scientific analytical techniques (i.e. Hunt 2001; Brothwell & Pollard 2005; Sanderson & Murphy 2010; French 2015).

In contrast, investigation of the Quaternary history of the non-glaciated European countries, and particularly those adjacent to the Mediterranean, was initially far less straightforward, since these generally lacked glacial features, bogs and lake basins. The techniques such as pollen analysis, which had been developed for the bogs of northern Europe, were not easily applied to the often highly oxidized deposits available in southern Europe. Thus, although pollen analysis was widely used in northern European countries, its appearance in southern Europe was delayed to the late 1950s. In southern European countries, much early attention was focussed on the relatively abundant and often spectacular archaeology of early humans and particularly on cave deposits, many of which contained archaeological and faunal remains. Consequently, ideas about climate change and human impact on landscapes remained very sketchy and were often extrapolated from models developed north of the Alps (Bowen 1978).

Although several individual researchers, notably Karl Butzer (Butzer 1960; Butzer & Cuerda 1962), Enrico Bonatti (1966) and Thomas van der Hammen *et al*. (1965) had carried out high-quality localized investigations, the first comprehensive attempt to investigate Quaternary environments in the countries of southern Europe and around the Mediterranean was '*Mediterranean Valleys: Geological Changes in Historical Times*' by Claudio Vita-Finzi (1969). This seminal publication provided the impetus for the wide-scale investigation of Quaternary landscapes in many Mediterranean countries, notably the work of Donald Davidson (1971, 1980), John Bintliff (1977) and Tjeerd van Andel (Van Andel & Runnels 1987) in Greece, and a group of English researchers, including David Gilbertson, Chris O. Hunt, Caroline Malone, Simon Stoddart, Antony Brown and Graeme Barker in Italy (Hunt *et al*. 1992; Malone & Stoddart 1994; Barker 1995, 1996; Brown & Ellis 1995; Hunt 1998), Libya (Barker *et al*. 1996), Jordan (Barker *et al*. 2007) and the wider Mediterranean (e.g. papers in Woodward *et al*. 1995). Most of this work dealt with the landscapes and deposits of river valleys, and collectively it demonstrated that landscapes around the Mediterranean were extremely sensitive both to climate change and to human activity. The research confirmed the early observations of Butzer and Cuerda (1962) and Bonatti (1966), of generally arid and cold Pleistocene episodes correlating broadly with episodes of glacial expansion in Northern Europe interspersed with relatively humid temperate phases which coincided with Northern European periods of glacier recession. This and later research identified in the Mediterranean countries a general pattern of aridification after the Early Holocene humid phase, with increasing environmental human impact through grazing and arable agricultural vegetation clearance and consequent soil erosion.

The Cambridge Gozo Project, led in the field by Caroline Malone, Simon Stoddart and David Trump, offered the opportunity to extend landscape research into the Maltese Islands which updated the work of Trechmann (1938) and Pedley *et al*. (1990). Hunt (1997) showed that Trechmann's (1938) synthesis of the Quaternary deposits of Malta had been far in advance of its time, but the supposed interglacial marginal marine deposits identified by Pedley *et al*. (1990) were in fact terrestrial colluvial cold-stage sediments. It was

apparent from this survey that terrestrial evidence for Quaternary landscape change was sparse and discontinuous in the extreme. On the other hand, it also became apparent that the estuaries of the Maltese Islands contained substantial sediment bodies. Reconnaissance coring of a few of these estuarine sediment bodies proved deep sequences of well-preserved, if discontinuous, Holocene sediments of Neolithic and later age containing abundant sedimentary and fossil evidence for past environments (Carroll *et al*. 2012). A key component of the *FRAGSUS Project* was therefore to extend this approach, to generate a continuous landscape and climatic history by systematically exploring the estuarine sediment bodies and their contained sedimentary and biotic evidence.

Shortcomings to all previous work on the prehistory of Malta (and indeed, of much of the southern Mediterranean) have been the lack of coordinated scientific fieldwork and data collection. That coupled with insufficient resources for intensive fieldwork and scientific analysis have resulted in research content simply to identify sites and pottery without background on the 'landscape' and 'monuments'. Too rarely had soil and environment been considered as an integral archaeological component of the record, other than in the general sense of a covering over buried sites. Indeed, never had a soil history been undertaken of Malta that investigated the changing nature of soil over time as it related to the human story. Geographers had undertaken some excellent work in preparation for Independence (Bowen-Jones *et al*. 1961) and observed a much more accessible and visible landscape than is possible today. That work, however, was not aimed at environmental reconstruction and such work was not attempted until the Cambridge Gozo Project from 1987–95. The survey (Boyle 2013; see Chapters 6 & 7) aimed to map the established soil distribution in relation to site location, but the harsh alkaline cave-like environment of the Xagħra Brochtorff Circle funerary site the was such that pollen was not preserved, and by definition it was located some distance from the living sites, where pollen data would be most informative. The environmental questions, nevertheless, remained and one of the team from the original Xagħra work (C.O. Hunt) continued in the quest to obtain suitable environmental material over the two decades before *FRAGSUS* to obtain meaningful pollen samples (Hunt 1997, 2015; Hunt & Schembri 1999; see Chapter 3). The initial history of vegetation change was indicative (Carroll *et al*. 2012; Fenech 2007; Hunt & Schembri 1999), but inconclusive, with substantial gaps in the sequence for Malta at crucial times in later prehistory. Likewise, other environmental work had not investigated animal bone and the settlement and economy of prehistoric Malta at a reliable level. The rise and florescence of the extraordinary Temple Culture could not be explained in socio-economic terms, so prediction of population levels and density in prehistory was speculative. In tandem, it was not possible to measure changes in socio-economic conditions over prehistory without better data and a more extensive chronology. Without a deeper understanding of the environmental or economic base, the Neolithic World Heritage Sites were 'mysterious' and liable to excessive interpretation based more on a fantasy goddess culture than on archaeological facts. Thus there was a solid case for new research which the European Research Council (ERC) assessors generously recognized.

0.4. The development of the *FRAGSUS Project* and its questions

In the years immediately following the 2009 publication of the Xagħra Brochtorff Circle (Malone *et al*. 2009a), while other fieldwork was developed elsewhere in the Mediterranean by the team, the various issues became a discussion point for some of us (especially Malone and Hunt in the Palaeocology Laboratory of Queen's University Belfast, and others in the Universities of Malta and Cambridge, and the newly established bodies of Heritage Malta and the Superintendence of Cultural Heritage), to develop a project that was resolutely designed to solve the many remaining questions, and extend scientifically informative research activity in Malta as well as on the smaller island of Gozo. The precious resources of pollen, soils and sediment thus became central foci for the new project together with investigation of subsistence, food and domestic life in prehistoric times. With the rich resource of the Xagħra Brochtorff Circle population ready for additional scientific analysis to contribute to such studies, the notion of an explicitly interdisciplinary approach was readily embraced by the extended team. It was also realized that the chronology of the Maltese Islands, although established in its broad outlines, was based on too few dating samples, and too much on pottery sequences. If the understanding of the tempo of island life from prehistory to more recent times was to be better established, it was considered vital to invest heavily in cutting edge chronometric techniques that included Optically Stimulated Luminescence (or OSL) as well as Accelerated Mass Spectrometry (or AMS) radiocarbon dating. Without a core of chronological control across all aspects of the research, we realized that the precision needed to understand human and environmental change in general and in the microcosm of Malta in particular would be all but pointless.

FRAGSUS specifically set out to tackle a number of interdisciplinary questions (as presented to the ERC for the grant aid that supported the project). These questions centred around a central query that demanded better understanding of the chronology, environment and its changes and potential for exploitation over several millennia. We were particularly interested to learn whether there had been continuity of cultural activity on the islands over the Neolithic Temple Period and into the Early Bronze Age. Obviously, only a major, very well-funded project could apply the necessary modern levels of interdisciplinary scientific analysis to test the questions, and potentially make an advance in understanding. A period of collaborative discussion in 2011–12 led to the application, headed by Malone, for funding from the European Research Council (ERC). *FRAGSUS* as a project was developed around the five principal questions (see §0.5) and the application of new and well tested approaches which we described as follows:

> *We bring a suite of specialised modern palaeoecological, environmental, landscape, anthropological, archaeological and chronological approaches – practical and analytical – to examine the issues of long-term cultural sustainability in this fragile environment. We will sample sediments, sites, material culture, human remains and landscapes to study interlinked elements which may collectively provide understanding of how a culture developed, was maintained and collapsed. Detailed chronology will be developed using state of the art AMS (Accelerator Mass Spectrometer) radiocarbon, tephra and cultural dating to provide vital control over the data, enabling realistic understanding of cultural and environmental change. We have pilot tested these approaches in previous fieldwork and will apply them to this key case study. As a central focus, eight pollen cores will be drilled, dated and studied for pollen, invertebrate and other fossils proxies to reconstruct the dynamic ancient environment in the context of the human landscape provided by the archaeological evidence of settlement and human remains.*

The application was submitted in April 2012. The multiple project questions were designed to provoke interdisciplinary approaches that employed original fieldwork, fresh data collection, various analyses and a range of new scientific approaches. Some questions were simple, supported by the outcomes of previous study, and they had superficially obvious answers, but mostly, simple questions tackled through new, demanding and precise methodology have invariably opened doors into new theoretical territory. It was the intention of the project to explore and tackle the unknown, to take risks and move the fields of study forward, and the works undertaken very much reflect these aspirations. As the reviewers of the ERC grant application commented, the aspirations were admirable, but although many might not fully succeed, the journey was worthwhile in itself. It was thus that the team set out in May 2013 to start a demanding five-year programme of research into past climate, landscapes, people and their cultures, to explore what enabled or hindered human sustainability in small islands in the past. Our focus was the Maltese Islands, selected partly for our previous knowledge, but also because the size and scale presented opportunities to examine the 'rise and fall' of a distinct civilization. Other parts of the Mediterranean or Aegean might have proven harder to distinguish such distinctiveness, but Malta with its remarkable Temple Culture presented the greatest potential to test our questions. Malta too, was chosen because of the long-standing collaborative relationship extending over decades, and the shared sense of affinity with a remarkable ancient people whose world we had already begun to observe at ever closer quarters since the late 1980s.

The *FRAGSUS Project* attempts to address the many issues identified here in the broader framework of resilience theory within a restricted island community. The concept of resilience may be considered narrowly as the return rate to equilibrium or stasis after a disruptive event, and also infers a capacity to persist and resist change (Folke 2019). In particular, it is a way of understanding the capacity of ecosystems to absorb and retain their current state, and recover to a state of equilibrium following disturbance, as well as how human actions may contribute to coping strategies or a loss of adaptability (Holling 1973; Gunderson 2000; Walker *et al*. 2004; Desjardins *et al*. 2015). It is a dynamic concept focusing on how to evolve and persist with change, with adaptability and preparedness being key (Folke *et al*. 2010). Importantly, social and ecological systems should be envisaged as intertwined (Folke 2006, 2019), and contemporary environmental change may only be fully understood with contributions from archaeological and palaeoenvironmental research over the *longue durée* (van der Leeuw & Redman 2002; Davis 2019).

FRAGSUS necessarily draws on the archaeological work of our predecessors, principally Zammit, Ugolini, Ashby, Evans, Trump and Renfrew, who had in their various ways laid the foundations for this continuing study. The project was born partly from this rich background, coupled with issues arising from

our previous archaeological fieldwork undertaken between 1987 and 1995 (The Cambridge Gozo Project and excavations at the Xagħra Brochtorff Circle), and the complementary studies in environmental change (Carroll *et al.* 2012; Fenech 2007; Hunt & Schembri 1999; Schembri *et al*. 2009). There were many questions that still remained to be addressed, and new studies demanded the investment of modern scientific infrastructure and expensive specialist analyses. *FRAGSUS* could never have been achieved without the availability of substantial funds from the European Research Council, provided through the award of the Advanced Researchers Grant No. 323727. We are very grateful for the support provided and trust that this and its partner volumes provide a suitable acknowledgement.

The original project team comprised comprising nineteen scholars spread between Britain and Malta, and initially from Queen's University Belfast, the University of Cambridge, the University of Malta, Heritage Malta and the Superintendence of Cultural Heritage. Later some colleagues moved to the Universities of Plymouth and Liverpool John Moores, whilst further collaboration with colleagues at University College, Maynooth and University College and Trinity College, Dublin, and SUERC (University of Glasgow) also joined the team. In addition, new research staff attached to the main partner institutions were engaged to undertake specific sub-programmes of specialist work, and over the years a number of post-graduate students also joined the project to undertake PhD and Masters dissertations.

0.5. Archaeological concerns in Maltese prehistory and the *FRAGSUS Project*

The project was devised to tackle the outstanding general questions and issues noted above, through five specific questions that addressed the central question about what occurred at the end of the Maltese Temple Culture. The interlinked questions centred on the fragility and resilience of island life were developed. As so often in such an intensive project, not only have many questions been addressed and partly answered, but also, the answers raise new questions for future researchers to tackle.

A central feature of the project design was to bring multiple techniques together to address the same questions from a variety of angles, thus strengthening the validity of many of the conclusions.

The seven important environmental/socio-cultural questions have been addressed by this project, and are considered in this volume and Volumes 2 (Malone *et al*. in press) and 3 (Stoddart *et al.* in press):

1. What was the impact of human settlement on Malta from Neolithic times onwards, and how rapid was the process of deforestation, erosion and degradation? When did technical mechanisms to manage the environment develop – such as terracing, water and food storage? Were such mechanisms in place before or after the Temple Culture collapsed?

Enormous advances have been made by the interlinking of well dated series of environmental samples taken both from seven new deep cored pollen locations (with a corresponding sevenfold increase in catchment), numerous valley profiles (this volume) and six new AMS dated archaeological stratigraphies (Volume 2). As this and the other *FRAGSUS* monographs will show, a highly complex and fragile turbiditic landscape has been uncovered. Questions about the introduction of terracing, control of water and development of food storage have been less effectively addressed and remain issues to be solved by the next generation of archaeologists.

2. How did a very small island community in prehistoric times manage to sustain dense, complex life over millennia, and what specific social, economic and ritual controls emerged to enable this? Were the monumental temples instrumental in this process of sustaining cultural life?

For the answers to these questions, we necessarily draw on the information provided by Zammit, Evans and Trump, as scholars who investigated the temples when they were better preserved. However, the *FRAGSUS Project* has supplemented this work by the investigation of sequences from four Neolithic temple sites at Ġgantija, Santa Verna, Skorba and Kordin III. In addition, the evidence from the settlement area of Taċ-Ċawla, even if a complex multi-period site, has permitted the elucidation of some of the essential differences between the communal activities of the temples and smaller scale activities of domestic living sites. These results form the basis of Volume 2.

3. What sort of agriculture was used, and what did people eat, especially as the landscape became increasingly degraded and the environment more unpredictable? Were there failures in the food supply?

A two-pronged approach has been successfully delivered, drawing on both the refuse of the living and the remains of the dead. The settlement site of Taċ-Ċawla has delivered an unprecedented series of refuse samples that give a measured development of the food resources (carbonized seed and bone) from the Maltese Islands which can be compared with the evidence from the bodily remains of their near neighbours and contemporaries

interred in the Xagħra Brochtorff Circle. The other sites have also yielded evidence of plant and animal refuse that further indicate evidence for exceptional foods and more routine diets (see Volume 2). Palaeosols, pollen and fungal spore analysis have provided indications of past landscape and land-use changes as well as the intensity of arable agriculture and cereals in the landscape over time (see Chapters 2–5).

4. What was the size and nature of the early Maltese population and what role did demographic connectivity (immigration) play in maintaining island sustainability? What impact did diet, disease and stress have on the population?

By understanding the impact of environmental instability, disease and stress on the early people over the first millennia of occupation, we may be able to assess how they coped, and the mechanisms that may have been in place to control their population and scarce resources. Our insights into the changing demography of the Maltese Islands remain indirect but nevertheless, much better informed than in any previous study. The Cambridge Gozo survey (undertaken in the late 1980s and early 1990s, with summaries presented in Chapters 6 and 7 and in Volume 2, Chapter 1) has given some sense of the relative and changing density of a small sampled part of the landscape. The studies of agricultural development and pastoralism (see Chapters 3, 5, 8 & 9) add to this work, by providing important insight into the potential carrying capacity of the islands. The soil, pollen and molluscan analyses have recorded the impact of these populations on the islands at a date even earlier than the settlement record (see Chapters 3–5). Studies of aDNA, isotopes and the physical anthropology (see Volume 3) have demonstrated different degrees of understanding of the connectivity of humans with the outside world which can be measured against the imported non-organic materials such as stone axes, as well as the local crops, trees, animals and other resources. A deeper understanding of demography remains a substantial challenge, and one that future generations can continue to tackle.

5. Was there social-economic or environmental failure at the end of the Temple Culture in the later third millennium BC*, and what may have caused society and its agricultural economy to change so drastically or possibly collapse? Was there a hiatus between the Temple Culture and later Bronze Age settlers?*

A number of indicators have been combined to investigate the environmental-economic and human situation at the end of the Temple Period, including pollen, molluscan, soil and sedimentary data, human remains and the distribution of radiocarbon dates. Collectively, these do support the evidence for important changes at about 2400–2300 BC, but similar analysis has also detected palaeoenvironmental and demographic changes in the fifth millennium BC, extending over a longer period (see Chapters 3, 6, 7 & 11 & Volumes 2 and 3). The definition and narrowing of these windows of change is one of the exciting results of the current work and stimulating prospects for further analysis by future generations of archaeologists.

6. What, if any, were the effects of long-term climate change on the agricultural resilience and sustainability of the Maltese Islands?

The suite of detailed of complementary pollen, molluscan, soils and sediment data with a robust, newly established chronology has suggested both long-term degradation of the landscape as well as variable imprints of agricultural use and intensification, and valley-by-valley sequences of fill related to catchment responses to human activities, erosion and changing climatic factors over the past 8000 years (see Chapters 2–5). Surprisingly, there has been a substantial degree of resilience in the Maltese landscapes over the longer term.

7. How does the Maltese sequence of palaeoenvironmental and cultural changes compare with the long-term records of environmental change and short-duration extreme events over the last 10,000 years observed elsewhere in the southern Mediterranean region, such as Sicily?

There appears to be a degree of synergy between the Maltese palaeoenvironmental records and other regions of the central and southern Mediterranean basin. Most notably the effects of aridification are evident in the palaeosol and vegetational sequences from the latter part of the Temple period (see Chapters 3–5). But there the detailed, chronological well-defined, studies of the valley deep cores (see Chapter 2) have greatly refined our ability to chart changing human-environment relationships in many parts of Malta and Gozo at a scale of resolution rarely attempted before, both temporally and spatially.

0.6. The research programme: the sites and their selection

The overall project focused on three forms of data collection:

- the environmental material buried in the landscape (this volume).

- the prehistoric sites and their buried deposit and material culture (Volume 2).
- the buried population of the Xagħra Brochtorff Circle and other prehistoric sites (Volume 3).

In addition, the data collected from the intensive landscape survey of Gozo between 1987 and 1995 were also reassessed through GIS and provided important supporting information for the three data groups above (see Chapter 7).

0.7. Investigating the palaeoenvironmental context

The *FRAGSUS Project* enabled an unrivalled opportunity to elucidate the Holocene palaeoenvironmental and archaeological history of the islands of Gozo and Malta. Particular emphasis was placed on the recognition of the impacts of the first Neolithic farmers and Temple Period builders, but also on the investigation of the imprint of human activities on the islands both before and after this unique period, and the impact of climate and environmental change on the human societies and how resilient the islands were to these changes.

Generally, strong monsoonal influence and Hadley circulation in the Early Holocene caused the southeastern and northwestern Mediterranean countries to be relatively humid, while the southwestern and northeastern countries were less humid (Weninger 2006; Magny *et al*. 2009, 2011; Carroll *et al*. 2012; Bini *et al*. 2018). As the Holocene progressed, the monsoonal influence declined and the southeastern and northwestern countries became less humid and the northeastern and southwestern countries became relatively more humid. Punctuating these trends were a series of short periods of climate disruption originating in the North Atlantic. These events at 9.3, 8.2, 6.5 and 4.3 ka BP (7350, 6250, 4550 and 2350 BC) seem to have impacted the countries around the Mediterranean with varying degrees of severity, and some appear to be synchronous with major episodes of societal disruption and population mobility (e.g. Weninger 2006). The trajectory of climate change in neighbouring lowland Sicily does not seem to have been affected severely by these events, although aridification seems to have started *c*. 3050 BC (Noti *et al*. 2009; Tinner *et al*. 2009), but Carroll *et al*. (2012) pointed out the coincidence between the dates associated with the end of the Temple period in Malta and the 4.3 ka BP (2350 BC) event, and demonstrated an interruption in cereal cultivation in the Salina Bay records at this time. Thus, the project aimed to provide new, chronologically robust palaeosol, palaeovegetational and palaeoclimatic data to compare with the archaeological record and with other long-term records of environmental change in the southern Mediterranean region (see Chapters 3–5).

Soil degradation and erosion in the islands of Malta and Gozo are regularly observed as a compelling and prevalent problem today and one that has its origins in earlier prehistoric times (Lang 1960; Blouet 1997; Vella 2003; Fenech 2007; Grima 2008b; Malone *et al*. 2009a). Moreover, these islands appear to share many of the soil characteristics and history of a continual struggle against aridification, dewatering and with the intensification of agriculture associated with the creation of extensive terraced landscapes, just as occurred in many other parts of the Mediterranean area (Brandt & Thornes 1996; Carroll *et al*. 2012; Sadori *et al*. 2013). As a corollary, the development of the typical red Mediterranean soils or *terra rossa* on limestone substrates of this region (Bridges 1978; Lang 1960; Yaalon 1997; Van Andel *et al*. 1990) were also be investigated.

It has always been assumed that the seasonally dry and hot Mediterranean climate made the Maltese landscape quite marginal in agricultural terms (Schembri 1997). As a consequence, it has sometimes been presumed that terracing was adopted extensively from prehistoric times in Malta and Gozo to conserve soils and moisture, and create a better landscape for subsistence based agriculture (Rolé 2007). Like many other parts of the Mediterranean, this landscape is thought to have been prone to deforestation, drought and soil erosion, combined with intensive human activity, and that this has been the case since Neolithic times (Brandt & Thornes 1996; Bevan & Conolly 2013; Grima 2008a & b; Grove & Rackham 2003; Hughes 2011; Djamali *et al*. 2013). This project explored the evidence for the subsistence practices of these early people, and it examined how they managed to develop a sufficiently productive economy to support and sustain temple building in the late fifth to mid-third millennia BC. The latest techniques of dating, geoarchaeology, palaeo-economy, remote sensing, survey and sampling were employed to push the boundaries of knowledge towards understanding this problem. By integrating the archaeological and landscape evidence with environmental reconstruction, chronology and population history, we should be able to connect the disparate bodies of evidence, and to propose models that explain the long-term impact of population and settlement on the Maltese Islands. Moreover, the models should have a wider application to other times and places, given the cyclical nature of human behaviour. This volume begins that process of modelling and integration, and the work continues in Volume 2 by developing the archaeological story and its implications for these islands.

The research reported on here aimed to examine these assumptions and questions and test them using a variety of palaeoenvironmental, geoarchaeological,

chronological, Geographical Information System, archaeological and historical approaches, both on- and off-site (cf. French 2015). This extensive, multi-disciplinary suite of approaches was combined to investigate issues of long-term cultural sustainability in this fragile environment. Multiple investigations of deep valley sediments, buried soils and landscapes, archaeological sites and human remains were all combined in an interlinked study which may collectively provide understanding of how a culture, environment and landscape developed through time. Detailed chronological investigations of off- and on-site locations were developed using state of the art Accelerated Mass Spectrometry (or AMS) radiocarbon, tephra, Optically Stimulated Luminescence (or OSL) and cultural dating techniques to provide vital control over the data, enabling realistic understandings of cultural and environmental changes. As a central focus, a substantial number of deep valley cores was drilled, dated and studied for pollen, invertebrate and other fossil proxies, and along with extensive geoarchaeological survey, sedimentary and buried soil analyses were to reconstruct the dynamic ancient environment through time in the context of the human landscape provided by the archaeological evidence of settlement and human remains (see Chapters 2–5). These combined approaches are still relatively rare, but have provided a stunning battery of new detailed sequence data for the Maltese Islands from which to interrogate and better explain the archaeological record.

0.8. Archaeological investigations

Archaeological sites were chosen to cover the chronological and functional range of human occupation of prehistory in the Maltese Islands to the end of the Temple Culture, with an equal attention to pragmatic issues such as access and ownership. By the end of the project one settlement zone around a probable water hole (Taċ-Ċawla), four temple sites (Ġgantija, Kordin III, Santa Verna and Skorba, the latter two with deep stratigraphies) and a Middle Bronze Age defensive settlement (In-Nuffara) had been investigated (Figs. 0.2 & 0.4). Already collected samples were analysed

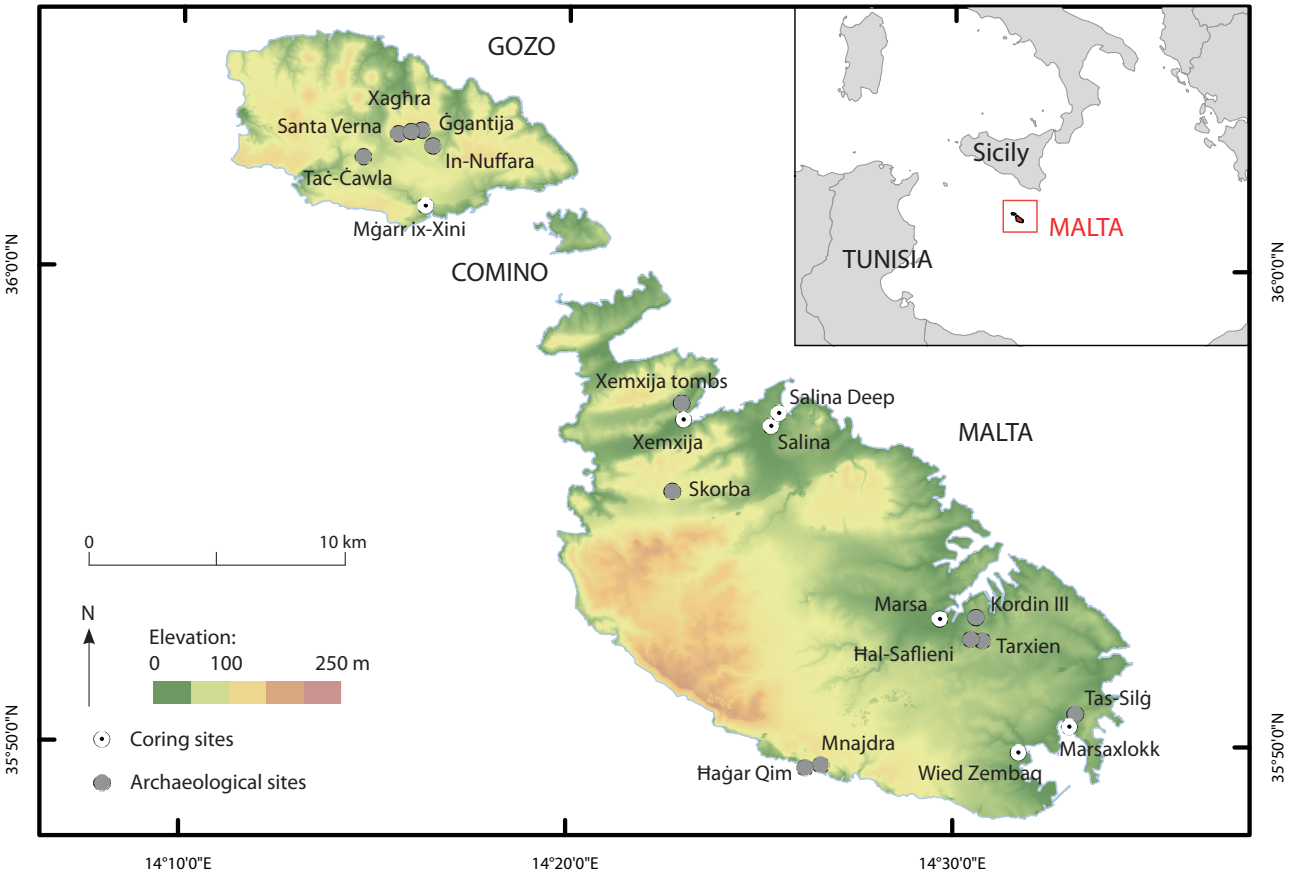

Figure 0.2. *Location of the main Neolithic archaeological and deep coring sites investigated on Malta and Gozo (R. McLaughlin).*

a

b

Figure 0.3 *(above and opposite). Some views of previous excavations on Gozo and Malta. a) Santa Verna, looking east (Ashby(o).XXXVII.91); b & c) Ġgantija, looking southeast (TA[PHP]-XXVII.083, TA[PHP]-XXVIII.011); d) stone circle, Xagħra (TA[PHP]-XXVII.100) (with kind permission from the Ashby Archive, The British School at Rome; all rights reserved).*

c

d

a

b

c

d

e

Figure 0.4. *Some views of recent excavations at Santa Verna (a), Ġgantija (b & c) and Skorba (d) temples, and In-Nuffara (e) (C. French).*

from a further two prehistoric sites (Xagħra Brochtorff Circle and Tarxien) and one medieval site (Mdina) (Fig. 0.3). The sites of Taċ-Ċawla, Santa Verna and Skorba provided the most elaborate and chronologically wide-ranging information, and Taċ-Ċawla, Santa Verna and Kordin III also enabled spatially informative information over the area of a site. The detailed results from this new fieldwork are presented in Volume 2.

The programme of work started with the extensive excavation of Taċ-Ċawla and survey of Ġgantija and Santa Verna (2014), progressed towards the excavation of Ġgantija, Santa Verna and In-Nuffara (spring 2015) and Kordin III (summer 2015), and ended with limited work at Skorba (spring 2016) (Fig. 0.4). The most substantial teams were present at Taċ-Ċawla, Santa Verna and Kordin III. The main personnel at each of these sites was provided by Queen's Belfast, the University of Cambridge and the University of Malta, respectively, together with university student assistance from each university.

The choice of sites for excavation was designed to assess the *FRAGSUS* questions by contributing to understanding of: (i) impact of human settlement on Malta, (ii) social sustainability, (iii) the size and nature of the prehistoric population, and (iv) the social and economic changes at the end of the Temple Period. They were also selected as being representative of particular landscapes that might inform on associated sites. For example, Kordin III, because the site was close to the Tarxien and Ħal Saflieni complex, offered potential insight into the prehistoric landscapes of the now highly urbanized city-scape of Paola.

A number of other sites were considered but were not eventually included in the study on grounds of time, access and certainty of contribution to the *FRAGSUS* questions. However, these continue to be very viable places for study of Malta's past for future generations of archaeologists. Ta' Marżiena (Gozo) (a probable temple site with deep stratigraphy) was laser scanned, but its access would have required negotiation with a private land-owner. The main Bronze Age fortifications of Borġ in-Nadur on Malta were scanned but some work had recently been undertaken and further work was logistically difficult. Xrobb L-Għaġin, a probable temple site on Malta, threatened by cliff collapse, was considered too dangerous to investigate. Għar ta' Għejżu on Gozo was scanned, but had already been badly damaged and contained no deposits. The Xemxija burial chambers were scanned and the skeletal remains recovered by Evans have been considered by Jess Thompson in Volume 3 in a fresh analysis. Għar Dalam was scanned, but the deposits considered too precious for further excavation. The south temple of Ġgantija was scanned but never considered for excavation, except on its margins where the two sondages were recorded (see Chapter 5 & Volume 2). The Xagħra Brochtorff Circle was 3-D scanned, but permission was never received for limited further excavation to assess the eroding condition and conservation needs of the site. The Skorba period site of Ta' Kuljat detected on the original Gozo survey was considered for excavation, but considered logistically too problematic. Many other sites across the now heavily threatened Maltese-Gozitan landscape could have been included, minor temple structures, isolated megaliths, rock cut tombs and exposed sections, but for the present, the six interventions and their associated environmental analysis are the harvest of the *FRAGSUS Project* (see Volume 2).